Journal of Water Economics 54 (2026): 59–92 ISSN 3111-2013

Water access and school absence among boys and girls: Evidence from rural Ghana

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This study investigates how access to water affects children's school attendance in rural Ghana. We use data from 7,227 school-aged girls and boys from the seventh Ghana Living Standard Survey wave. The econometric analysis suggests that rural girls living in households with travel times of one hour or more to the water source are 4.5 percentage points more likely to miss school than rural boys and miss 12.2 per cent more school hours. Further investigation of the mechanisms suggests that the link between water access and girls' school absenteeism in rural areas may be due to younger girls taking on the household duties of older sisters or mothers, so that the latter can travel to fetch drinking water. The findings suggest that policy interventions that reduce time and effort involved in fetching drinking water are a necessary condition for reducing gender inequalities in school attendance.

JEL: I24, I25, O12

Keywords: Access to drinking water, school attendance, gender equality, Ghana

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Acknowledgements: We thank the editor and two anonymous referees for helpful comments and suggestions that improved this paper. We are also grateful for feedback from participants at the 2024 Annual Meeting of the Canadian Economics Association and the 32nd International Conference of Agricultural Economists. All remaining errors are our own.

Disclosure statement: The third and fourth authors acknowledge funding from the Canadian Queen Elizabeth II Diamond Jubilee Scholarships: Advanced Scholars – West Africa (QES-AS West Africa). The QES is administered through a partnership among Universities Canada, the Rideau Hall Foundation (RHF), and Canadian universities. The QES-AS West Africa program is supported financially by the International Development Research Centre (IDRC). Data and code are available as online supplementary files. The authors declare no conflicts of interest.

Manuscript received: 2 Jun 2025; final version accepted: 20 Mar 2026; available online: 16 Apr 2026.

DOI: https://doi.org/10.15353/jwe.v54i.6856.

1 Introduction

Sub-Saharan Africa (SSA) has made important advances in school enrolment, particularly at the primary level over the past six decades driven by sustained investments and the implementation of universal basic education policies (Afoakwah and Koomson, 2021; Afoakwah et al., 2023). However, the region still exhibits the highest out-of-school population and remains the only one where this population is growing. At the same time, gender disparity persists, especially among children of secondary school age. Girls' out-of-school rate is 2.6 and 4.2 percentage points higher than that of boys at lower and upper secondary levels, respectively (UNESCO, 2022).

In Ghana, the government instituted two major educational policy reforms over the last four decades, alongside increased investment in education.[1] First, a reform in 1987 replaced the British–based O-level and A-level systems with Junior and Senior high schools and diversified the curriculum by introducing vocational, technical, and agricultural subjects (Osei, 2004). In addition, it reduced the length of pre-tertiary education from 17 years to 12 years, thus reducing the gender gaps in school attainment.[2] Second, the introduction of the Free Compulsory Universal Basic Education (FCUBE) in 1992 focused specifically on women's education.[3] As a result, the gender gap has largely closed at the elementary level. However, significant disparities persist between rural and urban areas. In the poorer northern regions of Ghana especially, girls remain disproportionately excluded from schooling opportunities (Afoakwah et al., 2023).

While policy interventions have addressed barriers to school enrolment, challenges related to regular school attendance continue to limit educational outcomes for girls, particularly in rural settings. Regular attendance is a crucial next step toward achieving gender equality in education. Even when children are formally enrolled, repeated absenteeism reduces learning progress, increases the risk of grade repetition, and ultimately raises the likelihood of dropping out, especially during the transition to secondary school. Hence, improving attendance represents a key policy frontier following the substantial success in expanding enrolment.

One possible explanation for persistent attendance gaps lies in deficiencies in basic infrastructure, such as access to safe drinking water. Rural areas remain comparatively under-serviced, and the task of water collection still falls largely on women and girls (Graham et al., 2016; Geere and Cortobius, 2017; Nauges, 2017; UNICEF, 2023).[4] This raises

[1] Public investment in education as a percentage of gross domestic product increased from 4.22 per cent to 8.14 per cent from 1971 to 2011. Public investment in education as a percentage of government expenditure increased from 7.74 per cent to 33.1 per cent from 1981 to 2011 (World Bank, 2011). Also, there has been a general increase in the total number of teachers at both the primary and secondary levels. From 1974 to 2013, the number of primary school teachers has increased from 33,752 to 129,599 and secondary school teachers from 21,841 to 134,431 (World Bank, 2013).

[2] Given the old system, one will be at least 23 years before tertiary education but the reduction enabled girls to finish secondary school before dropping out to get married.

[3] The government set up a department to specifically facilitate women's education.

[4] While access to at least basic drinking water services in SSA's rural areas increased from 44 per cent to 50 per cent between 2015 and 2022, it remains far below 83 per cent in 2015 and 85 per cent in 2022 in urban areas. These figures include drinking water from an improved source that is accessible on-site and within 30 minutes round trip including queuing. As of 2022, the rural-urban divide in on-site access to safe drinking water in SSA was 15:53 per cent, while basic coverage within 30 minutes was 35:32 per cent. In Ghana, on-site access to

an important question: are girls in rural areas more likely than boys to experience lower school attendance due to the time burden and adverse health effects associated with water fetching?

So far, empirical investigations of the association between water accessibility and gendered educational outcomes in SSA remain inconclusive. For example, Nauges (2017) find a positive association between reduced travel time to water sources and girls' school attendance at cluster level using four rounds of Ghana's Demographic and Health Surveys. They also find similar effects for boys and conclude that there is no gender discrimination. Shimamura et al. (2022) find no association between improved water access via newly constructed boreholes and school attendance in Zambia. Exploring mechanisms using a comprehensive time-use survey they conclude that improved access to water shifts the burden of water-related household chores from adult women to girls. A recent experimental study by Cook et al. (2024) shows that a free water-delivery treatment to reduce collection times to zero for randomly chosen households in rural Kenya increased self-reported but not school-recorded attendance, and children re-allocated time savings to other chores such as cleaning and cooking. No or little effects are also documented by Koolwal and Van de Walle (2013) in rural Uganda, Malawi, Madagascar and Rwanda, by Devoto et al. (2012) in urban Morocco, or by Gross et al. (2018) in rural Benin.[5]

Beyond time burden, a growing body of research highlights the physical and health impairments of regular water carrying (Hemson, 2007; Geere et al., 2010; Porter et al., 2012; Geere and Cortobius, 2017; Geere et al., 2018). More specifically, Porter et al. (2012) show that girls are more likely to report pain from load-carrying in Malawi and South Africa, with negative effects on schooling for both boys and girls. Qualitative evidence from South Africa suggests adverse effects in terms of being late for school, having difficulties concentrating, and experiencing fatigue and physical pain (Hemson, 2007).

In this article, we re-visit the link between travel time to fetch water and school absence among boys and girls using the most recent Ghana Living Standard Survey from 2016/2017 (GLSS7). Specifically, we aim to explore whether and to what extent travel time to drinking water affects children's school attendance, and whether we can detect a different effect between boys and girls. We also investigate three alternative channels, namely children's participation in household chores, economic activities, and health impairments, that may explain the effect of water access and school absence. To that end, we create an analytical sample of 7,227 school-aged children between six and 14 years and combine it with self-reported time spent going to the water source, queuing and returning, measured at the household level. Although the establishment of causality in a cross-sectional data set is difficult to achieve, we aim to assess the association between children's school absence and water access between households within the same communities (enumeration areas (EAs)) using EA fixed effects and a series of sensitivity tests.

Our results indicate an association between travel time to fetch water and school

safe drinking water is 19 per cent and 63 per cent in rural and urban areas, respectively (UNICEF, 2023).

[5]Empirical evidence from non-SSA countries shows a similarly mixed pattern. Positive associations are found in Yemen, Morocco, Nepal, and Pakistan (Koolwal and Van de Walle, 2013), in rural China (Zhang and Xu, 2016), in mountainous areas of Nepal (Dhital et al., 2022) and in Indonesia (Komarulzaman et al., 2019), For India, evidence is also mixed. While Choudhuri and Desai (2021) report a negative association, Hamlet et al. (2021) find that shorter water-fetching times are positively associated with learning achievements, especially for girls.

absence, both in terms of the likelihood of missing school and the number of hours missed, among girls living in rural areas of the country. On average, a girl from a rural household who travels an hour or more is 4.5 percentage points more likely to miss school and misses 12.2 per cent more hours, as compared to a boy. These estimates stay robust in terms of magnitude and level of statistical significance when one excludes households with immediate water access that reduces the correlation between travel time and observable child-, and household-level characteristics including household's welfare, education, and travel time to school to a minimum. In terms of underlying mechanisms, our analysis suggests that school absence seems to be driven by the necessity that girls need to take over additional household chores, while older sisters or mothers are out to fetch water. Our results are in contrast to earlier findings from SSA that suggest no or little differential effects of improved water accessibility on school outcomes between boys and girls (Koolwal and Van de Walle, 2013; Nauges, 2017; Gross et al., 2018; Shimamura et al., 2022). However, the underlying mechanism of a shift in household chores from adult women to girls resembles a pattern found by Shimamura et al. (2022) in Zambia or earlier discussions by Koolwal and Van de Walle (2013) for the non-African countries where improved water access improves schooling outcomes.

In the African context, our study contributes nationally representative evidence on the association between water access and school absence among girls and boys in rural Ghana. It complements the existing literature on children's education and access to basic infrastructure services such as drinking water in rural SSA (Koolwal and Van de Walle, 2013; Nauges, 2017; Gross et al., 2018; Shimamura et al., 2022), and more broadly, the extensive body of work on the determinants and consequences of educational investments in children, including the role of child labour and household production (Edmonds, 2007; Basu, 1999).

Yet, our study advances the literature in several important ways. First, while previous evidence for Ghana (Nauges, 2017) relies on cluster-level averages of school attendance derived from the Demographic and Health Surveys across four years, we use individual-level data on school absenteeism from the Ghana Living Standards Survey (GLSS7, 2016/2017) and link them directly to household-level measures of water access. Second, unlike most prior studies that focus on average attendance over longer periods, we examine school absenteeism over the past seven days - an observation window that aligns precisely with the reporting period for our proposed mechanisms. This enables a closer mapping between short-term fluctuations in water-fetching demands and missed schooling. Third, we move beyond documenting associations by explicitly investigating potential pathways, i.e., we analyze how children's participation in household chores, caregiving, economic activities, and health impairments mediate the relationship between travel time to drinking water and school absence.

In the next section, we describe our analytical data set, including the definition of the main variables of interest, and present descriptive statistics. Section 3 explains the empirical strategy, while Section 4 presents the estimation results including robustness checks and a discussion of underlying mechanisms. Finally, Section 5 concludes.

2 Data and descriptive statistics

We use the seventh wave of the Ghana Living Standard Survey (GLSS7) which we shortly introduce in what follows.

The GLSS is a comprehensive and nationally representative household survey that has been conducted since 1987. It is a multipurpose household survey that provides a wealth of data in assessing the living conditions of Ghanaians. The data collection activities related to the seventh round were carried out over 12 months between October 2016 and October 2017. A two-stage stratified sampling design was used to collect the data. In the first stage, 1,000 enumeration areas (EAs) were selected as the primary sampling unit. This selection was based on a probability proportional to population size of the then ten administrative regions.[6] The EAs were divided into urban and rural localities of residence based on population size. In the second stage, 15 households were systematically selected from each EA. Out of the target sample of 15,000 households, 14,009 households completed the survey, which resulted in a response rate of 93 per cent (Ghana Statistical Service, 2019).

The subsequent analysis focuses on rural localities, where problems of water access are considerably more severe than in urban areas (see Figures A1 and A2 in the Appendix). This rural-urban disparity is largely attributable to institutional constraints faced by the public water utility Ghana Water, which is mandated to prioritize water supply to urban populations (Dongzagla et al., 2022).

To address our objective to examine the relation between travel time to drinking water and school absence in rural Ghana, we use child-level data that includes children of school age between the ages of six and 14. The analytical sample contains 7,227 children from 4,013 households.[7] As shown in Table 1, 49.0 per cent of the children are girls, and the majority, i.e., 67.2 per cent, are enrolled in primary school between grades one and four.

Table A1 in the Appendix provides an overview of variables used in our analysis and the exact questions asked in the survey. We define two main outcome variables. First, we use a binary indicator equal to one if a child missed at least one hour of school in the past week due to domestic and labor-related reasons such as helping with household tasks, assisting the family business, caregiving, working outside the household, or other reported reasons potentially related to time constraints, zero otherwise.[8] Second, we measure the number of hours a child missed school analogously to the binary indicator. As can be seen in Table 1, 8.0 per cent of children missed school, and 0.832 hours are missed on average.

The main explanatory variable of interest is the travel time to fetch drinking water in

[6] Ghana is currently divided into 16 administrative regions.

[7] The full GLSS7 child sample includes 11,097 children aged 6 to 14 from 6,433 households. We restrict the main analysis to the rural subsample (7,227 children in 4,013 households), where water access constraints are considerably more severe than in urban areas as shown by descriptive statistics in Figures A1 and A2 and by a more formal test in Table B1 in the Appendix.

[8] Table A2 in the Appendix provides an overview of the reported reasons for missing school, along with their relative frequencies. The main reasons why a child missed school and is counted in our definition are to help with household chores (7.16 per cent), help family business (4.14 per cent), taking care of children or elderly (1.34 per cent), working outside the family business (0.89 per cent), or other (51.34 per cent). Absences due to illness, teacher absence, school vacation, bad weather, or school fee issues are not classified as domestic-related absences. Children reporting these reasons remain in the sample but are coded as zero for the domestic-absence indicator. There are no statistically significant differences between boys and girls on why school was missed (Table A3 in the Appendix).

Table 1: Summary statistics of rural sample at child level (N = 7,227)

	N	Mean	SD	Max	Min
Child characteristics					
Age (years)	7227	10.419	2.354	14	6
Girl (binary)	7227	0.490	0.500	1	0
Grade (binary)					
P1–P4	7227	0.672	0.469	1	0
P5–P6	7227	0.222	0.416	1	0
JSS1–JSS3	7227	0.104	0.305	1	0
SSS1–SSS3	7227	0.001	0.033	1	0
Missed school (binary)	7227	0.080	0.272	1	0
Hours missed	7227	0.832	3.634	40	0
Travel time to school (hrs)	7227	0.646	0.657	4.0	0
Household characteristics					
Household size	7227	7.421	3.648	28	2
Number of children	7227	3.877	2.274	18	1
Girl ratio	7227	0.487	0.302	1.0	0
Number of adults	7227	3.546	2.027	15	1
Dependency ratio	7227	0.560	0.158	1.0	0.083
Female ratio	7227	0.519	0.185	1.0	0.000
Mean age (years)	7227	22.017	6.630	59.333	8.200
Engaged in ag. (binary)	7227	0.909	0.288	1	0
Welfare (GH¢/AES)	7227	2070.35	1664.99	21 169.74	48.81
Household head characteristics					
Age (years)	7227	48.576	13.268	99	17
Female (binary)	7227	0.241	0.428	1	0
Education (categ.)	7227	1.026	1.186	5	0
Married (binary)	7227	0.823	0.382	1	0
Religious (binary)	7227	0.939	0.240	1	0
Access to drinking water					
Travel time (hrs)	7227	0.391	0.436	3.167	0
Travel distance (m)	7227	295.238	541.902	5000.000	0
Fetcher (binary)					
Adult woman 15+	7227	0.660	0.474	1	0
Adult man 15+	7227	0.062	0.242	1	0
Girl <15	7227	0.108	0.311	1	0
Boy <15	7227	0.049	0.216	1	0

Note: Welfare is measured in GH¢/per adult-equivalent (AES) and includes monetary and non-monetary income. Education is a categorical variable that reflects the household head's highest level of education attained, i.e., 0 - never attended school, 1 - primary school, 2 - junior or middle school, 3 - senior or secondary school, 4 - vocational training or certificates, 5 - tertiary education. Religious is a binary variable equal to one if the household head's religious denomination is Catholic, Protestant, Pentecostals/ Charismatic, Other X'tian, Islam or Traditionalist, zero otherwise.
Source: GLSS 7, own calculations.

hours, which is reported at the household level. The time reported includes the time it takes to go to the drinking water source, get water, and come back. Among our analytical sample, 88 per cent of children live in households that depend on fetching drinking water from a source outside their compound or a neighbour's compound. This observation echoes the limited share of households with access to water on their premises in rural Ghana as observed in other studies (Dongzagla et al., 2022). In most cases, i.e., 66.0 per cent, adult women aged 15 years and older are tasked with fetching water, and 6.2 per cent are adult men. Among children fetching water, girls are more than twice as likely to fetch water than boys, i.e., 10.8 percent and 4.9 per cent, respectively. The average travel time amounts to 0.391 hours (approximately 23 minutes), which corresponds to approximately 295.24 meters of distance travelled.

Before we turn to the introduction of our empirical strategy, Table 2 tests the statistical significance of differences in observable characteristics between children by school attendance and gender. Some interesting observations can be made. For example, in comparison to girls and boys who did not miss school, children who did miss school are more likely to be younger and enrolled in a lower grade. Furthermore, school-absent girls and boys exhibit larger travel times to fetch water than their respective counterparts, whereby the difference between school-absent girls and non-absent girls is even more pronounced than the difference between boys. Focusing on gender differences among children who missed school, boys are more likely related to households with a larger number of children, higher dependency ratio, lower share of girls and women, and more likely to be engaged in agriculture than girls. In terms of water access and who in the household fetches water, the share of girls sent to fetch water is approximately 7.3 percentage points higher among school-absent girls than among school-absent boys (i.e., 0.149 – 0.076). The same pattern can be observed among school-absent boys when boys are sent to fetch water (0.072 – 0.018 ∼ 5.4 percentage points). As one would expect, there is an association between who fetches water, especially among children of school age, and school attendance. To further investigate these associations, the next section introduces the empirical strategy.

3 Empirical specification

We aim to explore whether and to what extent time spent fetching drinking water at the household level affects children's school attendance. To do so, we specify the following model:

$$Y_{ijv} = \beta_g Girl_{ijv} + \beta_{TT} TT_{jv} + \beta_{gTT} Girl_{ijv} * TT_{jv} + \gamma X'_{ijv} + \delta Z'_{jv} + \theta_v + \varepsilon_{ijv}, \quad (1)$$

where Y_{ijv} represents two educational outcome variables that measure the extensive and intensive margins of school absenteeism, i.e., (i) a binary indicator equal to one if child i, living in household j and enumeration area (EA) v missed at least one hour at school during the past week, zero otherwise, and (ii) a continuous variable measuring how many school hours child i missed during the past week. Furthermore, we specified an interaction between a binary indicator for child's i sex,$Girl_{ijv}$, and the self-reported travel time to fetch drinking water in hours at the household level, TT_{jv}, to capture the heterogeneous impact of water accessibility on educational outcomes between girls and boys. The matrix X_{ijv}

Table 2: Differences in child and household characteristics by school absence due to domestic- or labor-related reasons

	Child did not miss school				Child did miss school			
	Girl		Boy		Girl		Boy	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Child characteristics								
Age (years)	10.410	2.339	10.455	2.381	10.373	2.294	10.155[d]	2.247
Grade (binary)								
P1–P4	0.654	0.476	0.677[a]	0.468	0.736[c]	0.442	0.766[d]	0.424
P5–P6	0.230	0.421	0.221	0.415	0.192	0.395	0.178	0.383
JSS1–JSS3	0.115	0.319	0.101	0.301	0.072[c]	0.260	0.056[d]	0.230
SSS1–SSS3	0.001	0.030	0.001	0.038	0.000	0.000	0.000	0.000
Missed school (binary)	0.000	0.000	0.000	0.000	1.000	0.000	1.000	0.000
Hours missed	0.000	0.000	0.000	0.000	10.819[c]	8.411	9.964[d]	7.810
Travel time to school (hrs)	0.643	0.647	0.639	0.650	0.696[c]	0.745	0.720[d]	0.741
Household characteristics								
Household size	7.412	3.754	7.406	3.550	7.388	3.424	7.727	3.765
Number of children	3.854	2.305	3.861	2.226	3.888	2.217	4.283[b,d]	2.476
Girl ratio	0.673	0.243	0.308[a]	0.239	0.683	0.244	0.316[b]	0.239
Number of adults	3.559	2.086	3.546	1.984	3.500	1.934	3.444	1.946
Dependency ratio	0.561	0.159	0.557	0.157	0.554	0.156	0.592[b,d]	0.150
Female ratio	0.610	0.168	0.432[a]	0.156	0.607	0.166	0.439[b]	0.153
Mean age (years)	22.324	6.846	21.838[a]	6.427	21.463	6.324	21.210[d]	6.624
Engaged in ag. (binary)	0.898	0.303	0.914[a]	0.280	0.938	0.241	0.944[b]	0.230
Welfare (GHc/AES)	2121.05	1662.80	2019.88 [a]	1606.88	2119.11	1893.18	2042.98	2084.84
Household head characteristics								
Age (years)	48.963	13.422	48.325[a]	13.190	48.043[c]	12.672	47.694	12.936
Female (binary)	0.262	0.440	0.219[a]	0.414	0.268	0.444	0.224	0.417
Education (categ.)	1.051	1.205	1.027	1.180	0.906	1.108	0.859[d]	1.100
Married (binary)	0.809	0.393	0.837[a]	0.369	0.804	0.397	0.829	0.377
Religious (binary)	0.945	0.229	0.934	0.248	0.935	0.247	0.928	0.260
Access to drinking water								
Travel time (hrs)	0.377	0.417	0.390	0.444	0.499[c]	0.537	0.434[d]	0.438
Travel distance (m)	279.221	501.065	296.135	547.425	407.575	750.406	355.293	652.528
Fetcher (binary)								
Adult woman 15+	0.642	0.479	0.671[a]	0.470	0.663	0.474	0.724	0.448
Adult man 15+	0.054	0.226	0.073[a]	0.260	0.058	0.234	0.039[d]	0.195
Girl <15	0.147	0.354	0.070[a]	0.255	0.149	0.356	0.076[b]	0.265
Boy <15	0.028	0.166	0.069[a]	0.254	0.018	0.134	0.072[b]	0.260
Observations	3265		3382		276		304	

Note: [a] and [b] denote differences in means between boys and girls among children that did not miss school and children that did miss school due to domestic- or labor-related reasons in the last week, respectively, while [c] and [d] denote differences in means between girls that missed and girls that did not miss school, and between boys that missed and did not miss school, respectively. Differences in means are based on Wilcoxon rank sum test and Fisher's exact test at 5 per cent significant level or lower. Welfare is measured in GH¢ per adult-equivalent (AES) and includes monetary and non-monetary income generated by household members. Education is a categorical variable that reflects the household head's highest level of education attained, i.e., 0 - never attended school, 1 - primary school, 2 - junior or middle school, 3 - senior or secondary school, 4 - vocational training or certificates, 5 - tertiary education. Religious is a binary variable equal to one if the household head's religious denomination is Catholic, Protestant, Pentecostals/ Charismatic, Other X'tian, Islam or Traditionalist, zero otherwise.
Source: GLSS 7, own calculations.

contains child characteristics such as age, travel time to school, and what grade is currently attended. The matrix Z_{jv} includes household characteristics such as who fetches water, household size, the share of girls among all children below the age of 15, dependency ratio, the share of girls and women within the household, average age, whether the household is engaged in own agricultural production, and a welfare aggregate that includes all monetary and non-monetary income sources. Z_{jv} also contains the household head's age, sex, marital status, education, and religious background. We include EA fixed effects (θ_v) and cluster standard errors at the household level that corresponds to the level of measurement of our treatment variable, i.e., travel time.

When the dependent variable is specified as a binary indicator of whether school was missed, we chose to estimate a linear probability model for ease of interpretation and given the consistency of results for linear and non-linear specifications with binary outcomes (Wooldridge, 2010; Angrist and Pischke, 2009). In either case, the coefficient of interest is β_{gTT}, which reflects the differential effect of a one-hour increase in travel time to fetch drinking water on school absence between boys and girls. Recognizing that endogeneity from omitted variables and simultaneity is difficult to eliminate in cross-sectional data, we assess the robustness of our findings through several sensitivity tests in Section 4.2.

4 Results

Following our empirical strategy described above, we first present the regression results of whether a child of school age missed at least one school hour in the past week and the extent of missed hours specified in Equation (1), in Section 4.1. We then examine the sensitivity of results in Section 4.2, and explore mechanisms in Section 4.3.

4.1 Main results

Table 3 presents the estimation results of Equation (1) for the two dependent variables, whether a child missed at least one hour of school in the last week (Columns 1 and 3) and how many hours were missed (Columns 2 and 4). Columns 1 and 2 include all rural households, while Columns 3 and 4 exclude rural households with immediate access to drinking water. [9]

[9]Before restricting the analysis to rural areas, we estimated Equation (1) using the full sample of rural and urban households, introducing a triple interaction term between travel time to drinking water, being a girl, and residing in a rural area. Because rural status does not vary within enumeration areas, its main effect is absorbed by the fixed effects. Table B1 reports the interaction coefficients and a joint Wald test of the Travel Time × Rural and Travel Time × Girl × Rural terms. While the joint test does not reject equality of slopes in the full sample, it yields $F(2, 4519) = 2.88$ ($p = 0.056$) for hours missed and $F(2, 4519) = 2.41$ ($p = 0.089$) for the binary outcome when excluding households with immediate water access. These results provide suggestive evidence that the relationship between water-fetching time, gender, and school absenteeism differs across rural and urban areas. Given that meaningful variation in travel time is concentrated in rural areas, the subsequent analysis focuses on the rural subsample without immediate water access.

Table 3: OLS of whether child missed school last week and how many hours were missed in rural areas and excluding those with immediate water access

	Rural		Excluding households with immediate water access	
	Missed school	Hours missed (ln)	Missed school	Hours missed (ln)
Travel time (hrs)	−0.006	−0.020	−0.009	−0.027
	(0.013)	(0.033)	(0.014)	(0.034)
Girl (binary)	−0.023 ***	−0.061 ***	−0.028 ***	−0.072 ***
	(0.007)	(0.017)	(0.009)	(0.021)
Travel time × Girl	0.045 ***	0.122 ***	0.051 ***	0.137 ***
	(0.017)	(0.041)	(0.019)	(0.045)
Fetcher (base: Girl <15)				
Boy <15	0.004	0.017	0.004	0.017
	(0.023)	(0.053)	(0.024)	(0.055)
Adult woman 15+	−0.001	0.006	0.001	0.010
	(0.014)	(0.031)	(0.014)	(0.030)
Adult man 15+	−0.016	−0.017	−0.013	−0.011
	(0.018)	(0.043)	(0.018)	(0.043)
No need to fetch	−0.003	0.004	0.003	0.012
	(0.019)	(0.042)	(0.019)	(0.040)
Child characteristics				
Age (years)	0.001	0.002	0.001	0.002
	(0.002)	(0.004)	(0.002)	(0.004)
Grade (base: P1–P4)				
P5–P6	−0.003	−0.010	−0.002	−0.009
	(0.008)	(0.019)	(0.009)	(0.021)
JSS1–JSS3	−0.013	−0.030	−0.020 **	−0.049 **
	(0.010)	(0.022)	(0.010)	(0.023)
SSS1–SSS3	−0.082	−0.182	−0.118	−0.253
	(0.062)	(0.130)	(0.085)	(0.171)
Travel time to school (hrs)	0.009	0.021	0.007	0.012
	(0.008)	(0.020)	(0.009)	(0.022)
Household characteristics				
Household size	−0.002	−0.003	−0.003 *	−0.004
	(0.002)	(0.004)	(0.002)	(0.004)
Girl ratio	−0.009	0.002	−0.008	0.009
	(0.021)	(0.048)	(0.023)	(0.051)
Dependency ratio	0.028	0.064	0.022	0.048
	(0.026)	(0.059)	(0.028)	(0.060)
Female ratio	0.009	0.015	0.016	0.023
	(0.037)	(0.082)	(0.040)	(0.086)
Mean age (years)	0.000 04	0.001	−0.0001	0.001
	(0.001)	(0.002)	(0.001)	(0.002)
Engaged in ag. (binary)	−0.008	−0.035	−0.014	−0.054
	(0.015)	(0.040)	(0.017)	(0.046)
Welfare quintile (base: Q1)				
Q2	0.009	0.021	0.011	0.026
	(0.011)	(0.024)	(0.013)	(0.027)
Q3	−0.028 **	−0.065 **	−0.029 **	−0.067 **
	(0.012)	(0.028)	(0.013)	(0.030)
Q4	−0.010	−0.025	−0.028	−0.067
	(0.018)	(0.041)	(0.020)	(0.046)

Continued on next page

	Rural		Excluding households with immediate water access	
	Missed school	Hours missed (ln)	Missed school	Hours missed (ln)
Q5	−0.008	−0.031	−0.030	−0.089 *
	(0.023)	(0.052)	(0.023)	(0.053)
Household head characteristics				
Age (years)	0.0001	0.0001	0.0004	0.001
	(0.000 4)	(0.001)	(0.000 5)	(0.001)
Female (binary)	0.0002	0.013	0.007	0.031
	(0.012)	(0.029)	(0.013)	(0.033)
Education (1–5)	0.001	0.002	0.001	0.004
	(0.004)	(0.008)	(0.004)	(0.009)
Married (binary)	0.001	0.005	0.008	0.024
	(0.012)	(0.030)	(0.014)	(0.034)
Religious (binary)	−0.015	−0.060	0.002	−0.024
	(0.018)	(0.045)	(0.016)	(0.044)
Observations	7227	7227	6371	6371
R^2	0.458	0.437	0.471	0.460

Note: The dependent variable in columns 1 and 3 is missed school, which is a binary variable equal to one if a child (below 15 years and above 5 years of age) missed at least one hour of school in the last week due to domestic- or labor-related reasons other than vacation, absent teacher, physical/emotional violence from teachers or peers, illness, bad weather, or sent for school fees, zero otherwise. Columns (2) and (4) use the log of hours missed. Standard errors clustered at the household level in parentheses. All regressions include enumeration area fixed effects. ***, **, * denote significance at the 1%, 5%, and 10% levels.
Source: GLSS 7, own calculations.

Focusing on the interaction term between travel time to fetch drinking water and being a girl, the estimated coefficient β_{gTT} is positive and statistically significant at the 1 per cent level across all specifications. More specifically, β_{gTT} in Column 1 is 0.045, which implies that an additional hour of travel time increases the likelihood of school absence for rural girls by 4.5 percentage points relative to rural boys. This effect represents more than half of the average school absenteeism rate among rural girls (= 4.5/7.79 ~ 58 per cent). Observing β_{gTT} in Column 2 suggests that rural girls, with one additional hour of fetching water, miss 12.2 per cent more hours at school than rural boys.

When the analysis is restricted to rural households without immediate water access in Columns 3 and 4, the estimated interaction coefficients increase slightly, confirming that the negative impact of water-fetching on girls' school attendance is even more pronounced when households lack on-premises water access.

Looking at the other components of the interaction term across all four specifications, one can note negative and statistically insignificant coefficients on travel time and negative and statistically significant coefficients on being a girl. The first set of results suggests that the association between water accessibility and rural boys' school performance is not statistically different from zero, while the second set suggests that rural girls are less likely to miss school and miss fewer hours than rural boys when travel time to fetch water is zero, i.e. when they live in households with immediate access to water.

At this stage, the results indicate that school-aged girls in rural areas in Ghana seem to be adversely affected by longer travel times to fetch water. This result is in contrast to other studies in SSA that find no or only small gender differences in school outcomes due to water inaccessibility (Koolwal and Van de Walle, 2013; Nauges, 2017; Gross et al., 2018; Shimamura et al., 2022). As shown in Table 1, it is mostly adult women above 15 years that fetch water. Our results may, hence, indicate that even if girls are likely not the ones who travel themselves, girls in rural localities seem to exhibit a higher school absence likelihood and a larger number of missed hours, possibly because they need to take over additional household responsibilities while their older sisters or mothers are out to fetch water. Before we explore the underlying mechanisms further, we test the sensitivity of these results in the next section.

4.2 Sensitivity tests

One prominent concern in relation to water access and children's educational outcomes in a cross-sectional setting like ours is the possibility of omitted variable bias and simultaneity. While enumeration area (EA) fixed effects, implemented as θ_v in Equation (1), remove the effect of between-EA heterogeneity, one may be concerned that our treatment variable, i.e., travel time to fetch drinking water at the household level, is not orthogonal to observed and unobserved characteristics within EAs. Wealthier households, for example, may have the financial means to have immediate water access, e.g., through pipe-borne drinking water inside their dwelling or on their compound, or through their residential selection in proximity to water sources. Furthermore, residential selection may also be correlated with the accessibility of other facilities or amenities within EAs such as schools. A household's proximity to the water source, hence, may reflect observable and unobservable characteristics at the household and/or EA level, which, in turn, affect children's school absence.

To address this concern at least with respect to observable characteristics, we perform the following two tests. First, we investigate whether households that travel less than the within-EA median travel time to the water source are on average statistically different from households that travel more than the within-EA median. Second, we test the correlation between travel time to drinking water and observable characteristics.

Panel A of Table 4 shows the test results for the full rural household sample. As can be seen in Columns 2 and 4, households located closer to the water source exhibit slightly lower travel times to school, are on average smaller, wealthier, and have household heads who are younger and better educated. The Spearman correlation coefficients between these variables and travel time to drinking water source ranges between |0.072| and |0.310|. Together, the two tests suggest that households traveling longer times to a water source are poorer, larger, and headed by older and less educated individuals.

When households with immediate access to drinking water are excluded in Panel B of Table 4, both the mean differences and the correlation coefficients decrease substantially, although they remain statistically different from zero. The exception is travel-time to school. Overall, these results suggest that immediate water access reflects a household's socioeconomic status within the community, whereas among households without such access, travel time to water is only weakly related to observable household and household head characteristics such as household size, welfare and education.

In addition to these tests, we further examine whether unobserved heterogeneity within households might bias our results. The analytical sample consists of 7,227 children from

Table 4: Balancing and correlation test

	Balancing test				Correlation test	
	HH closer to water source than EA median		HH farther from water source than EA median		Correlation with travel time to water source	
	N	Mean	N	Mean	Spearman corr.	P-value
Panel A: Full rural household sample (N = 7,991)						
JSS1–JSS3	2523	0.171	1490	0.180	−0.071	0.000
Travel time to school	2523	0.641	1490	0.689[a]	0.174	0.000
Household size	5180	4.582	2811	4.861[a]	0.208	0.000
Welfare	5180	3274.98	2811	2666.39 [a]	−0.310	0.000
Own house	5180	0.312	2811	0.332	0.088	0.000
House built within 10 years	1614	0.569	933	0.569	−0.031	0.124
House built within 10 to 20 years	1614	0.278	933	0.262	0.006	0.752
House built more than 20 years ago	1614	0.149	933	0.167	0.042	0.035
Household head's age	5180	46.732	2811	48.544[a]	0.072	0.000
HH head is female	5180	0.274	2811	0.293	−0.069	0.000
HH head's education	5180	1.319	2811	1.115[a]	−0.279	0.000
Panel B: Rural HHs without immediate water access (N = 6,739)						
JSS1–JSS3	2227	0.160	1297	0.172	−0.043	0.011
Travel time to school	2227	0.640	1297	0.702[a]	0.194	0.000
Household size	4344	4.795	2395	5.028[a]	0.148	0.000
Welfare	4344	2659.77	2395	2480.29 [a]	−0.150	0.000
Own house	4344	0.329	2395	0.345	0.052	0.000
House built within 10 years	1430	0.563	826	0.575	−0.031	0.137
House built within 10 to 20 years	1430	0.279	826	0.259	0.010	0.648
House built more than 20 years ago	1430	0.154	826	0.163	0.043	0.042
Household head's age	4344	47.574	2395	48.626[a]	0.026	0.030
HH head is female	4344	0.270	2395	0.279	−0.062	0.000
HH head's education	4344	1.113	2395	1.048[a]	−0.170	0.000

Note: The balancing and correlation test are run with the rural household sample and a reduced rural household sample, where households with immediate access to drinking water are excluded, in Panel A and Panel B, respectively. [a] indicates differences in means that are statistically different from zero at 5 per cent significant level or lower, based on Wilcoxon rank sum test.
Source: GLSS 7, own calculations.

4,013 households, implying that some children share the same household environment. To test the robustness of our findings to unobserved within-household factors, we re-estimate Equation (1) using household fixed effects instead of EA fixed effects, effectively restricting identification to variation among children within the same household. Because travel time to water is measured at the household level, its main effect is absorbed by the household fixed effects and is therefore not separately identified. The specification instead identifies the interaction between travel time and the girl indicator by comparing boys and girls within the same household and testing whether the gender gap in absenteeism widens in households with longer travel times. The results, shown in Table B2 in the Appendix, display a similar pattern of coefficients as in Table 3. However, the estimates are not statistically different from zero. This attenuation is expected, as the identifying variation is limited to within-household gender differences and variation in school absence across siblings is relatively small, reducing statistical power. At the same time, the attenuation may also reflect that household fixed effects absorb time-invariant household characteristics, such as parental preferences regarding girls' domestic roles or attitudes toward education, that could partly contribute to the association observed in the EA fixed effects specification (Table 3). One can therefore interpret the EA fixed effects estimates as conditional on community-level controls and view the household fixed effects results as a conservative bound rather than a refutation of the main findings.

The second concern relates to the measurement of the dependent and main independent variables. In the absence of administrative records on school attendance, information on children's school absence during the past week is reported by the household head in the GLSS7. While self-reported measures may be affected by social desirability and recall errors, particularly when provided by proxy respondents, the short one-week recall window likely limits major recall problems. Existing studies in developed country contexts rely on administrative attendance records (e.g., Kirksey (2025); Klein and Sosu (2024) and documents that absence patterns are socially structured and systematically associated with socioeconomic and demographic characteristics. These studies do not directly examine discrepancies between survey and administrative reports. In our setting, for reporting bias to explain the results, it would need to be differentially correlated with both household water travel time and child gender, which appears unlikely. There are similar issues with self-reported travel times to water source as discussed by Ho et al. (2014) or Dhital et al. (2022). Unless one has accurately measured travel routes to drinking water sources e.g., with an enumerator measuring directly the distance or accompanying a respondent (White et al., 2002; Pickering et al., 2011), and complete information on route selection, it is difficult to identify the direction of bias that is driven by the correlation between the self-reported travel time and unobserved components of school absence.

In addition to travel time, the GLSS7 data provides self-reported information on the distance from the household to the drinking water source. This variable helps to distinguish between physical remoteness and other factors that influence the time burden of water collection, such as queuing, terrain, or individual walking speeds. We conduct two complementary robustness checks. First, we include distance as an additional control variable in the main specification (Table B3 in the Appendix). The estimated coefficients on the interaction between travel time and being a girl remain virtually unchanged, confirming that the main results are not driven by omitted variation in physical distance. Second, we re-estimate the main model by replacing travel time with travel distance as the treatment variable. The estimated interaction effect remains statistically significant but decreases by roughly 50 per cent (Table B4 in the Appendix). This reduction suggests that travel time captures not only physical distance but also additional burdens associated with terrain, queuing, and water-fetching logistics. At the same time, one may also argue that water fetching is not purely a burden but can provide an opportunity for women to socialize and exchange information with peers. This interpretation aligns with our finding that, when focusing on travel distance rather than travel time, the estimated effects remain statistically significant but are somewhat reduced - possibly reflecting the compensating social value of shared water-fetching activities. Using either travel time or distance to the water source, we acknowledge several additional data limitations common to large-scale household surveys such as the GLSS7. First, the measure of water access refers only to the main source of drinking water, even though households often rely on multiple sources for different purposes such as cooking, bathing, and cleaning. Second, while the data record round-trip travel time or distance to this main source, they do not capture the frequency of water-fetching trips or the total volume of water collected. Because the overall time burden of water collection depends jointly on trip frequency, distance, and household preferences over water use and sanitation, this unobserved variation may interact with our outcomes in ways that cannot be fully identified with the available data. [10]

Third, travel time to fetch water is, among others, a function of the characteristics of the specific household member who fetches the water. The GLSS7 data does not allow the identification of the specific household member but provides information on the member cohort by sex (female or male) and age (below or above 15 years). Testing differences in travel times between children and adult water fetchers shows that both girls and boys are statistically and significantly faster than adult women, but not than adult men.[11] If otherwise identical households differ in terms of which member fetches water, the self-reported travel times of girls can be shorter than those of adults. Consequently, the estimated effect of travel time could be understated. To examine potential heterogeneity by water fetcher, we split the sample according to whether adults or children fetch water and re-estimate Equation (1). Table 5 shows that when adults fetch water (Columns 1 and 2), the interaction term between travel time and being a girl is positive and statistically significant at the 1 per cent level. This finding reaffirms that in such households, longer water-fetching times are associated with higher school absenteeism among girls compared to boys. In contrast, when children themselves fetch water (Columns 3 and 4), the interaction term becomes negative and is weakly significant only in the binary specification, suggesting that girls who collect water may not experience the same additional time constraint or may under-report their travel times. While the last set of results needs to be considered cautiously due to the large reduction in sample size, the overall pattern indicates that the negative schooling effect of water-fetching time for girls is driven primarily by households where adults, especially women, bear the responsibility for water collection.

4.3 Potential mechanisms

Finally, we explore possible mechanisms that may explain the observed effect of household-level water access on children's school absence. The analyses so far show that increases in travel time to fetch water are associated with a higher likelihood of school absence and a larger number of missed school hours among girls in Ghana's rural areas. This relation holds within a child-level sample restricted to households without immediate access to drinking water on their compounds, and when older siblings or parents are responsible for water collection, but not when children themselves fetch water.

A plausible mechanism is that when adults are away fetching water, girls may be expected to take on additional responsibilities such as caregiving for younger siblings,

[10] More recently, innovative approaches have been used to capture water access. For example, Ashraf et al. (2021) use microdata from the primary water utility in Lusaka, Zambia, on the timing and location of supply complaints to identify piped water outages and examine their effects on disease prevalence and financial transactions via a mobile money provider.

[11] More specifically, girls spend on average 5.71 minutes less than adult women and 0.83 minutes less than adult men, whereas boys spend 7.67 minutes less than adult women and 2.79 minutes less than adult men.

Table 5: Association between water accessibility and school absenteeism by water fetcher

	Water fetcher = adult women or men (15+ years)		Water fetcher = children (< 15 years)	
	Missed school (binary)	Hours missed (ln)	Missed school (binary)	Hours missed (ln)
Travel time (hrs)	−0.009	−0.028	0.111	0.269
	(0.014)	(0.037)	(0.068)	(0.165)
Girl (binary)	−0.035***	−0.085***	0.021	0.016
	(0.010)	(0.024)	(0.021)	(0.046)
Travel time × Girl	0.063***	0.163***	−0.079*	−0.140
	(0.021)	(0.050)	(0.048)	(0.109)
Observations	5220	5220	1136	1136
R^2	0.488	0.485	0.616	0.591

Note: The dependent variable in columns 1 and 3 is missed school, which is a binary variable equal to one if a child (below 15 years and above 5 years of age) missed at least one hour of school in the last week due to domestic- or labor-related reasons other than vacation, absent teacher, physical/emotional violence from teachers or peers, illness, bad weather, or sent for school fees, zero otherwise. The dependent variable in columns 2 and 4 is the number of hours absent from school (ln). All regressions include the same set of controls as specified in Table 3, including enumeration area fixed effects. ***, **, and * indicate 1, 5, and 10 per cent significant levels, respectively. Standard errors clustered at the household level in parentheses.
Source: GLSS 7, own calculations.

assisting with household chores, or helping in family businesses, thereby reducing the time available for schooling. Indeed, in 23.2 per cent of girls' cases and 18.8 per cent of boys' cases, these reasons correspond to the self-reported causes of school absence. However, for the majority, i.e., 76.8 per cent of girls and 81.2 per cent of boys, the reported reason for missing school falls under the unspecific category "other," preventing further differentiation (Table A3 in the Appendix).[12]

Nevertheless, the GLSS7 data set allows the identification of the household member mainly responsible for preparing food or buying food outside, participation in different economic activities such as wage work, farm work, or work in a non-farm enterprise during the past seven days, and who usually looks after a child below 60 months of age during the daytime. We use this information to construct proxies for school-aged children's participation in household chores, economic activities, and caregiving, respectively.

To further explore whether the burden of water collection disproportionately affects girls in larger or more care-dependent households, we use the number of children below the age of 60 months as additional potential mechanism. In addition, Graham et al. (2016) suggest that children may refrain from attending school if they are infected with a stigmatized disease related to water fetching. Thus, an alternative mechanism may relate to a stigmatized disease of the water fetcher. While the GLSS7 data set does not contain information on specific diseases, it records which household member suffered from an illness or injury during the past two weeks.

Table 6 presents the summary statistics for the variables that may serve as potential

[12] The results remain robust when excluding absences categorized as "Other," although effect sizes are modestly attenuated (Table B5).

mechanisms through which water accessibility might affect children's school absence. One can note that school-aged children's participation in any of these activities is relatively low. The highest participation rates are observed for farm work (21 per cent for boys and 14.7 per cent for girls), followed by cooking, in which 7.3 per cent of girls participate. More than half of the children in our sample have younger siblings below the age of 60 months, who are primarily cared for by their mothers or older sisters. With respect to illness, 26.4 per cent of the children live in a household where at least one of the adult women, often responsible for fetching water, reported being ill during the previous two weeks.

Table 6: Summary statistics of potential mechanisms

	Pooled		Girls		Boys	
Statistic	Mean	SD	Mean	SD	Mean	SD
Children engaged in household chores						
Cooking	0.040	0.195	0.073	0.260	0.008	0.090
Children engaged in economic activities						
Any economic activity	0.211	0.408	0.188	0.390	0.233	0.422
Wage work	0.005	0.067	0.004	0.059	0.005	0.074
Domestic work	0.0003	0.018	0.000	0.000	0.001	0.025
Work at own farm	0.180	0.384	0.147	0.354	0.210	0.408
Work at non-farm enterprise	0.006	0.078	0.007	0.086	0.005	0.070
Family help in non-farm enterprise	0.020	0.141	0.031	0.173	0.010	0.100
Non-productive agriculture	0.007	0.086	0.008	0.091	0.006	0.080
Caregiving of children below 60 months						
Children below 60 months	0.585	0.493	0.574	0.495	0.596	0.491
Number of children below 60 months	0.915	1.025	0.896	1.029	0.932	1.020
Cared for by adult	0.561	0.494	0.549	0.495	0.573	0.492
Cared for by children	0.008	0.086	0.008	0.086	0.008	0.086
Illness among HH members						
Adult woman is ill	0.264	0.441	0.264	0.441	0.264	0.441
N	6371		3098		3273	

Note: All variables reported are binary indicators equal to one if a school-aged child is engaged in the respective activity such as household chores, economic activities, or caregiving, or lives in a household with the respective characteristic such as children below 60 months of age, or where an adult woman has been sick in the past two weeks, and zero otherwise. With respect to economic activities, non-productive agriculture relates to fishing, hunting, gathering, and any economic activity summarizes the six individual activities.
Source: GLSS 7, own calculations.

To test the potential mechanisms through which water accessibility may affect children's school attendance, we restrict the following investigation to rural households without immediate water access. First, we investigate whether and to what extent travel time to drinking water is associated with the proposed mechanism variables. Second, we test whether these mechanisms are linked to children's school outcomes. Table 7 shows the results of regressing each mechanism variable on travel time to drinking water including the same set of controls as specified in Equation (1), except when a given control variable serves as the mechanism under investigation.

Panel A of Table 7 shows the non-interacted effects of travel time to water and being a girl, while Panel B shows the interaction term components as defined before. In Panel A, we find a positive and significant association with the presence of children below the age of 60 months and caregiving by an adult. These patterns suggest that, where fetching water takes longer, caregiving responsibilities tend to concentrate among adult women in households with young children. Furthermore, girls are more likely than boys to engage in cooking and to assist in non-farm family businesses, whereas boys are more frequently involved in farm work, which is consistent with traditional gendered divisions of labor.

Re-estimating the models with an interaction term between travel time to drinking water and being a girl (Panel B) reveals a positive and statistically significant coefficient for illness and a negative and statistically significant coefficient for helping in the family business. This suggests that the association between water fetching, most likely being executed by adult women, and women's health impairment is more pronounced for girls, whereas the opposite holds when girls are engaged in family business activities.

Finally, Table 8 shows the association between the suggested mechanisms and children's school absence, focusing on the binary specification of whether a child missed class during the past week. Panel B suggests a positive coefficient on the interaction term between being mainly in charge of cooking and being a girl which is statistically significant at the 5 per cent level. This indicates that the effect of being responsible for cooking on missing school is larger for girls than for boys.

Overall, taking the results from Tables 7 and 8 together, one can conclude that part of the association between school absence among rural girls and water fetching trips mostly executed by adult women seems to be driven by increased participation in household duties, specifically related to food preparation. While we also find a larger increase in health impairments among adult women due to water fetching, there is no association between women's health impairments and girls' school outcomes.

Table 7: Mechanism analysis: Association between water accessibility and mechanisms

	Chores	Economic activities						Caregiving				Illness
	Cooking	Any	Wage	Farm	Non-farm	Family help non-farm	Non-prod. ag	Children < 60 m	No. children < 60 m	Adult woman	Child	Women
Panel A: No interaction between travel time and child's sex												
Travel time (hrs)	0.012	−0.010	−0.003	−0.014	0.003	0.005	0.001	0.070***	0.068	0.061**	0.008	0.035
	(0.010)	(0.018)	(0.002)	(0.018)	(0.004)	(0.007)	(0.003)	(0.023)	(0.053)	(0.025)	(0.011)	(0.033)
Girl (binary)	0.068***	−0.045***	0.000	−0.053***	0.004	0.014***	−0.002	−0.006	−0.009	0.000	−0.002	−0.021*
	(0.007)	(0.013)	(0.001)	(0.012)	(0.003)	(0.005)	(0.004)	(0.009)	(0.020)	(0.009)	(0.002)	(0.011)
Observations	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371
R^2	0.254	0.439	0.295	0.430	0.240	0.188	0.237	0.579	0.637	0.565	0.393	0.354
Panel B: Interaction between travel time and child's sex												
Travel time (hrs)	0.006	−0.002	−0.004	−0.010	0.006	0.016*	−0.002	0.059**	0.058	0.057**	0.005	0.012
	(0.010)	(0.023)	(0.003)	(0.023)	(0.005)	(0.008)	(0.003)	(0.025)	(0.052)	(0.028)	(0.012)	(0.035)
Girl (binary)	0.063***	−0.037**	−0.001	−0.050***	0.007**	0.024***	−0.004	−0.016	−0.019	−0.003	−0.005	−0.043***
	(0.009)	(0.016)	(0.001)	(0.015)	(0.004)	(0.006)	(0.005)	(0.014)	(0.027)	(0.014)	(0.003)	(0.016)
Travel time × Girl	0.012	−0.019	0.001	−0.008	−0.007*	−0.023**	0.005	0.024	0.023	0.009	0.007	0.053**
	(0.013)	(0.025)	(0.003)	(0.025)	(0.004)	(0.009)	(0.004)	(0.021)	(0.044)	(0.022)	(0.008)	(0.025)
Observations	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371
R^2	0.255	0.439	0.295	0.430	0.240	0.189	0.237	0.579	0.637	0.565	0.394	0.354

Note: The dependent variables in columns 1 to 12 are whether a school-aged child is engaged in the respective activity such as household chores, economic activities, or caregiving, or lives in a household with the respective characteristic such as children below 60 months of age, or where an adult woman has been sick in the past two weeks, zero otherwise. With respect to economic activities, non-productive agriculture relates to fishing, hunting, gathering, and any economic activity summarizes the six individual activities. All regressions include the same set of controls as specified in Table 3. ***, **, and * indicate 1, 5, and 10 per cent significant levels, respectively. All regressions include enumeration area fixed effects. Standard errors clustered at the household level in parentheses.
Source: GLSS 7, own calculations.

Table 8: Mechanism analysis: Association between mechanisms and probability to miss school

	Chores	Economic activities						Caregiving				Illness
	Cooking	Any	Wage	Farm	Non-farm	Family help non-farm	Non-prod. ag	Children < 60 m	No. children < 60 m	Adult woman	Child	Women
Panel A: No interaction between mechanism and child's sex												
Mechanism	0.017	0.005	−0.059	0.016	−0.129	−0.007	−0.021	0.002	0.004	0.003	0.107	−0.003
	(0.017)	(0.012)	(0.064)	(0.013)	(0.095)	(0.021)	(0.048)	(0.013)	(0.007)	(0.013)	(0.073)	(0.012)
Girl (binary)	−0.006	−0.006	−0.006	−0.006	−0.006	−0.006	−0.007	−0.006	−0.006	−0.006	−0.006	−0.007
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Observations	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371
R^2	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.470	0.469
Panel B: Interaction between mechanism and child's sex												
Mechanism	−0.072*	−0.001	−0.050	0.010	−0.137	0.0002	−0.012	0.005	0.004	0.008	0.103	0.006
	(0.040)	(0.013)	(0.086)	(0.014)	(0.122)	(0.040)	(0.056)	(0.015)	(0.008)	(0.015)	(0.101)	(0.015)
Girl (binary)	−0.009	−0.009	−0.006	−0.008	−0.006	−0.006	−0.006	−0.003	−0.006	0.001	−0.006	−0.002
	(0.007)	(0.007)	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.010)	(0.009)	(0.010)	(0.006)	(0.008)
Mechanism × Girl	0.102**	0.014	−0.023	0.015	0.012	−0.010	−0.017	−0.006	0.0002	−0.011	0.009	−0.017
	(0.047)	(0.016)	(0.082)	(0.019)	(0.066)	(0.045)	(0.086)	(0.013)	(0.007)	(0.013)	(0.169)	(0.016)
Observations	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371	6371
R^2	0.470	0.469	0.469	0.470	0.471	0.469	0.469	0.469	0.469	0.469	0.470	0.469

Note: The dependent variable in columns 1 to 12 is missed school, which is a binary variable equal to one if a child (below 15 years and above 5 years of age) missed at least one hour of school in the last week due to domestic- or labor-related reasons other than vacation, absent teacher, physical/emotional violence from teachers or peers, illness, bad weather, or sent for school fees, zero otherwise. Missed school is regressed on each mechanism variable separately. All regressions include the same set of controls as specified in Table 3. ***, **, and * indicate 1, 5, and 10 per cent significant levels, respectively. All regressions include enumeration area fixed effects. Standard errors clustered at the household level in parentheses.
Source: GLSS 7, own calculations.

5 Summary and conclusions

This article set out to explore the relationship between travel time to drinking water and school attendance among children in rural Ghana, with a particular focus on potential gender differences. In addition, we explored underlying mechanisms that may link water access and schooling outcomes, including household chores, economic activities, and health impairments. To do so, we drew on data from 7,227 school-aged children captured in the rural sample of the Ghana Living Standards Survey (GLSS7).

Unlike Nauges (2017)'s cluster-level analysis for Ghana, this article uses a nationally representative, child-level data set to investigate the link between water inaccessibility at the household level and school absence among school-aged girls and boys. Exploiting between-household variation in travel time to fetch drinking water, we compare children's likelihood of missing school and the number of hours missed within enumeration areas (EAs). Our identification strategy takes into account time-invariant heterogeneity between EAs that may be correlated with decisions related to water access and school attendance.

Although establishing causality in a cross-sectional study such as ours is inherently difficult, we conducted a series of robustness checks and present the following key findings. First, our econometric analysis reveals that girls are 4.5 percentage points more likely to miss school for each additional hour of travel time to fetch water, and they miss 12.2 per cent more school hours than rural boys. These estimates remain robust when excluding households with immediate water access, as well as when excluding school-aged children who themselves are responsible for fetching water. The negative associations found particularly for girls contrast with previous studies across sub-Saharan Africa that report limited or no gender disparities (Koolwal and Van de Walle, 2013; Nauges, 2017; Gross et al., 2018; Shimamura et al., 2022). Second, given that water collection in our sample is predominantly undertaken by female adolescents and adult women, a plausible explanation for girls' higher absenteeism is their increased involvement in substituting for older sisters or mothers during long water-fetching trips. Approximately one-fifth of reported reasons for missing school relate to household or family business duties, lending further support to this mechanism. In contrast, the alternative explanation proposed by Graham et al. (2016), that children might feel ashamed to attend school if a family member engaged in water fetching contracts a stigmatized disease, is not supported by our data. While our mechanism analysis must be interpreted with caution due to incomplete information on children's domestic responsibilities and illness types, the findings suggest that household duties, particularly meal preparation, may be a relevant channel through which water inaccessibility affects girls' school attendance.

In terms of policy implications, our findings highlight the importance of improving access to drinking water as a pathway to enhancing educational participation, particularly among girls in rural areas. Reducing the time burden of water collection through investments in nearby water infrastructure and reliable supply systems can yield substantial co-benefits beyond health and hygiene, advancing gender equality in education and strengthening overall human capital. At the same time, policy measures should recognize that water fetching also carries social functions: it can provide an opportunity for women to interact, exchange information, and maintain community ties. Consequently, interventions aimed at improving water access should be designed in ways that preserve or replace these social spaces - for example, by integrating communal water points or other local meeting opportunities. Finally, aligning water provision policies with rural education and gender equality strategies can generate multiplier effects: reducing unpaid care burdens, promoting school attendance, and fostering long-term social and economic inclusion. Future research should continue to explore these interlinkages using panel household data, which would more effectively exploit within-household variation in water access and schooling outcomes over time, thereby enabling stronger causal identification than is possible with cross-sectional data. Experimental approaches could further help identify specific mechanisms and inform the design of socially and gender-sensitive interventions.

Appendix A: Variable definition and descriptive statistics

Table A1: Overview of variables

Variable name	GLSS7 Section and page number	GLSS7 Survey question
Dependent variables		
Missed school (binary)	Section 2.A: Education (page 2.2)	How many hours of class did (NAME) miss in the past week?
Hours missed	Section 2.A: Education (page 2.2)	How many hours of class did (NAME) miss in the past week?
Main explanatory variables		
Travel time (hrs)	Section 7: Water and Sanitation (page 7.3)	How long does it take to go to the water source, get water, and come back?
Travel distance (m)	Section 7: Water and Sanitation (page 7.3)	How far is this source of water from your dwelling?
Controls		
Child characteristics		
Girl (binary)	Section 2.A: Education (page 2.1)	What is the sex of (NAME)?
Age (years)	Section 2.A: Education (page 2.1)	How old is (NAME)?
Grade	Section 2.A: Education (page 2.1)	What is the current grade for (NAME)?
Travel time to school (hrs)	Section 2.A: Education (page 2.2)	How much time does (NAME) spend going to and from school daily?
Household characteristics		
Fetcher	Section 7: Water and Sanitation (page 7.3)	Who usually goes to this source to collect the water for your household?
Household size	Section 1: Household Roster (page 1.1)	How many people live in this household?
Girl ratio	Section 1: Household Roster (page 1.1)	Sex composition of household members
Dependency ratio	Section 1: Household Roster (page 1.1)	Ratio of household members aged < 15 and ≥ 65 to those aged 15–64
Female ratio	Section 1: Household Roster (page 1.1)	Proportion of female household members
Mean age (years)	Section 1: Household Roster (page 1.1)	Average age of household members
Engaged in agriculture (binary)	Section 4.A: Economic Activity (page 4.1)	During the past 7 days, did (NAME) work on a farm owned or rented by a household member for at least one hour?
Welfare quintile	Section 9: Household Wealth (page 9.2)	DHS wealth index quintile derived from household assets and dwelling characteristics

Continued on next page

Table A1 continued

Variable name	GLSS7 Section and page number	GLSS7 Survey question
Household head characteristics		
Age (years)	Section 1: Household Roster (page 1.1)	How old is the head of household?
Female (binary)	Section 1: Household Roster (page 1.1)	Is the head of household female?
Education (1–5)	Section 1: Household Roster (page 1.3)	What is the highest level of education attained by the head of household?
Married (binary)	Section 1: Household Roster (page 1.1)	Is the head of household currently married or living with a partner?
Religious (binary)	Section 1: Household Roster (page 1.1)	Does the head of household identify with a religious denomination?
Mechanisms		
Cooking	Section 6: Child Chores (page 6.1)	Who is primarily responsible for preparing food in the household?
Any economic activity	Section 4.A: Economic Activity (page 4.2)	During the past 7 days, did (NAME) engage in any economic activity for at least one hour?
Wage work	Section 4.A: Economic Activity (page 4.2)	During the past 7 days, did (NAME) work for a wage, salary, commission, or payment in kind for someone outside the household for at least one hour?
Domestic work	Section 4.A: Economic Activity (page 4.2)	During the past 7 days, did (NAME) work as a domestic worker for someone in the household for at least one hour?
Work at own farm	Section 4.A: Economic Activity (page 4.2)	During the past 7 days, did (NAME) work on a farm owned or rented by a household member for at least one hour?
Work at non-farm enterprise	Section 4.A: Economic Activity (page 4.2)	During the past 7 days, did (NAME) run or help with a non-farm enterprise owned by the household for at least one hour?
Non-productive agriculture	Section 4.A: Economic Activity (page 4.2)	During the past 7 days, did (NAME) engage in fishing, hunting, gathering, or other non-productive agricultural activities for at least one hour?
Caregiving (children < 60 months)	Section 3.C: Postnatal Care (page 3.7)	Who usually looks after children under 60 months during the daytime?
Adult illness	Section 3.A: Health (page 3.1)	During the past 2 weeks, has any adult woman in your household suffered from an illness or injury?

Table A2: Reasons why school was missed

Reason school was missed	Observations	Percentage (%)
School vacation	69	7.72
Teacher absents	36	4.03
Physical/emotional violence from teacher	1	0.11
Physical/emotional violence from peers	1	0.11
Bad weather	23	2.57
To help family business*	37	4.14
Working outside family business*	8	0.89
Taking care of children/elderly*	12	1.34
To help with household tasks*	64	7.16
Illness/injury	162	18.12
Sent for school fees	22	2.46
Other*	459	51.34
NA	6333	–
Total	7227	100.00

Note: Reasons marked with * are classified as domestic- or labor-related absences and are coded as 1 in the binary indicator of school absence. All other reported reasons remain in the sample but are coded as 0 for the domestic-related absence indicator. Percentage (%) relates to those observations that reported school absence, hence excluding NA.

Source: GLSS 7, own calculations.

Table A3: Differences in reasons between boys and girls on why school was missed due to domestic- or labor-related absences

	Girls			Boys		
Reason school was missed	N	Mean	SD	N	Mean	SD
To help family business	276	0.062	0.241	304	0.066	0.248
Working outside family business	276	0.007	0.085	304	0.020	0.139
Taking care of children/elderly	276	0.033	0.178	304	0.010	0.099
To help with household tasks	276	0.130	0.337	304	0.092	0.290
Other	276	0.768	0.423	304	0.812	0.391

Note: Differences in means between girls and boys are tested based on Wilcoxon rank sum test. None yield a p-value at or below 0.05.

Source: GLSS 7, own calculations.

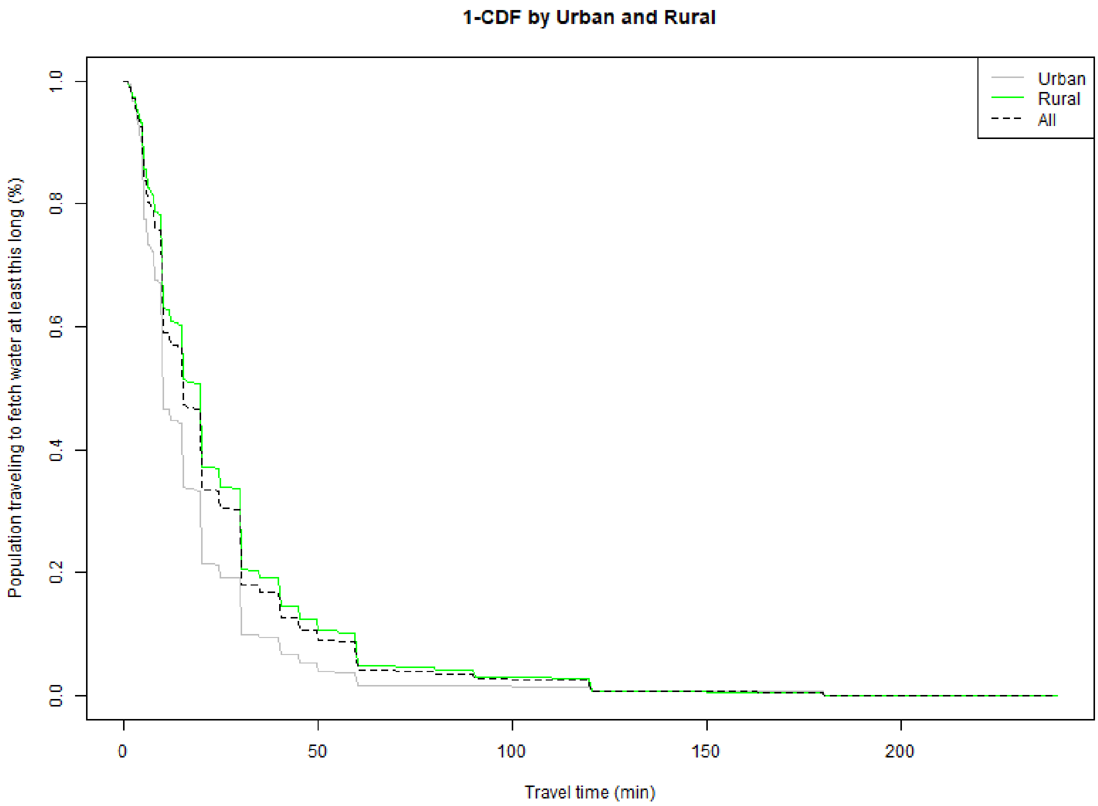

Figure A1: 1 minus empirical cumulative distribution function of travel time in minutes at household level (N=14,009). *Source:* GLSS7, own calculations.

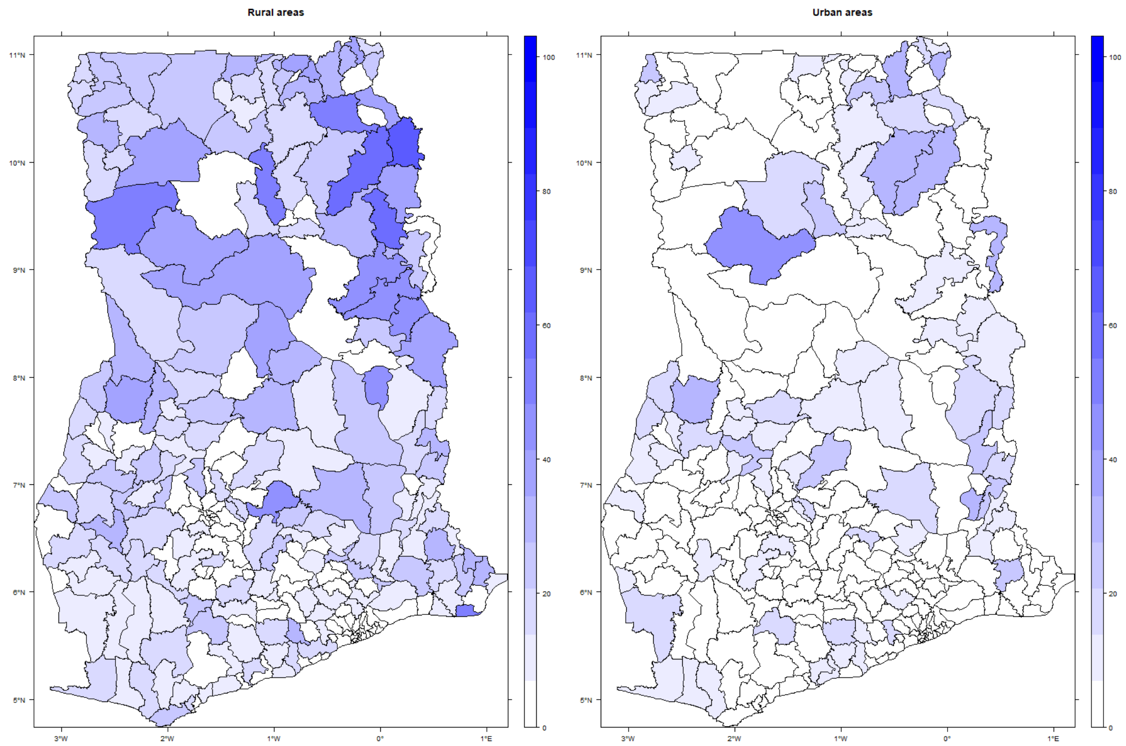

Figure A2: Average travel time (min) to fetch drinking water in rural and urban areas. *Note:* Travel time in minutes at household level is aggregated at district level. *Source:* GLSS7, own calculations.

Appendix B: Additional robustness checks

Table B1: Test for structural break between urban and rural households

	Full sample (rural and urban)		Excluding households with immediate water access	
	Missed school (binary)	Hours missed (ln)	Missed school (binary)	Hours missed (ln)
Travel time (hrs)	−0.014	−0.037*	−0.014	−0.030
	(0.009)	(0.022)	(0.011)	(0.026)
Girl	−0.002	−0.019	0.007	0.011
	(0.007)	(0.019)	(0.012)	(0.027)
Rural	-	-	-	-
	(0.000)	(0.000)	(0.000)	(0.000)
Travel Time × Girl	0.017	0.057	−0.001	0.007
	(0.015)	(0.036)	(0.018)	(0.036)
Travel time × Rural	0.008	0.014	0.004	−0.0005
	(0.016)	(0.039)	(0.018)	(0.043)
Girl × Rural	−0.027***	−0.050**	−0.038**	−0.087***
	(0.010)	(0.025)	(0.015)	(0.034)
Travel Time × Girl × Rural	0.027	0.063	0.052**	0.131**
	(0.023)	(0.055)	(0.026)	(0.059)
Joint Wald test: Travel Time × Rural = 0 and Travel Time × Girl × Rural = 0	$F = 1.46$ ($p = 0.232$)	$F = 1.25$ ($p = 0.287$)	$F = 2.41$ ($p = 0.089$)	$F = 2.88$ ($p = 0.056$)
Observations	11 097	11 097	8009	8009
R^2	0.494	0.446	0.500	0.471

Note: The dependent variable in columns 1 and 3 is missed school, which is a binary variable equal to one if a child (below 15 years and above 5 years of age) missed at least one hour of school in the last week due to domestic- or labor-related reasons other than vacation, absent teacher, physical/emotional violence from teachers or peers, illness, bad weather, or sent for school fees, zero otherwise. The dependent variable in columns 2 and 4 is the number of hours absent from school (ln). All regressions include the same set of controls as specified in Table 3 in the main document, including enumeration area fixed effects. ***, **, and * indicate 1, 5, and 10 per cent significant levels, respectively. Standard errors clustered at the household level in parentheses.

Source: GLSS 7, own calculations.

Table B2: Test of main equation with household fixed effects

	Rural		Excluding households with immediate water access	
	Missed school (binary)	Hours missed (ln)	Missed school (binary)	Hours missed (ln)
Travel time (hrs)	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Girl (binary)	−0.009	−0.021	−0.012	−0.028
	(0.007)	(0.016)	(0.009)	(0.019)
Travel time × Girl	0.015	0.048	0.018	0.057
	(0.017)	(0.036)	(0.018)	(0.039)
Observations	7227	7227	6371	6371
R^2	0.873	0.869	0.868	0.866

Note: The dependent variable in columns 1 and 3 is missed school, which is a binary variable equal to one if a child (below 15 years and above 5 years of age) missed at least one hour of school in the last week due to domestic- or labor-related reasons other than vacation, absent teacher, physical/emotional violence from teachers or peers, illness, bad weather, or sent for school fees, zero otherwise. The dependent variable in columns 2 and 4 is the number of hours absent from school (ln). All regressions include the same set of controls as specified in Table 3 in the main document, except that enumeration area fixed effects are replaced with household fixed effects. ***, **, and * indicate 1, 5, and 10 per cent significant levels, respectively. Standard errors clustered at the household level in parentheses.

Source: GLSS 7, own calculations.

Table B3: Test distance to drinking water source (in km) as an additional control variable

	Rural		Excluding households with immediate water access	
	Missed school (binary)	Hours missed (ln)	Missed school (binary)	Hours missed (ln)
Travel time (hrs)	−0.001	−0.015	−0.004	−0.022
	(0.014)	(0.036)	(0.015)	(0.037)
Girl (binary)	−0.023***	−0.061***	−0.028***	−0.072***
	(0.007)	(0.017)	(0.009)	(0.021)
Travel distance (km)	−0.010	−0.012	−0.010	−0.011
	(0.014)	(0.031)	(0.015)	(0.033)
Travel time × Girl	0.045***	0.122***	0.051***	0.137***
	(0.017)	(0.041)	(0.019)	(0.045)
Observations	7227	7227	6371	6371
R^2	0.458	0.437	0.471	0.460

Note: The dependent variable in columns 1 and 3 is missed school, which is a binary variable equal to one if a child (below 15 years and above 5 years of age) missed at least one hour of school in the last week due to domestic- or labor-related reasons other than vacation, absent teacher, physical/emotional violence from teachers or peers, illness, bad weather, or sent for school fees, zero otherwise. The dependent variable in columns 2 and 4 is the number of hours absent from school (ln). All regressions include the same set of controls as specified in Table 3 in the main document and travel distance in km. ***, **, and * indicate 1, 5, and 10 per cent significant levels, respectively. Standard errors clustered at the household level in parentheses.

Source: GLSS 7, own calculations.

Table B4: Test distance to drinking water source (in km) as the main explanatory variable

	Rural		Excluding households with immediate water access	
	Missed school (binary)	Hours missed (ln)	Missed school (binary)	Hours missed (ln)
Travel distance (km)	−0.016	−0.034	−0.017	−0.034
	(0.013)	(0.031)	(0.014)	(0.033)
Girl (binary)	−0.015**	−0.039***	−0.015**	−0.041**
	(0.006)	(0.014)	(0.007)	(0.016)
Travel distance × Girl	0.028**	0.079**	0.028**	0.079**
	(0.013)	(0.034)	(0.014)	(0.035)
Observations	7227	7227	6371	6371
R^2	0.457	0.436	0.470	0.459

Note: The dependent variable in columns 1 and 3 is missed school, which is a binary variable equal to one if a child (below 15 years and above 5 years of age) missed at least one hour of school in the last week due to domestic- or labor-related reasons other than vacation, absent teacher, physical/emotional violence from teachers or peers, illness, bad weather, or sent for school fees, zero otherwise. The dependent variable in columns 2 and 4 is the number of hours absent from school (ln). All regressions include the same set of controls as specified in Table 3 in the main document, except that travel time to drinking water source (in hrs) is replaced with travel distance in km. ***, **, and * indicate 1, 5, and 10 per cent significant levels, respectively. Standard errors clustered at the household level in parentheses.

Source: GLSS 7, own calculations.

Table B5: Test of main equation with modified dependent variables excluding "Other" as reason of missed school

	Rural		Excluding households with immediate water access	
	Missed school (binary)	Hours missed (ln)	Missed school (binary)	Hours missed (ln)
Travel time (hrs)	0.003	0.007	0.004	0.009
	(0.007)	(0.017)	(0.008)	(0.018)
Girl (binary)	−0.005	−0.015	−0.007	−0.019
	(0.005)	(0.011)	(0.006)	(0.014)
Travel time × Girl	0.037***	0.091***	0.039***	0.095***
	(0.012)	(0.028)	(0.014)	(0.032)
Observations	7227	7227	6371	6371
R^2	0.152	0.154	0.147	0.151

Note: The dependent variable in columns 1 and 3 is missed school, which is a binary variable equal to one if a child (below 15 years and above 5 years of age) missed at least one hour of school in the last week due to domestic- or labor-related reasons other than other, vacation, absent teacher, physical/emotional violence from teachers or peers, illness, bad weather, or sent for school fees, zero otherwise. The dependent variable in columns 2 and 4 is the number of hours absent from school (ln). All regressions include the same set of controls as specified in Table 3 in the main document, except that enumeration area fixed effects are replaced with household fixed effects. ***, **, and * indicate 1, 5, and 10 per cent significant levels, respectively. Standard errors clustered at the household level in parentheses.

Source: GLSS 7, own calculations.

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