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Abstract

We investigate the relationship between access to safe drinking water and improved sanitation (WASH) and children's educational outcomes using longitudinal data from the Young Lives study in Ethiopia and India. We examine the effects of access to WASH, both jointly and separately, in each country and in the pooled sample. Using child fixed-effects models, we find that contemporaneous access to combined WASH services increases years of schooling and grade progression by approximately 26 and 41 days, respectively, while reducing the probability of school dropout by 1.4 percentage points. The benefits are substantially larger when accumulated exposure is considered: cumulative access increases years of schooling and grade progression by nearly 117 and 190 days, respectively, and reduces the likelihood of school dropout by 4.3 percentage points. While sanitation exerts a stronger influence on contemporaneous educational outcomes, water access becomes the dominant factor when the duration of exposure is taken into account. Our findings further suggest that improvements in children's daily time allocation and nutritional status may represent important pathways through which WASH contributes to educational attainment.

1 Introduction

Access to safe water and improved sanitation (WASH) is one of the most basic human needs for health and well-being and is recognised as a fundamental human right under the United Nations SDG 6. [1] However, as of 2024, 1 in 4 people around the world still lack safely managed drinking water, and 2 out of 5 people still lack safely managed sanitation. This is well short of achieving the

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[1] Even though we are aware that WASH refers to water, sanitation and hygiene, we use this term for access to safe water and improved sanitation, as these are our focus of study due to data nonavailability for the later

SDGs' objective of ensuring universal and equitable access to safe water and adequate and equitable sanitation for all by 2030, demanding that low-income countries require a dramatic sevenfold increase in basic water and an 18-fold increase in basic sanitation (WHO and UNICEF, 2025).

Children, being the most vulnerable group in these countries, are disproportionately impacted and face significant challenges. Limited access to water and sanitation exposes them to widespread faecal contamination of their living environment, ongoing exposure to pathogenic microorganisms, recurrent waterborne and enteric infections, and significant concerns regarding privacy, safety, and dignity associated with open defecation. Additionally, young children—especially girls—often bear the burden of collecting water and handling domestic chores. These unhealthy environments can negatively affect their development, particularly in health and education (Ashraf et al., 2021; Cameron et al., 2021). They risk nutritional deficiencies, missed school opportunities, and long-term impacts, highlighting the urgent need for access to safe water and improved sanitation services.

A growing body of literature has examined the relationship between access to WASH and child developmental outcomes. Studies have focused on child health (Kremer et al., 2011; Gong et al., 2026; Mudadu Silva et al., 2023; Li and Xiao, 2023; Headey and Palloni, 2019; Kresch, 2020; Kwami et al., 2019; Balza et al., 2025); cognition (Dearden et al., 2017; Pakhtigian, 2024) and school attendance (Adukia, 2017; Zhang and Xu, 2016; Santiago Ortiz-Correa et al., 2016; Bhalotra et al., 2021). However, evidence on educational attainment remains limited, mainly due to a lack of consideration of the duration of access to WASH, a focus only on school-based WASH services, a lack of analysis of combined access to both water and sanitation, and reliance on cross-sectional studies.

Even studies in longitudinal settings typically focus on the contemporaneous (or current-period) treatment effect, which isolates the average immediate impact of accessing WASH services, a focus that arises from the structure of simple fixed-effects estimation. However, such a data setup also allows capturing a running cumulative period of WASH access, which reflects long-term access, and enables estimating the additional period of accumulated WASH access for the outcomes of interest. As financial economists argue, the value of an additional deposit to the accumulated account has a greater long-term impact than a standalone single year's deposit(Chetty et al., 2014), which may also hold true for long-term WASH access to child education. In our context, only Zhang and Xu (2016) has causal identification based on exogenous variations in access to a treated water program in China, and Pohn and Schulze (2026) has studied access duration, but only to water service, by exploiting variation between siblings within the same household, not within the same child across rounds. This approach potentially suffers from sibling heterogeneity, including birth order, gender, parental investment, and health shocks, which are not captured in within-child variation estimation.

In this study, we employ a longitudinal dataset from the Young Lives study hosted at the UK Data Service and examine the roles of access to safe drinking water and improved sanitation in the educational outcomes of young children. We classify and address education outcomes into two categories. *i)Stock measure of human capital*; in this category, we took a measure that can capture the accumulated measure of child education regardless of whether a child is enrolled or not

during the time of the interview. We therefore took the years of education completed as our main educational variable. *ii*) *Flow measures of human capital*; in this category, we took measures that vary depending on whether a child is enrolled at the time of the interview. Accordingly, we used grade progression, which captures the child's current grade level at the time of the survey, and school dropout, which captures both temporary and permanent cessation of schooling after initial enrollment.

We begin our analysis by examining the contemporaneous association between access to WASH services (both combined and individually) and educational outcomes across three sample settings: the combined sample, the Ethiopia-only sample, and the India-only sample. We then ask whether access duration could matter, construct a running cumulative access-to-WASH variable, and estimate its associations with child educational outcomes using a similar sample setup. This helps us isolate the marginal cumulative effect, taking into account WASH access in previous rounds (if any). This is what we call a duration/cumulative effect, which we believe provides a more reliable estimate for children with multiple exposures compared to the contemporaneous effect. The latter assumes a uniform, independent benefit in each period, while the cumulative-duration links outcomes to total exposure over time.

In exploring the linkages between access to WASH and educational outcomes, the general empirical challenge stems from multiple sources of endogeneity. Omitted-variable bias is a common source of error arising from unmeasured confounders, including variables such as attitudes and behavioural changes associated with education, health, and labour demand. The intricate relationship between child education and access to WASH services is another potential threat to our study, potentially leading to reverse causality from child education to access to WASH services. For instance, wealthier households or those with stronger preferences for education may simultaneously invest in improved WASH and schooling.

To address these issues, we use the YL longitudinal dataset, which spans nearly 25 years across 7 rounds, and estimate with child fixed effects. This allows us to eliminate time-invariant confounding factors and estimate the effect of within-household changes in access to WASH services on child educational outcomes, while controlling for important time-varying confounders at the child, parental, household, and community levels. [2] To further mitigate omitted-variable bias, we include state-year fixed effects, which capture unobserved state-specific time-varying factors that may jointly affect household WASH access and children's educational outcomes. Since many policy, economic, and infrastructure changes occur at the sub-national level, state-year fixed effects provide a more demanding identification strategy than country-year fixed effects alone. Moreover, because states are nested within the two countries in our sample, this specification also absorbs country-level shocks and national trends that are common to all states within a given year. To reduce reverse causality, we conduct a lead test showing that future WASH cannot predict current child outcomes, but current WASH can.

[2] As the dataset includes only one child per household, the use of child fixed effects is equivalent to the use of household fixed effects.

However, we cannot fully rule out OVB or reverse causality, so we interpret results cautiously. Our identifying assumption is therefore that, after controlling for different-level fixed effects and a battery of time-varying controls at the child, household, and community levels, changes in WASH access are not driven by other unobserved, time-varying factors that also affect the outcomes of interest.

Our estimates of the full sample show that, conditional on our assumption, rounds where a household has access to combined water and sanitation lead to an increase of approximately 26 and 41 days, respectively, in years of completed education and grade enrollment and a 1.4% decrease in the probability of school dropout, the effects being driven largely by the Ethiopian sample. Access to sanitation services alone is also significantly associated with greater years of education completed and grade enrollment, but not for water.

As the main contribution of this study, we also examine the role of cumulative access to all services. We find substantially larger and highly significant estimates in almost all cases. For every additional round of accumulated access to both services (combined), years of education and grade enrolment increase by nearly 117 and 190 days, respectively, and decrease the likelihood of school dropout by about 4.3%. Taking into account the duration of access also makes estimates for water access increase and exceed those for sanitation, unlike in the contemporaneous (current-period access) case.

We then examine variation in our estimates by the children's gender and the households' residential areas. While gender shows that young boys benefit more from combined access to WASH in all sample settings, young girls benefit more from access to sanitation services in all our samples. Location-based results suggest country-level differences in access to services. While urban children benefit more in Ethiopia, children from rural areas are found to benefit a lot in India

What explains the positive associations? To explore the mechanisms underlying these estimates, particularly current-period access estimates of years of education, we first identify potential transmission channels from children's daily time allocations and their nutritional measures. We then tested the validity of these transmission mechanisms and found that while daily hours children spent in domestic tasks and height-for-age score play a complementary role with WASH access in their effects on years of education, child leisure hours and body mass index play a substitute role in their effects on years of education.

Our results survive a battery of validity checks and robustness tests. To address concerns about reverse causality, we implement a placebo test in which we regress the outcome variables on future WASH access—both jointly and separately—and find no evidence of anticipatory effects. In addition, we assess the robustness of our estimates to the inclusion of an extensive set of time-varying controls. The results remain stable across specifications, thereby reducing the likelihood that our findings are driven by omitted variable bias and reinforcing the credibility of the estimated treatment effects.

This study contributes to the existing literature in the following ways. First, several studies on WASH and educational outcomes focus on school-based WASH infrastructure (McMichael, 2019;

Adukia, 2017; Jasper et al., 2012), which is likely to have a different impact than home-based WASH infrastructure, which our study focuses on. Home-based WASH infrastructure is also likely better positioned to see young children's time and health as reliable transmission mechanisms.

Second, while existing studies focus on current WASH access or long-run effects of early access (Pakhtigian, 2024; Dearden et al., 2017), little attention has been given to the duration of exposure to WASH services over a child's life course. We argue that accumulated and persistent access to WASH infrastructure is much more important and merits consideration, as evidenced by recent reviews that explicitly note that WASH effects depend on the timing and persistence of exposure, not just access(Headey, 2016; Headey and Palloni, 2019; Gong et al., 2026).

Third, following SDG's Goal 6, *'Ensure availability and sustainable management of water and sanitation for all,'* several literature syntheses and empirical studies call for a comprehensive analysis of combined WASH services that considers collective access to both water and sanitation and their effects on children's development in general and on their education in particular (Adugna et al., 2026; Balza et al., 2025). Our study takes this into account and examines the relative effectiveness of access to safe water and improved sanitation, both collectively and individually, across a variety of educational outcomes within a longitudinal framework, aligning with SDG targets 6.1 and 6.2.

Finally, compared with two closely related studies (Pakhtigian, 2024; Dearden et al., 2017) that used the same dataset on cognitive outcomes, our study focused on direct academic outcomes—such as years of schooling, grade advancement, and dropout rates. Those studies provide cross-sectional estimates of cognitive effects from water and sanitation access 15 years earlier, without accounting for subsequent treatments. Our research addresses these factors by employing child fixed effects in a 25-year longitudinal dataset. This also allows us to analyse treatment duration and assess both individual and combined effects of water and sanitation services, unlike previous studies.

The remaining sections of the study flow as follows. Section 2 presents the relevant literature focusing on the potential impacts of WASH on education. Then, we discuss the descriptive analysis of the data in Section 3. The empirical strategy and identification are presented in Section 4, followed by results in Section 5, where we discuss the core findings. Then heterogeneity, potential transmission mechanisms, and the conclusion follow in Sections 6, 7, and 9, respectively.

2 Literature review

2.1 Potential impacts of WASH on children's education

Growing evidence of a direct link between access to WASH and educational outcomes predominantly supports a positive role for WASH services in child education. A series of systematic literature reviews from a developing country's perspective provides evidence that supports a positive effect from sanitation on cognitive development (Sclar et al., 2017), avoidance of school during menstruation when there is a lack of water and sanitation facilities in schools (Jasper et al., 2012), and a significant improvement in academic performance among students receiving both nutrition and WASH

(Adugna et al., 2026). As to school dropout and absenteeism, however, studies do not synthesise a conclusive conclusion on a positive association from WASH services, suggesting further rigorous studies with potential pathways (Sclar et al., 2017; McMichael, 2019)

Similarly, empirical studies strengthen the positive role of access to WASH services, particularly in school enrolment, years of schooling completed, and academic achievement. A rigorous study by (Adukia, 2017) finds that school-based sanitation increases primary school enrolment in India, particularly for girls. (Santiago Ortiz-Correa et al., 2016) uses a household utility maximisation model applied to data from Brazil and suggests that access to water and sanitation services has a positive and significant effect on schooling when measured by the completed number of school years. Alam et al. (2025) employs large DHS data from Bangladesh and shows the positive role of household access to water, sanitation, and hygiene facilities in early childhood education enrolment. In addition to access, treatment of water intended to improve the quality of available water has also been a subject of study. Accordingly, interventions, including investments in spring infrastructure, increased water chlorination coverage, and water purification, have a significant effect on reducing waterborne disease and improving child health outcomes, the probability of school enrollment, and higher grades completed. (Kremer et al., 2011; Zhang and Xu, 2016; Alam et al., 2025; Li and Xiao, 2023; Bhalotra et al., 2021; Dupas et al., 2023; Jones, 2019).

Reviewing studies from the reverse angle, which flips access to lack of access or exposure to unimproved or contaminated water and sanitation on educational outcomes, helps to see the effect from the water and environmental stressor angle. From this perspective, (Pitt et al., 2021) examined the effects of ingesting and retaining inorganic arsenic from well-water contamination in Bangladesh on measures of cognitive and physical capabilities, as well as on schooling attainment. The study shows that higher levels of retained arsenic are associated with lower cognitive scores, reflected in lower schooling attainment, no relationship with BMI and height measures, and a lower likelihood of holding a skilled occupation or becoming an entrepreneur. Ashraf et al. (2021) studied water outages in Zambia and highlights that it could adversely impact the ability to perform academic tasks by extending the amount of time young girls dedicate to their chores. Cameron et al. (2021) further shows that children exposed to unimproved sanitation in their community are likely to experience increased child stunting and cognitive issues.

The period during which a child has access to WASH services is an important factor and has also been studied, particularly in relation to measures of academic performance. In this line of literature, studies have focused on the timing of access and documented the educational benefits of improved water and sanitation access at early childhood as compared to older ages. For example, Zhang and Xu (2016) used longitudinal data from China and concluded that children with access to treated water in early childhood experienced significantly higher gains in years of schooling than those who gained access at later stages of life. Moreover, consecutive studies on the Indian Total Sanitation Campaign show that children who belong to villages with improved sanitation at an early age are more likely to recognise letters and simple numbers by age six (Spears and Lamba, 2016) and scored significantly higher on a cognitive test measuring analytic ability ten years later

(Orgill-Meyer and Pattanayak, 2020). Employing the Young Lives data, Dearden et al. (2017) and Pakhtigian (2024) also show that children with early-life access to improved drinking water and sanitation score higher in both language and mathematics at later ages.

Apart from time of access, the duration of access to WASH services is another important yet rarely addressed concept in the WASH-to-education literature. An exception is Pohn and Schulze (2026), which employs the longitudinal Indonesian Family Life Survey and concludes that lifetime and early access to clean water are associated with secondary school completion.

Supporting evidence comes from Headey (2016), which stresses the need to consider duration in access to WASH, and from Headey and Palloni (2019), which examines whether longer-term changes in water and sanitation at the subnational level predict child morbidity and mortality. The study concludes that while subnational sanitation coverage predicts sizable improvements, only water piped into the home predicts significant reductions in child stunting. Evidence also comes from Gong et al. (2026), which demonstrates that the health gains from improved water supply materialise only when national investments are complemented by adequate local delivery infrastructure. Their results imply that the value of water access is not immediate but depends on sustained, effective service provision. These studies underscore the importance of considering the duration of access, as long-term exposure to reliable WASH services is more likely to generate meaningful improvements in human capital outcomes than temporary or intermittent access.

Another point of interest that merits consideration in the study of water and sanitation is the intricate relationship between the two infrastructures and the resulting changes in their effectiveness. While the favourable effects of access to both services are well documented, unintended consequences may arise when inadequate sanitation infrastructure and degraded water pipelines interact. For example, recent studies in Mexico show that inadequate sanitation infrastructure and the age (degradation) of water pipes have substantially attenuated the benefits of reduced child mortality from water treatment programmes (Bhalotra et al., 2021). Similarly, the Indian sanitation policy initiated in 2014 is documented to have negative externalities that increase faecal contamination of rivers by 72%, which eliminates its positive effect on diarrhoea reduction (Motohashi, 2026). This suggests that access to one service may depend on the other for its individual effect on child development, and that this should be taken into account in the analysis.

Overall, the literature review and empirical studies indicate the need for a comprehensive analysis of WASH services, considering both water and sanitation access individually and together, in relation to children's educational outcomes. Our study takes this into consideration and examines the relative effectiveness of these services, both individually and in combination, for child educational outcomes within a longitudinal framework. Our study focuses on home-based WASH access, with attention to duration of exposure and possible transmission mechanisms.

2.1.1 Potential mechanisms

For young children, time and health outcomes are the immediate, direct pathways through which WASH services affect educational outcomes. The benefits of access to WASH operate through im-

proved health outcomes, such as reduced diarrheal disease and reduced time burdens from collecting water or travelling to open defecation or shared sanitation sites (Kremer et al., 2011; Orgill-Meyer, 2022; Ashraf et al., 2021). Studies linking WASH to educational outcomes identify health outcomes—such as reduced disease burden and improved well-being—as the primary channel through which WASH affects education, particularly attendance and learning capacity. They also acknowledge time-related constraints, such as the burden of water collection and other domestic chores, as relevant channels that compete with schooling time (Orgill-Meyer, 2022; Ngure et al., 2014; Tofail et al., 2025; Haile and Haile, 2012; Ashraf et al., 2021)

Time path: Improved water and sanitation access reduces time and safety costs by lessening water collection and sanitation searches. This frees more time for schooling, study, and rest. While much research focuses on water access and gender-specific time use, sanitation also guarantees safety, privacy (Hossain et al., 2022) and health. Using data from India, Hamlet et al. (2021) shows that for each extra hour of fetching water, children's scores in numerical and language tests drop by 1.3 and 1.1 standard deviations, respectively. Similarly, in rural Ethiopia, domestic chores like fetching water and firewood hinder school attendance(Haile and Haile, 2012).

Women and girls are disproportionately affected by poor WASH services because they handle most domestic chores and often travel long distances for water, reducing time for education, work, and leisure. When many share sanitation facilities, women and girls' safety and privacy are at risk. Research shows that more water collection time harms girls' and women's learning, while less time improves it. More water-fetching leads to girls dropping out and boys repeating grades (Dhital et al., 2022). Other studies in India and sub-Saharan Africa confirm the gender-specific impact of water scarcity chores on girls' school time (Hamlet et al., 2021; Haile and Haile, 2012; Ashraf et al., 2021). Parental workload also links WASH time demands to children's education. Better water access decreases parental unpaid labour, allows more childcare, and may boost educational outcomes. However, even with reduced parental chores, education gains aren't guaranteed, as household labour may shift to other tasks. For example, a Kenyan study found that reducing adult water-fetching time resulted in more leisure and household tasks, with no effect on school attendance or study time (Koolwal and van, 2013; Cook et al., 2024).

Health and nutrition path: Access to clean water and sanitation reduces exposure to pathogens and environmental enteropathy, lowering the risk of diarrhoea and waterborne diseases. It also improves child health and nutritional outcomes, as well as overall physical and psychological fitness, thereby improving education and cognitive capacity. Evidence from several countries supports these findings. For instance, improvement in access to water and sanitation has been positively associated with early childhood development and lower rates of stunting and mortality in Latin America and the Caribbean (Kresch, 2020; Balza et al., 2025). Studies focusing on water quality improvements have also documented significant benefits for child health. For example, a water chlorination program in urban areas of Mexico, from 58 percent to over 90 percent, reduced childhood diarrheal disease mortality rates by 45 to 67 percent (Bhalotra et al., 2021).Drawing on evidence from China,

Li and Xiao (2023) show that early exposure to treated water increases childhood height by nearly 0.3 standard deviations between ages 1 and 11. Similarly, Kremer et al. (2011) find that improving water source quality in rural Kenya reduces the incidence of child diarrhoea by approximately one quarter.

Beyond health, access to improved water and sanitation services can also enhance educational outcomes. Longitudinal evidence from Bangladesh, reported by Tofail et al. (2025), together with findings from Martorell et al. (2010), indicates that early-life WASH and nutrition interventions that reduced diarrheal disease and improved height-for-age z-scores (HAZ) generated lasting gains in schooling and cognitive performance during later childhood. Related evidence from Indonesia and Ethiopia further suggests that improved water and sanitation access reduces stunting, wasting, and anaemia while enhancing children's cognitive development (Staneva et al., 2021; Cameron et al., 2021).

Overall, it can be inferred that the time spent on household chores and health outcomes through nutritional values are the main channels by which access to or lack of WASH could affect young children's educational outcomes. It is also worth noting that the relative importance of transmission channels differs across services, with child time more closely associated with access to water and child nutrition with improved sanitation, suggesting the need for both combined and individual treatment evaluation within a longitudinal framework.

3 Data and Descriptive Analysis

3.1 Data

We used the Young Lives longitudinal study, a household- and child-level dataset that tracks the lives of 12,000 children across four countries: Ethiopia, India, Vietnam, and Peru. The sample frame consists of two cohorts of children - the young cohort, born in 2001–2002, and the old cohort, born in 1994–95. Seven waves of data have thus far been collected: 2002, 2006, 2009, 2013, 2016, 2020, and 2024.[3]

In each country, children were selected using a two-stage sampling procedure. In the first stage, 20 sentinel sites (clusters) were defined, with poor households oversampled to reflect diversity in living conditions. In Ethiopia, sites were purposively selected from Amhara, Oromia, SNNP, Tigray, and Addis Ababa, with food-insecure woredas oversampled. In India, Andhra Pradesh and Telangana were selected for their geographic and economic diversity.[4] In the second stage, a random village was selected within each cluster, and households were contacted until about 100 families with children aged 6–18 months (YC) or 7–8 years (OC) agreed to participate.[5] This has resulted in our full sample comprising 4010 children/households in the first round in 2002 and 3361 young children interviewed in round 7 in 2024, representing nearly 16% attrition, which appears

[3] We do not use the 2020 phone survey data as it differs from other in-person collected data and lacks key variables.

[4] No data were collected in Vietnam in Round 7.

[5] Household locations as well as the names and addresses of two contacts for the child within the community but outside the household were used to trace the child.

acceptable for data spanning nearly a quarter of a century (Deza and Favara, 2025; Mihaylova et al., 2025).

Our analysis is based on an unbalanced panel of children observed during the data collection periods and for whom information on our variables of interest is available. As a result, we restrict the sample to the younger cohort and to the Ethiopian and Indian samples, as well as their combined sample. Furthermore, for consistency, we restrict the sample to children who gave consent, were interviewed in person, and successfully completed the interview.[6] Table 1 reports the total number of observations after each restriction is imposed.

Table 1: Sample size after each restriction

Restrictions made	**Total Observations**		
	Ethiopia	India	Combined sample
No restrictions (all households)	11,994	12,066	24,060
Keep only children with in-person interview	11,865	12,066	23,931
Keep only children successfully complete the interview	10,889	11,533	22,422

Notes: This table presents the total number of observations after each restriction is applied to the raw datasets. The sample for in-person interviews excludes those who completed the interview by phone. The sample that completes the interview comprises those who don't refuse the interview and successfully complete it. Source: own computation using the YL data.

3.2 Variables and measures

The YL has collected and constructed three sets of data at the child, household, and community levels in each survey round, with interviews conducted with a representative of the household and the community and directly with the children.

Household surveys gather basic data on members, covering parental background, education, livelihood, assets, expenditures, socioeconomic status, and access to basic services including water and sanitation. In particular, the survey uses measures of the main source of drinking water and toilet facilities for household members. Access to 'improved' water and sanitation follows the WHO/UNICEF JMP criteria, including piped water, public taps, tube wells, protected wells, springs, and rainwater and other protected water sources. Access to "improved" toilets is classified as household flush toilet, piped sewer system connection, septic system connection, composting toilet, and pit latrine (Dearden et al., 2017; Pakhtigian, 2024). We then construct a combined measure of access to improved water and sanitation by selecting children who have access to both services during the survey round. Our core results are therefore based on this measure of access to both improved water and sanitation (WASH). To address the question of cumulative access, we further construct a running cumulative access-to-WASH variable as the sum of rounds of pre-existing access to water and sanitation services, both collectively and individually.

[6] Due to the ongoing civil war in Ethiopia, data were collected via phone in round 7 for a few children.

The child-level survey contains important information on our outcome variables. In particular, from the child education section of the questionnaire, we obtained the highest school grade completed variable, and we constructed years of education completed as a measure of the cumulative number of grades a child has successfully completed. Unlike current grade enrollment (see the paragraph below), this measure assesses a child's academic achievement regardless of current enrollment and age, making it a stock measure of human capital accumulation.

While years of education can tell us the accumulated stock of child human capital, they can't tell us whether a child is progressing well or is actually enrolled. We address this by using two flow measures of child human capital. *i*) Grade progression: We construct a grade progression variable from the current grade enrolled variable, which captures the child's current grade level at the time of the survey. Unlike years of education completed, this measure requires the child to be enrolled to be included in our study, making it a flow measure. *ii*) School dropout: Following standard definitions in the education literature (e.g., Baron (2022)), we define school dropout as a temporary or permanent cessation of schooling after initial enrollment. Specifically, a child is classified as having dropped out in any survey round where they are not currently enrolled in school, provided they had been enrolled in a prior round. This definition captures both permanent dropouts (children who leave school and never return) and temporary dropouts (children who leave and later re-enrol)[7]

3.3 Descriptive analysis

Figure 1 presents raw data on access to safe water and improved sanitation, showing a steady increase in access to both services (individually and collectively across survey rounds) in both Ethiopia and India. The proportion of households with WASH access increased from 30% and 27% in round 1 to 70% and 85% in round 7, representing more than double and more than triple improvements in Ethiopia and India, respectively. Similar upward trends are observed for water and sanitation individually in Ethiopia, indicating consistent progress in basic infrastructure coverage over the study period. In India, however, while access to sanitation shows a steady increase, access to water remains consistently high, exceeding 95% in the last five rounds and exhibiting little temporal variation, which may contribute to the insignificant FE estimates. [8]

Table 2 presents the mean comparisons of the key variables used in the study. Since we are interested in estimating the effects of combined access to both improved water and sanitation (WASH) on educational outcomes, the primary outcome variables are years of education completed, grade progression, and a dummy variable for school dropout. The table shows that children in the WASH group have higher years of school completion and higher grade-level enrollment across all samples. Unexpectedly, however, children in the WASH group show higher school dropout rates than those in the non-WASH group.

[7] Rounds prior to the first enrollment are coded as missing because the child was not yet at risk of dropping out.

[8] A steady increase in Indian sanitation is likely due to the nationwide sanitation policy stated in 2014; see (Motohashi, 2026)

Table 2: Mean comparison test between WASH and non-WASH groups

	Combined			**Ethiopia**			**India**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Outcomes	No wash	Wash	M. diff	No wash	Wash	M. diff	No wash	Wash	M.diff
Years completed	3.27	5.54	-2.27***	2.62	4.35	-1.74***	3.85	6.71	-2.86***
Grade progression	3.34	5.34	-2.00***	2.60	4.33	-1.72***	3.98	6.45	-2.46***
School dropout	0.13	0.24	-0.11***	0.15	0.19	-0.04***	0.11	0.28	-0.16***
Mediators									
Child health	2.96	3.15	-0.20***	3.09	3.30	-0.22***	2.84	3.01	-0.17***
Child bmi	15.28	17.14	-1.86***	15.33	16.52	-1.19***	15.24	17.76	-2.52***
Height for age zscore	-1.62	-1.35	-0.27*	-1.59	-1.16	-0.43***	-1.65	-1.56	-0.09
Hours for HH tasks	1.08	1.11	-0.03	1.81	1.36	0.45***	0.41	0.86	-0.44***
Hours for studying	4.79	5.85	-1.06***	3.24	4.98	-1.74***	6.18	6.70	-0.52***
Covariates									
Male (=1)	0.54	0.52	0.01**	0.54	0.51	0.03***	0.54	0.54	-0.00
Age in years	7.54	10.18	-2.64***	7.96	11.22	-3.25***	7.13	8.71	-1.58***
Mother's education	1.90	5.47	-3.57***	1.70	4.75	-3.06***	2.07	6.26	-4.19***
Wealth index	0.33	0.61	-0.28***	0.23	0.51	-0.28***	0.42	0.71	-0.29***
Household size	5.61	5.49	0.12***	5.96	5.88	0.08**	5.30	5.05	0.25***
Urban (=1)	0.10	0.63	-0.52***	0.17	0.60	-0.44***	0.04	0.65	-0.61***
Access to cooking fuel	0.11	0.52	-0.41***	0.03	0.23	-0.20***	0.18	0.80	-0.63***

Notes: This table presents the summary statistics of all variables used in the study by treatment status. Combined sample is obtained after merging Ethiopia and India. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

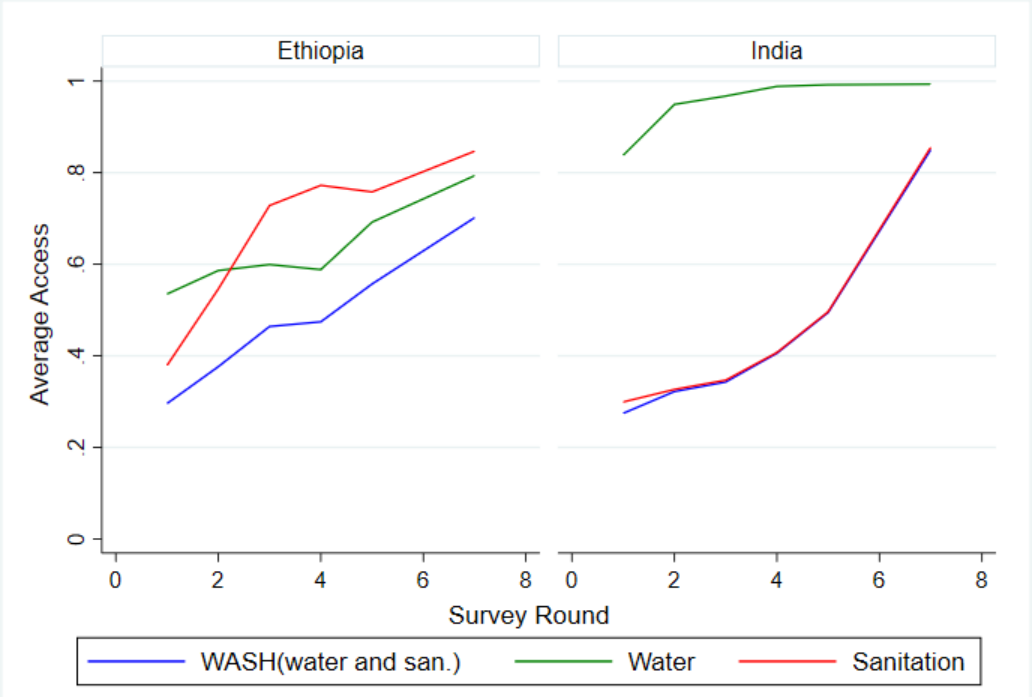

Figure 1: Access to Safe water and sanitation over survey rounds.

Notes: These figures show the trend of access to both water and sanitation (individually and collectively) by country. Source: Author's illustration using YL data.

These mean differences are clearly confounded by selection bias. As shown in the bottom panel of the table, every covariate is statistically different between the WASH children and the non-WASH children in all sample settings. On average, children in the WASH group live in smaller households, are more likely to live in urban areas, and have mothers with at least 4 years of education. Families with WASH access also have better access to cooking fuel than those without. Similar trends in mean differences are also observed in the individual samples.

Most figures in Table 2 show the expected mean difference and the level of significance. However, the table simply pools the data and compares children from WASH and non-WASH households, regardless of the duration or number of survey rounds for which a household has access to WASH. To address this, we compare the mean outcomes of the non-WASH group with those of the WASH groups by duration of WASH access for the full sample in Table 3.

Overall, the table shows the expected mean difference and the level of significance for all outcomes, including school dropout, unlike the unexpected mean difference in Table 2. As the duration of access to WASH increases from 1 or 2 waves (T1) to 3 or 4 waves (T2) and then to 5 or 6 waves (T3), the magnitude of the mean difference in outcomes relative to the non-WASH group increases and becomes statistically significant. This suggests the greater importance of persistent access to safe water and sanitation for educational outcomes.

Table 3: Mean comparison of outcome variables by treatment duration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcomes	Control	T1	M. diff	T2	M. diff	T3	M. diff
Years completed	3.82	4.31	-0.49***	4.21	-0.39***	4.95	-1.13***
Grade progression	3.47	4.07	-0.60***	4.15	-0.68***	5.04	-1.57***
School dropout	0.23	0.21	0.02**	0.17	0.06***	0.14	0.09***

*Notes: This table presents the mean difference of education outcomes by combined access to WASH to the full sample. T1 = Children from households who accessed WASH in 1 or 2 waves. T2 = Children from households who accessed WASH in 3 or 4 waves.T3 = Children from households who accessed WASH in 5 or 6 waves. The full sample is obtained after merging Ethiopia and India. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$*

4 Estimation strategies

We seek to test for the association between access to WASH services and young children's educational outcomes. A naive correlation might have major endogeneity issues, such as households with better access to WASH services may differ systematically from those without access in ways that also affect educational outcomes. For instance, wealthier households or those with stronger preferences for education may simultaneously invest in improved sanitation and schooling.

Hence, because of the possible bias brought on by this and the bias of the omitted variable, a pooled OLS estimate could suffer from inconsistency and inefficiency. To address this concern, we exploit the longitudinal structure of the data, which follows the same children over time. This allows us to control for unobserved characteristics that are time-invariant within a child but differ across children. Specifically, rather than comparing different children, we compare each child to themselves over time. This approach eliminates all time-invariant differences across children, such as baseline wealth, cultural norms, or long-standing preferences(Wooldridge, 2010). As a result, we used the following panel fixed-effects model specification

$$Y_{iht} = \alpha_0 + \mu_i + \beta\,\text{WashAccess}_{ht} + \alpha_1 X'_{iht} + \gamma_{rt} + \varepsilon_{iht} \tag{1}$$

Where Y_{iht} denotes education outcome of child i from household h at time t; WashAccess_{ht} a dummy variable indicating whether, in round t, a household h has access to water or sanitation or both to which child i belongs (equal to one if so and zero otherwise); μ_i are child fixed effects accounting for time invariant child level factors; X'_{iht} are vectors of time varying controls at child, household, and community level; γ_{rt} represents region/state-year fixed effects. γ_{rt} represents region/state-year fixed effects. These absorb all time-varying and time-invariant factors common to a region/state in a given year (such as education governance, infrastructure provision, and public service delivery), as well as other contextual characteristics that may simultaneously influence household WASH access and children's educational outcomes. Because these factors are likely to operate at the sub-national level, controlling for region- or state-year fixed effects pro-

vides a more stringent adjustment for omitted-variable bias than country-level fixed effects alone. [9] Moreover, because country effects are nested within regions/states, the specification also captures country-level heterogeneity. Finally, ε_{iht} is the error term.

It is likely that a child's unobserved characteristics, such as innate ability, health endowment, or household environment, that affect educational outcomes in every round persist over time. To account for this, we cluster standard errors at the child level. In the above formulation, β is the parameter of interest that captures the association between WASH access and child outcomes.It measures how temporal change from non-WASH to WASH within the same household is associated with changes in child educational outcomes.

4.1 Identification and addressing potential threats

Identification relies on the assumption that, once we account for child fixed effects, region/state-round fixed effects, and observable controls, changes in WASH access are not driven by other unobserved time-varying factors that also affect the outcomes of interest. Our specification, $\mu_i + \gamma_{rt}$, which is relatively finer, controls for all time-invariant heterogeneity and all time-varying regional/state-level, and by construction, country-level omitted variables. The remaining threats in this regard, therefore, stem from time-varying individual, household, village, and sub-state/sub-regional-level omitted variables. Our rich dataset allows us to address this by incorporating relevant time-varying controls into our estimations and further assess the robustness of our estimates by including additional controls.

Another source of threat to our identification is reverse causality. We support this by conducting a placebo-treatment test in which we show that future WASH (combined and individual) should not predict current child educational outcomes, whereas current WASH does. However, despite our supporting mechanisms, we cannot fully rule out either the OVB or reverse causality, and thus need to interpret our results with caution.

5 Results

5.1 Access to WASH and child education

In this section, we present and discuss our results on the estimated association between access to WASH services and young children's educational outcomes. For all our estimates, we control for time-varying characteristics at the child, parental, and household levels, in addition to fixed effects, and present estimates for full and individual country samples, as well as for combined and individual access to WASH services. We emphasise the full sample and combined access to WASH, while also highlighting individual countries and services for comparison.

Table 4 columns 1, 4, and 7 show our estimates for the full sample for the years of education completed, grade enrollment, and school dropout, respectively. We find that combined access to

[9] See Faguet et al. (2021) and Kameshwara et al. (2024) for discussions of substantial regional and state variation in educational governance, infrastructure, and educational outcomes within countries.

both improved water and sanitation is significantly associated with all measures of educational outcomes, with the expected signs observed.

In particular, column 1 shows that, on average, a child's years of education are 0.07 years higher in rounds with access to WASH services than in rounds without access. The estimate suggests a positive effect of access to both water and sanitation on years of school completion. However, as a relatively stock measure of educational attainment, the finding does not indicate whether it also helps children keep enrolled and continue schooling. That is, this coefficient does not tell us whether the child continues schooling beyond their completed years.

Column 4 uses grade enrollment, a relatively flow-based measure of educational outcomes, to answer this specific question. Our estimate confirms that in rounds where a household gains combined access to both improved water and sanitation, a child's grade enrollment is associated with an average 0.11-year increase.[10] Both estimates are at an acceptable level of statistical significance, and they correspond to increases of approximately 26 and 41 days, respectively, in years of education completed and grade enrollment for rounds in which they have access to WASH services.

Column 1 estimates might also not tell the whole story of success in schooling, especially if the school years completed are achieved with temporary and/or permanent dropout.[11] To address this piece of the question, we use school dropout-another flow measure of educational outcome and examine its association with access to both services. Our estimate in column 7 shows predictive evidence of favourable effects of WASH services in reducing school dropout.[12] Specifically, combined access to both water and sanitation is associated with a 1.4% decrease in the likelihood of school dropout. But this effect is only marginally significant ($p < 0.10$).

Table 4: Access to WASH and education outcomes

	Years Completed			**Grade progression**			**School dropout**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Combined	Ethiopia	India	Combined	Ethiopia	India	Combined	Ethiopia	India
WASH	0.066**	0.116**	0.010	0.112**	0.149**	0.064	-0.014*	-0.017	-0.012
	(0.032)	(0.046)	(0.045)	(0.050)	(0.061)	(0.086)	(0.008)	(0.011)	(0.012)
Water	0.032	0.076	-0.147	0.026	0.075	-0.264	0.002	0.003	-0.003
	(0.043)	(0.050)	(0.095)	(0.059)	(0.064)	(0.182)	(0.010)	(0.011)	(0.026)
Sanitation	0.062**	0.112**	0.010	0.065	0.072	0.062	-0.008	-0.003	-0.012
	(0.031)	(0.044)	(0.045)	(0.048)	(0.059)	(0.086)	(0.008)	(0.012)	(0.012)
Observations	14470	7091	7379	14461	7038	7423	10381	4554	5827
Household FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Region-round trends	yes	yes	yes	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

[10] grade enrollment is sometimes referred to as school progression

[11] It's a reminder that success isn't just about finishing but also about staying engaged throughout.

[12] Although a fixed-effects logit model is the preferred estimator for this binary outcome, we employ a linear probability (LPM) fixed-effects model because the conditional logit estimator results in substantial sample attrition, raising concerns about potential sample-selection bias.

Table 4 columns 1, 4 and 7 also present the association of access to individual services, either improved water or sanitation, with child educational outcomes in the full sample. Overall, we see that only access to sanitation has a relatively strong and significant association with the years of education completed. The association of water with all outcomes and of sanitation with grade enrollment and school dropout, however, is not statistically significant; the signs observed are in the expected direction in almost all estimates.

Table 4 also presents the estimates for the individual countries -Ethiopia columns 2, 5 and 8 and India columns 3, 6 and 9. Our global estimates suggest that access to both water and sanitation, in both combined and separate forms, is more effective in Ethiopia than in India. In particular, in rounds with combined access to WASH, it is associated with 0.12 years of higher education completion and 0.15 years of higher grade enrollment, with an acceptable level of significance. Investigating the association from the individual services column 2 shows that rounds with access to sanitation improve the years of school completion by 0.11 years, equivalent of 41 days.

When we compare our results to the broader literature, our findings are consistent with a strand of research suggesting that combined, rather than separate, access to both services has larger impacts on child developmental outcomes (Motohashi, 2026; Adugna et al., 2026; Balza et al., 2025). Our results are also consistent with a line of studies that show a stronger effect of sanitation service relative to water service for child education outcomes (Mudadu Silva et al., 2023) and weaker effects of water access on child education outcomes (Headey and Palloni, 2019). Using YL data and different educational outcomes, and cross-sectional estimates of early access to water and sanitation, Pakhtigian (2024) shows a positive role of water and sanitation in some language and numerical scores in Ethiopia, but an insignificant association with both outcomes for the Indian adolescent sample. Overall results suggest that improved household WASH access contributes to better educational outcomes, with a greater effect from combined access, and the evidence is consistent with and suggestive of a causal effect.

5.2 Does duration matter?

Another interest of our study is the duration of access to WASH services and its association with child education outcomes. The raw data in our full sample show that nearly 48% of our observations have access to improved water in all rounds, 46% have access to sanitation in 4 or more rounds, and nearly 43% have access to both water and sanitation in 3 or more rounds. This makes a duration analysis worthwhile.

While the results in Table 4 exploit temporal variation in service access and can be understood as the short-run association of WASH with our outcome variable, in this subsection we investigate the cumulative educational benefits that accrue with longer durations of access to water and sanitation.

To achieve this, we first constructed a running cumulative duration variable that captures the accumulated number of rounds a household has access to WASH services over the survey rounds. We then estimate a within-child change in educational outcomes associated with one additional round of accumulated access to WASH services. This highlights the role of treatment duration and

hence provides evidence on the longer-term association between sustained WASH exposure and child educational outcomes.

This requires equation 1 be modified and specified as below;

$$Y_{iht} = \alpha_0 + \mu_i + \beta\,\text{WashDuration}_{ht} + \alpha_1 X'_{iht} + \gamma_{rt} + \varepsilon_{iht} \tag{2}$$

Where WashDuration_{ht} now measures a running cumulative access duration showing the number of rounds a household has access to WASH services. Similar to equation 1, our coefficient of interest is β, but now it refers to the within-child change in education outcomes associated with one additional round of accumulated WASH access- suggesting the cumulative exposure (duration) effect.

Table 5 presents our estimates of β from equation 2. Remarkably, all our estimates are precise and show a substantial increase in educational outcomes for each additional period of accumulated access to WASH. In particular, Columns 1, 4 and 7 present our estimates of years of education completed, grade progression and school dropout for the full sample. It clearly shows that, on average, each additional round of accumulated combined access to water and sanitation is associated with a 0.32-year and 0.52-year increase in the years of education completed and grade progression, respectively, and a 4.3% decrease in the likelihood of school dropout. All estimates are statistically highly significant.

Economically, these estimates are meaningful, suggesting that each additional round of accumulated access to both services increases years of education and grade progression by nearly 117 and 190 days, respectively, and substantially reduces the likelihood of dropping out of school.

Table 5: Access duration to WASH and education outcomes

	Years completed			**Grade progression**			**School dropout**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Combined	Ethiopia	India	Combined	Ethiopia	India	Combined	Ethiopia	India
wash_dur	0.319***	0.582***	0.137***	0.515***	0.699***	0.396***	-0.043***	-0.041***	-0.045***
	(0.023)	(0.040)	(0.027)	(0.035)	(0.047)	(0.050)	(0.005)	(0.008)	(0.007)
water_dur	0.534***	0.531***	0.376***	0.661***	0.708***	0.248	-0.035***	-0.043***	-0.002
	(0.038)	(0.040)	(0.114)	(0.049)	(0.051)	(0.181)	(0.010)	(0.010)	(0.032)
san_dur	0.205***	0.357***	0.131***	0.359***	0.319***	0.393***	-0.035***	-0.005	-0.045***
	(0.023)	(0.045)	(0.027)	(0.038)	(0.060)	(0.050)	(0.006)	(0.012)	(0.007)
Observation	14470	7091	7379	14461	7038	7423	10381	4554	5827
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Household FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Region round trends	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Columns 1, 4, and 7 also show the association between cumulative access to individual services and educational outcomes for the full sample. We find stronger estimates for almost all associations

between access to improved water and sanitation, considered separately, and all educational outcomes. Specifically, for every one-round increase in cumulative access to safe water and improved sanitation, the years of schooling completed increase by nearly 195 and 75 days, respectively, and grade enrollment increases by nearly 242 and 131 days, respectively, on average. Such access to safe water and improved sanitation also reduces the likelihood of school dropout by about 3.5%. The results confirm that access duration matters more for both services, and they further suggest that water is more important than sanitation for all outcomes when access duration is taken into account, unlike the contemporaneous case in Table 4, where the reverse held.

Table 5 also presents our estimates for individual countries. Columns 2, 5, and 8 show estimates for Ethiopia. Our estimates indicate a strong and substantial association between cumulative access to water and sanitation (both combined and individually) and all educational outcomes. Cumulative access to water shows a stronger association with all outcomes than cumulative access to sanitation. For India, columns 3, 6, and 9 show a similar, strong, and substantial association between cumulative access to combined water and sanitation and all educational outcomes. However, unlike sanitation, we find that water has an insignificant association with grade progression and school dropout, possibly due to skewed water distribution that would limit the within-child variation n(see figure 1).

When we compare our estimates in tables 4 and 5, we can see some noteworthy points. First, our estimates in table 5 are quite laudable and substantially larger in magnitude. This suggests that while educational benefits from contemporaneous (or current-period) access to water and sanitation (both combined and individually) may be hardly detectable, sustained, long-term access to water and sanitation is required, which further suggests the accumulation of educational benefits over time.

Second, for individual services, water shows a larger boost than sanitation. While contemporaneous access to water service in Table 4 is insignificant for educational outcomes, which are also much lower than those for sanitation, it becomes quite estimable and economically meaningful when we consider access duration. The only exception is India, in terms of grade progression and school dropout. This is an accepted estimate, given the justification we provided above.

Overall, the results in tables 4 and 5 indicate that while current-period access to both safe water and improved sanitation is associated with better educational outcomes, the cumulative exposure measure yields larger estimated effects that are also economically meaningful, suggesting that longer access duration generates additional gains.

6 Heterogeneity

Our baseline regressions in Tables 4 and 5 implicitly assume homogeneous effects of WASH services across different characteristics of the children. However, the need for WASH services, the sources of those services, and the burden of satisfying household demand for those services could be characteristics that determine their effect on child education differently (Sweetman and Medland, 2017).

Therefore, we investigate possible effect heterogeneity by children's gender and household location. We do this by fitting each sample separately into 1.

6.1 Gender

Figure 2 presents our estimates of equation 1 for young girls and young boys separately across all outcomes and all WASH services (combined and separate). [13].Figures in Panel A show our estimates for combined WASH access, and those in Panels B and C show our estimates for water and sanitation, respectively. Panel A shows a significant association between access to combined WASH and all outcomes among younger boys, but not among young girls. Furthermore, the figure shows that the effect from the Ethiopian sample largely contributed to the combined sample. However, splitting WASH into water and sanitation (Panels B and C) shows that young girls seem to benefit significantly from access to sanitation services in all sample settings, particularly for their years of school completion and grade enrolment.

6.2 Residential area

Table 6 presents effect heterogeneity by residential area of the children, with Panel A and B showing estimates from urban and rural samples, respectively. For the urban sample, Panel A shows that children in the Ethiopian sample benefited significantly from access to water for their years of schooling and moderately from access to sanitation for their grade progression.

On the other hand, Panel B shows a significant association between access to combined WASH and all educational outcomes for children from rural areas in our combined sample. This panel further shows that these effects are largely driven by the rural sample from India. Furthermore, access to sanitation alone shows a significant association with grade progression and school dropout in the rural areas of India and a moderate positive effect on the years of school completion for the full sample. It is worth noting that, for the Indian sample, access to combined WASH shows a negative but moderate association with child grade progression in urban areas, whereas it is positive and significant in rural areas.

Overall, the gender analysis shows that young boys benefited more from combined access to WASH in both sample settings. Splitting the service into water and sanitation shows us that young girls benefit more from access to sanitation services in all sample settings. On the other hand, our location-based analysis suggests differential effects of access to services by location and countries. While urban children benefit more in Ethiopia, children from rural areas benefit more in India.

7 Mechanisms

Our discussion in section 5 shows the contributing roles of access to WASH to child educational outcomes, mainly to the years of education completed and when the service is provided in combination. In this section, we strengthen our discussion in section 5 by further investigating the

[13]See table A1 for a corresponding table

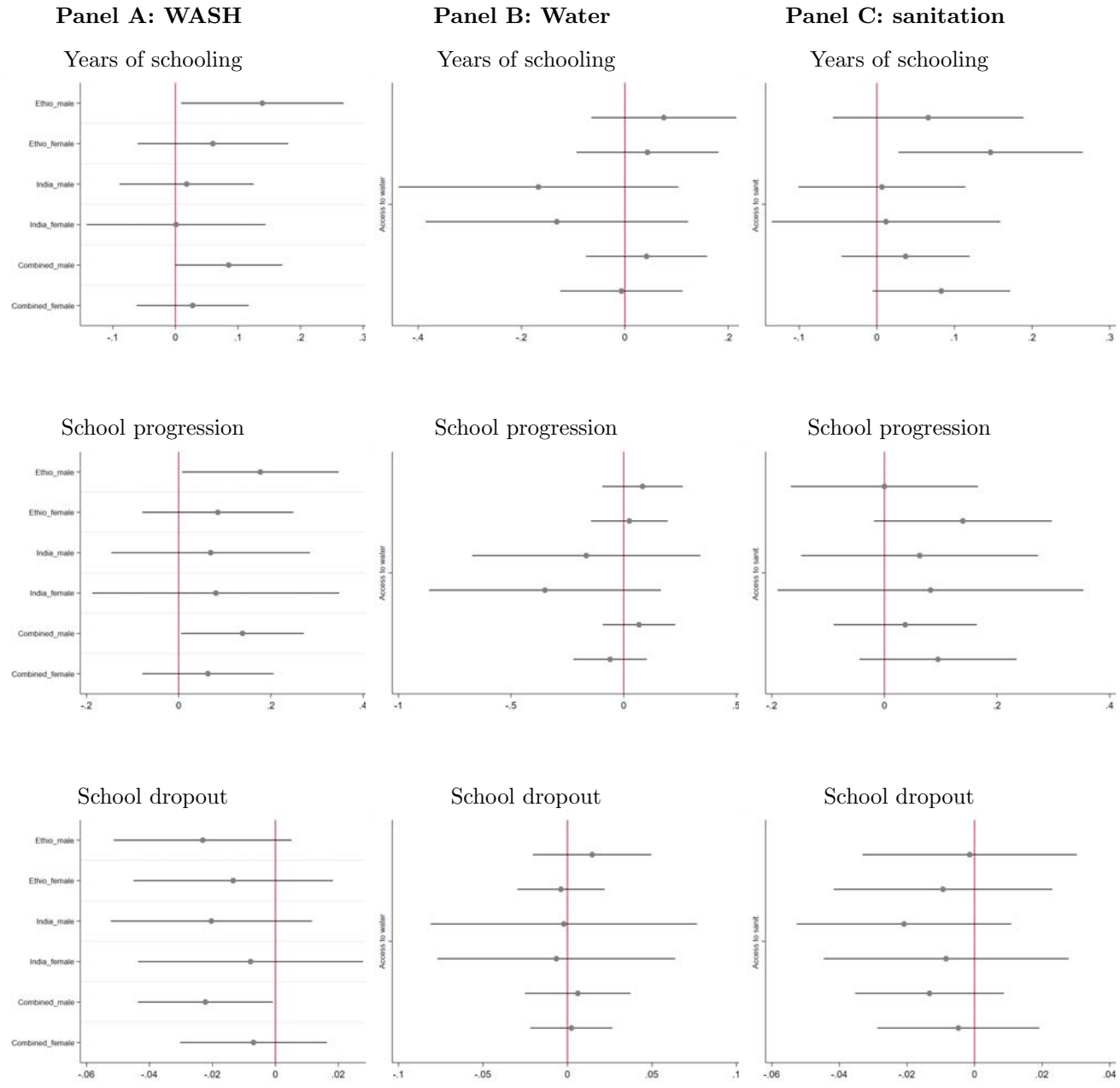

Figure 2: Access to WASH services and education

Notes: These figures present the estimates β with 95% CI from equation 1, showing the effects of access to water and/or services on educational outcomes by gender and country of study.

Table 6: Access to WASH and education outcomes by residential area

	Years Completed			**Grade progression**			**School dropout**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Combined	Ethiopia	India	Combined	Ethiopia	India	Combined	Ethiopia	India
Panel A: Urban									
WASH	0.049	0.124*	-0.108	-0.006	0.128	-0.326*	0.002	-0.006	0.020
	(0.055)	(0.064)	(0.126)	(0.080)	(0.088)	(0.197)	(0.012)	(0.013)	(0.030)
Water	0.125*	0.163**	-0.133	0.003	0.033	-0.064	0.028	0.027	0.003
	(0.071)	(0.075)	(0.133)	(0.124)	(0.126)	(0.154)	(0.021)	(0.021)	(0.018)
Sanitation	0.021	0.092	-0.101	0.014	0.181*	-0.335	-0.007	-0.020	0.019
	(0.060)	(0.070)	(0.132)	(0.091)	(0.101)	(0.205)	(0.014)	(0.016)	(0.031)
Observations	4491	2469	2022	4474	2444	2030	3363	1773	1590
Panel B: Rural									
WASH	0.078**	0.046	0.046	0.162***	0.074	0.208**	-0.021**	-0.012	-0.028**
	(0.038)	(0.056)	(0.049)	(0.061)	(0.076)	(0.099)	(0.010)	(0.015)	(0.014)
Water	0.042	0.003	-0.139	0.054	0.022	-0.199	-0.007	0.000	-0.015
	(0.049)	(0.060)	(0.103)	(0.068)	(0.077)	(0.196)	(0.012)	(0.015)	(0.029)
Sanitation	0.069*	0.030	0.043	0.094	-0.034	0.202**	-0.009	0.014	-0.028**
	(0.035)	(0.052)	(0.050)	(0.057)	(0.073)	(0.097)	(0.010)	(0.016)	(0.014)
Observations	9979	4622	5357	9987	4594	5393	7018	2781	4237
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Household FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Region_round trends	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

potential mechanisms underlying the contributing role of WASH for child educational outcomes, particularly for years of education. As discussed in section 2, access to safe water and improved sanitation could improve child educational outcomes through two main and immediate channels. *i*) Time channel: Access to WASH reduces time burdens for children in the household. This includes reducing daily hours required for household chores like collecting water and related family tasks or travelling to open defecation or shared sanitation sites, thereby improving educational attainment (Orgill-Meyer, 2022; Ashraf et al., 2021; Hamlet et al., 2021). *ii*) Health channel: access to WASH also has a direct health implication on the children. Improved WASH reduces exposure to pathogens and environmental enteropathy, resulting in a lower risk of diarrhoea and mortality, and improves nutritional benefits. These further improve educational attainment (Kresch, 2020; Ngure et al., 2014; Martorell et al., 2010).

We therefore used the YL data sections on the daily time allocation of the children and anthropometry to investigate these possible pathways. First we categorised time information into three. Hours for domestic tasks; where the children spend time on household chores, including domestic and farm work, which are unpaid hours. Hours for paid activities, where the children are involved in income-generating activities. And playtime, where the children spend part of their daily hours on leisure activities. To address the nutritional pathway, we use standardised information on child height-for-age (HAZ) and age-adjusted body mass index (BMI). These measures are widely used as indicators of the cumulative effects of nutritional adequacy and are more informative about later childhood stages, respectively (WHO, 2009).

We then estimate the association between access to WASH and these child time allocations and their nutritional measures. We used a version of equation 1 where the outcome variables are now time allocation and nutritional measures. This helps us identify the potential transmission mechanisms. Second, we estimate how strongly WASH services are associated with children's years of education completion, more so for the children whose time allocation and nutritional measures are affected by WASH services. This helps us decompose and identify the contributions of each of the identified channels. To achieve this, we interact the WASH variable with the potential channels in a regression with years of education completed as the outcome variable.

7.1 Time allocation path

Tables 7 present our estimates on the association between access to collective WASH and children daily hours allocation to different activities. We find suggestive evidence that access to collective WASH services decreases the daily hours children spend on domestic tasks but increases the hours they spend on leisure activities. In particular, panel A, columns 1 and 3 show that, on average, WASH significantly reduces child daily hours spent on household unpaid tasks by about 0.08 hours per day for the full sample and by about 0.13 hours per day for the Indian sample. In panel C, we further show that access to collective WASH services moderately increases the hours children allocate to leisure activities. This estimate is also visible for the full sample and the Indian sample, at nearly 0.13 hours and 0.17 hours, but not for the Ethiopian sample. On the other hand, our

estimates in Panel B show no significant association between access to WASH services and hours spent on paid activities.

Table 7: Access to WASH and child time allocation

	Full sample	Ethiopia	India
	(1)	(2)	(3)
Panel A: Daily hours in domestic/farm/family tasks	-0.083**	-0.031	-0.126***
	(0.042)	(0.070)	(0.040)
Observations	13783	6528	7255
Panel B: Daily hours in paid work	-0.006	-0.008	0.009
	(0.030)	(0.034)	(0.055)
Observations	13784	6528	7256
Panel C: Daily hours in leisure	0.127*	0.104	0.170*
	(0.071)	(0.103)	(0.100)
Observations	13786	6530	7256
Controls	yes	yes	yes
Household FE	yes	yes	yes
Region round trends	yes	yes	yes

Notes: This table presents estimates of equation 1. All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

7.2 Nutritional path

Table 8 presents our estimates of the association between access to collective WASH services and child nutritional measures. The results provide suggestive evidence that access to WASH improves child nutritional outcomes in the full sample and the Ethiopian sample, but not in the Indian sample. In Column 1, Panel A, we show that access to WASH increases the child BMI-for-age score by about 0.06 SD, significantly for the full sample and moderately for the Ethiopian sample. In Panel B, we also show a moderate increase in the height-for-age score of about 0.05 and 0.06 SD for the full and Ethiopian samples, respectively.

Overall, our estimates show access to collective WASH services decreases the child burden of domestic chores, increases their leisure hours, and further improves their nutritional outcomes. Furthermore, other studies often show academic outcomes, mainly years of school completion, benefit from a lower time burden on household chores, more time on leisure, and better nutritional outcomes (Kremer et al., 2011; Ashraf et al., 2021; Hamlet et al., 2021). Our estimates, therefore, suggest that hours spent on domestic tasks, leisure time, and nutritional measures, as potential channels through WASH, may lead to higher years of education completed.

Table 8: Access to WASH and child nutritional value

	Full sample	Ethiopia	India
	(1)	(2)	(3)
Panel A: BMI-for-age z-score	0.063**	0.058*	0.044
	(0.025)	(0.033)	(0.040)
Observations	18228	8845	9383
Panel B: Height-for-age z-score	0.045*	0.063*	0.046
	(0.024)	(0.035)	(0.033)
Observations	18252	8892	9360
Controls	yes	yes	yes
Household FE	yes	yes	yes
Region round trends	yes	yes	yes

Notes: This table presents estimates of equation 1 with nutritional measures as the dependent variables. All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

7.3 Mechanism Validation

To examine whether the identified channels represent plausible mechanisms through which WASH access operates, Table 9 tests whether the effect of WASH operates through these proposed channels by interacting access to WASH with channel measures.

Column 2 includes an interaction term between WASH service and the child's daily hours spent on domestic tasks. The positive and significant interaction term suggests that the association with WASH is stronger at higher levels of domestic tasks. This implies that WASH plays a mitigating role by offsetting the adverse effects associated with hours spent on domestic tasks, suggesting that hours on domestic tasks constitute an important pathway linking WASH to years of school completion. In Column 3, we include the interaction term between WASH service and the daily hours spent on leisure activities. The negative interaction term suggests diminishing marginal effects, with the effects of WASH being stronger at lower levels of play hours, further suggesting that play hours represent a potential pathway.

In Column 4, we include the interaction term between WASH service and child BMI scores. The negative and significant interaction term suggests that the marginal effect of WASH declines as BMI score increases. The impact of WASH is stronger at lower BMI levels, providing further suggestive evidence that BMI may serve as a transmission channel. In Column 5, we include the interaction term between WASH service and child HAZ scores. The positive and significant interaction term indicates that the effect of WASH is stronger at higher levels of HAZ. Considering that HAZ is associated with worse Years of education, this suggests that WASH mitigates the adverse influence of HAZ, providing evidence consistent with HAZ representing a potential pathway through which WASH affects Years of education.

Overall, our estimates suggest that all our potential channels are pathways through which

Table 9: Channels through which WASH affects years of school completion

	Years of school completion					
	(1)	(2)	(3)	(4)	(5)	(6)
Access to WASH	0.066**	-0.020	0.424***	-0.068	0.201***	0.264***
	(0.032)	(0.035)	(0.048)	(0.045)	(0.047)	(0.068)
Daily hours in domestic tasks (htask)		-0.117***				-0.105***
		(0.012)				(0.013)
wash_x_htask		0.086***				0.064***
		(0.019)				(0.019)
Daily hours in leisure activities (hplay)			0.046***			0.029***
			(0.006)			(0.007)
wash_x_hplay			-0.082***			-0.063***
			(0.009)			(0.009)
BMI-for-age z-score (zbfa)				0.120***		0.101***
				(0.019)		(0.018)
wash_x_zbfa				-0.100***		-0.070***
				(0.022)		(0.022)
Height-for-age z-score (zhfa)					-0.070***	-0.022
					(0.024)	(0.024)
wash_x_zhfa					0.095***	0.060**
					(0.026)	(0.026)
Observations	14470	13728	13731	14393	14408	13633
Controls	yes	yes	yes	yes	yes	yes
Household FE	yes	yes	yes	yes	yes	yes
Region-round trends	yes	yes	yes	yes	yes	yes

Notes: This table presents estimates of equation 1 that interact WASH with identified mechanisms. All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

access to WASH could improve children's years of schooling. This is further confirmed in column 6, which includes all interaction terms simultaneously and shows consistent estimates with moderate significance for the HAZ score. Considering that WASH mitigates the adverse effects of hours spent on domestic chores and higher HAZ scores, it plays a complementary role with these channels in their effects on Years of education. However, given that WASH plays a stronger role at lower levels of children's playtime and BMI scores, it serves as a substitute for these channels in their effects on years of school completion.

8 Robustness Checks

In our specification of Equation 1, if educational outcomes lead to better access to water and sanitation services rather than the reverse, the previous estimates may be subject to reverse causality. To address this concern, we adhere to the placebo-test logic commonly employed in the event-study literature and conduct a placebo-treatment test (Sun and Abraham, 2021).[14] Future access to water and sanitation is examined to determine whether current educational outcomes demonstrate anticipatory responses or pre-existing trends prior to access to these services.

Accordingly, if future WASH access predicts current educational outcomes, the estimated relationship may reflect reverse causality or omitted variables rather than the relationship our estimates claim. The absence of statistically significant lead effects supports the identifying assumptions underlying the fixed-effects specification (Autor, 2003).

As a result, we replaced contemporaneous WASH access in equation 1 with its one-period lead, as estimated in the following equation.

$$Y_{iht} = \alpha_0 + \mu_i + \beta\,\text{WashAccess}_{ht+1} + \alpha_1 X'_{iht} + \gamma_{rt} + \varepsilon_{iht} \tag{3}$$

Where WashAccess $_{ht+1}$ now measures access to safe water and improved sanitation one period ahead. Table 10 presents our estimates of β from equation 3 and shows that future WASH access has little explanatory power for current educational outcomes. All estimates are statistically insignificant at conventional levels, except one that is marginally significant at the 10 percent level, providing limited evidence that future WASH exposure predicts current outcomes. This suggests that access to safe water and sanitation led to the educational outcomes rather than vice versa.

Time-varying confounders are another potential challenge to our identification strategy. We assess the robustness of our findings by incorporating additional covariates, including more comprehensive demographic variables, the number of employed males and females within the household, the count of male and female dependents, the educational attainment of the father, land ownership status pertaining to the household, and caregivers' behavioural attributes related to their subjective well-being in overall life.

Estimates are presented in Table A8. After incorporating a comprehensive set of household and child characteristics, the estimated coefficients remain largely consistent. Although a limited num-

[14] Related methodologies are also utilised in Autor (2003)

Table 10: Future access to WASH and education outcomes

	Years completed			**Grade progression**			**School dropout**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Combined	Ethiopia	India	Combined	Ethiopia	India	Combined	Ethiopia	India
F.WASH	-0.003	-0.001	0.007	0.029	0.053	0.007	-0.005	-0.000	-0.009
	(0.030)	(0.040)	(0.044)	(0.034)	(0.045)	(0.051)	(0.007)	(0.012)	(0.009)
F.Water	-0.043	-0.024	-0.188	-0.036	-0.046	0.063	0.013	0.020	-0.019
	(0.039)	(0.041)	(0.119)	(0.044)	(0.047)	(0.125)	(0.013)	(0.015)	(0.026)
F.Sanitation	0.010	0.031	-0.004	0.043	0.085*	0.002	-0.011	-0.015	-0.009
	(0.030)	(0.040)	(0.044)	(0.035)	(0.046)	(0.052)	(0.008)	(0.015)	(0.009)
Observations	10793	5285	5508	10856	5272	5584	6805	2819	3986
Household FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Region-round trends	yes	yes	yes	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

ber of coefficients change marginally in statistical significance, the overall pattern and magnitude of the results remain largely unchanged, indicating that the findings are not primarily influenced by omitted observable characteristics.

9 Conclusion

Despite the necessity of accessing safe drinking water and improved sanitation services, nearly 25 and 40 percent of the global population still lacks these services as of 2024, with stark inequalities across and within countries. Low-income countries in general and children and girls in particular are disproportionately affected by this and face challenges from faecal contamination of their living environment, ongoing exposure to pathogenic microorganisms, recurrent waterborne and enteric infections, and significant concerns regarding privacy, safety, and dignity associated with open and unsafe defecation, which ultimately affects their human capital accumulation and productivity (Hossain et al., 2022; WHO and UNICEF, 2025).

In this study, we investigate WHO/UNICEF Joint Monitoring Program criteria-based access to water and sanitation and its contributions to the educational outcomes of young children. We studied a longitudinal framework and considered access to water and sanitation both collectively and individually. We found that combined access to both services significantly increases years of schooling completed and grade progression, and decreases the likelihood of dropping out of school. We also observe an increase in years of education with access only to sanitation, but not to water.

We further emphasise the duration of access and found highly significant and economically sound estimates. In particular, we found that for every additional round of accumulated access to combined services, years of education, and grade enrollment increase by nearly 117 and 190

days, respectively, and substantially decrease the likelihood of school dropout. Another interesting finding is a boost in the importance of water. Unlike contemporaneous access, we found that cumulative access to water substantially improves educational outcomes.

The improvement in educational outcomes shows substantial heterogeneity by gender, household location, country of residence, and access format. We show that combined access to both services benefits more of the educational outcomes of young boys than girls to all our sample settings. However, splitting access to sanitation and water shows that young girls benefit more from sanitation, particularly in their completed school years and grade progression. Our location-based analysis shows that while urban children benefit more in Ethiopia, children from rural areas benefit more in India, particularly from access to combined WASH.

We also extend the paper to examine possible mechanisms underlying the positive association between access to combined WASH services and school completion years. We find suggestive evidence that children's daily time allocation and nutritional measures are potential pathways. In particular, daily hours spent on domestic tasks and standardised child height-for-age score play a complementary role alongside WASH services, such that WASH mitigates the adverse effects of hours spent on domestic chores and higher HAZ scores on years of education. On the other hand, we show that WASH plays a substitutive role with daily hours for play and child BMI score in their effects on years of school completion, such that it plays a stronger role at lower levels of children's playtime and BMI scores,

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Appendix A

Table A1: Access to WASH and education outcomes by child gender

	Years Completed			**Grade progression**			**School dropout**		
	Combined	Ethiopia	India	Combined	Ethiopia	India	Combined	Ethiopia	India
Panel A: Male									
WASH	0.085*	0.139**	0.018	0.138**	0.177**	0.069	-0.022**	-0.023	-0.020
	(0.044)	(0.066)	(0.055)	(0.068)	(0.086)	(0.110)	(0.011)	(0.014)	(0.016)
Water	0.042	0.075	-0.167	0.068	0.083	-0.166	0.006	0.015	-0.002
	(0.060)	(0.072)	(0.138)	(0.082)	(0.091)	(0.258)	(0.016)	(0.018)	(0.040)
Sanitation	0.037	0.066	0.006	0.037	-0.000	0.063	-0.013	-0.001	-0.021
	(0.042)	(0.063)	(0.055)	(0.065)	(0.085)	(0.107)	(0.011)	(0.016)	(0.016)
Observation	7751	3772	3979	7749	3745	4004	5494	2386	3108
Panel B: Female									
WASH	0.028	0.060	0.001	0.064	0.085	0.081	-0.007	-0.013	-0.008
	(0.046)	(0.061)	(0.073)	(0.073)	(0.084)	(0.136)	(0.012)	(0.016)	(0.018)
Wwater	-0.007	0.044	-0.132	-0.060	0.025	-0.350	0.002	-0.004	-0.007
	(0.060)	(0.070)	(0.129)	(0.083)	(0.087)	(0.262)	(0.012)	(0.013)	(0.036)
Sanitation	0.083*	0.146**	0.012	0.095	0.139*	0.082	-0.005	-0.009	-0.008
	(0.045)	(0.060)	(0.075)	(0.071)	(0.080)	(0.138)	(0.012)	(0.016)	(0.018)
Observation	6719	3319	3400	6712	3293	3419	4887	2168	2719
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Household FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Region-round trend	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A2: Table: Years of Education Completed - Combined Countries

	Fixed Effects		**Random Effects**			
	(1)	(2)	(3)	(4)	(5)	(6)
WASH	0.066**					
	(0.032)					
Water		0.032				
		(0.043)				
Sanitation		0.062**				
		(0.031)				
Rounds with water access			0.129***			
			(0.012)			
watar access catagories =4				0.198***		
				(0.060)		
watar access catagories =5				0.355***		
				(0.054)		
watar access catagories =6				0.487***		
				(0.054)		
Rounds with sanitation					0.014	
					(0.010)	
sanitation access catagories =1						0.187***
						(0.056)
sanitation access catagories =2						0.130**
						(0.059)
sanitation access catagories =3						0.191***
						(0.058)
sanitation access catagories =4						0.121**
						(0.060)
sanitation access catagories =5						0.281***
						(0.064)
Child sex	0.000	0.000	-0.202***	-0.204***	-0.207***	-0.204***
	(.)	(.)	(0.028)	(0.028)	(0.028)	(0.028)
Age in years	0.127***	0.127***	0.287***	0.286***	0.282***	0.284***
	(0.038)	(0.038)	(0.027)	(0.027)	(0.027)	(0.027)
Mother's education	0.032**	0.032**	0.038***	0.038***	0.038***	0.037***
	(0.016)	(0.016)	(0.004)	(0.004)	(0.004)	(0.004)
Wealth index	-0.414***	-0.434***	0.272***	0.328***	0.484***	0.450***
	(0.139)	(0.145)	(0.101)	(0.101)	(0.099)	(0.100)
Household size	-0.006	-0.006	-0.013**	-0.014**	-0.014**	-0.014**
	(0.008)	(0.008)	(0.006)	(0.006)	(0.006)	(0.006)
Urban/rural residence	-0.047	-0.045	0.025	0.033	0.083**	0.072*
	(0.070)	(0.070)	(0.037)	(0.038)	(0.038)	(0.039)
Access to cooking fuels	0.136***	0.138***	0.028	0.017	-0.027	-0.026
	(0.034)	(0.034)	(0.031)	(0.031)	(0.031)	(0.031)
Constant	2.627***	2.614***	-1.536***	-1.329***	-1.346***	-1.435***
	(0.439)	(0.440)	(0.136)	(0.136)	(0.137)	(0.143)
Observations	14470.000	14470.000	14470.000	14470.000	14470.000	14470.000
Household FE	yes	yes	—-	—	—	—
Region-specific time trends	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes

Notes:All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A3: Years of Education Completed - Ethiopia and India

	Ethiopia						India					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
WASH	0.116**						0.010					
	(0.046)						(0.045)					
Water		0.076						-0.147				
		(0.050)						(0.095)				
Sanitation		0.112**						0.010				
		(0.044)						(0.045)				
Cum.water access			0.092***						0.057**			
			(0.016)						(0.023)			
watar access =4				0.047						0.156		
				(0.067)						(0.133)		
watar access =5				0.190***						0.118		
				(0.066)						(0.106)		
watar access =6				0.366***						0.215**		
				(0.076)						(0.095)		
Cum. san. access					0.110***						0.020	
					(0.014)						(0.014)	
san.access =1						0.232***						0.130*
						(0.089)						(0.072)
san.access =2						0.285***						0.148*
						(0.084)						(0.080)
san.access =3						0.386***						0.259***
						(0.078)						(0.089)
san.access =4						0.467***						0.006
						(0.083)						(0.085)
san.access =5						0.655***						0.227**
						(0.089)						(0.095)
Child sex	0.000	0.000	-0.159***	-0.164***	-0.159***	-0.159***	0.000	0.000	-0.239***	-0.239***	-0.234***	-0.236***
	(.)	(.)	(0.039)	(0.039)	(0.039)	(0.039)	(.)	(.)	(0.038)	(0.038)	(0.038)	(0.038)
Age in years	-0.019	-0.021	0.208***	0.205***	0.212***	0.211***	0.216***	0.216***	0.347***	0.347***	0.346***	0.347***
	(0.068)	(0.068)	(0.037)	(0.037)	(0.036)	(0.036)	(0.044)	(0.044)	(0.039)	(0.039)	(0.039)	(0.039)
Mother's education	0.069***	0.069***	0.048***	0.047***	0.044***	0.043***	-0.011	-0.011	0.033***	0.033***	0.031***	0.033***
	(0.021)	(0.021)	(0.007)	(0.007)	(0.007)	(0.007)	(0.023)	(0.023)	(0.006)	(0.006)	(0.006)	(0.006)
Wealth index	-0.501**	-0.619**	0.462***	0.577***	0.409**	0.409**	-0.321*	-0.276	0.093	0.099	0.074	0.073
	(0.242)	(0.266)	(0.167)	(0.165)	(0.161)	(0.163)	(0.168)	(0.171)	(0.122)	(0.124)	(0.129)	(0.128)
Household size	0.002	0.002	-0.011	-0.012	-0.015	-0.015	-0.014	-0.014	-0.012*	-0.013*	-0.013*	-0.013*
	(0.014)	(0.014)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.007)	(0.007)	(0.007)	(0.007)
Urban (=1)	-0.114	-0.105	0.279***	0.281***	0.398***	0.393***	0.007	0.006	-0.091**	-0.093**	-0.127**	-0.113**
	(0.141)	(0.141)	(0.062)	(0.063)	(0.060)	(0.061)	(0.074)	(0.074)	(0.046)	(0.046)	(0.052)	(0.054)
Cooking fuels	0.467***	0.478***	0.386***	0.374***	0.363***	0.363***	0.010	0.004	-0.018	-0.018	-0.024	-0.020
	(0.068)	(0.069)	(0.065)	(0.065)	(0.064)	(0.064)	(0.038)	(0.038)	(0.036)	(0.036)	(0.036)	(0.036)
Constant	-1.111**	-1.118**	-1.245***	-1.089***	-1.401***	-1.352***	-0.730***	-0.610**	-1.818***	-1.684***	-1.522***	-1.608***
	(0.461)	(0.464)	(0.184)	(0.183)	(0.184)	(0.190)	(0.262)	(0.271)	(0.226)	(0.217)	(0.197)	(0.206)
Observations	7091.000	7091.000	7091.000	7091.000	7091.000	7091.000	7379.000	7379.000	7379.000	7379.000	7379.000	7379.000
Household FE	yes	yes	—-	—	—	—	yes	yes	—-	—	—	—
Region-specific time trends	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

*Notes:All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$,*

Table A4: Table: Grade progression - Combined Countries

	Fixed Effects		**Random Effects**			
	(1)	(2)	(3)	(4)	(5)	(6)
Access to WASH	0.112**					
	(0.050)					
Access to water		0.026				
		(0.059)				
Access to sanitation		0.065				
		(0.048)				
Rounds with water access			0.151***			
			(0.017)			
Watar access =4				0.249***		
				(0.075)		
Watar access =5				0.403***		
				(0.071)		
Watar access =6				0.518***		
				(0.072)		
Rounds with sanitation access					0.014	
					(0.014)	
Sanitation access =1						0.322***
						(0.083)
Sanitation access =2						0.237***
						(0.084)
sanitation access =3						0.298***
						(0.084)
Sanitation access =4						0.197**
						(0.087)
Sanitation access =5						0.361***
						(0.093)
Child sex	0.000	0.000	-0.247***	-0.248***	-0.252***	-0.246***
	(.)	(.)	(0.037)	(0.037)	(0.037)	(0.037)
Age in years	0.045	0.045	0.208***	0.205***	0.203***	0.206***
	(0.054)	(0.054)	(0.037)	(0.037)	(0.037)	(0.037)
Mother's education	0.072***	0.072***	0.061***	0.061***	0.061***	0.060***
	(0.020)	(0.020)	(0.006)	(0.006)	(0.006)	(0.006)
Wealth index	-0.615***	-0.552**	0.661***	0.763***	0.979***	0.927***
	(0.232)	(0.244)	(0.150)	(0.150)	(0.147)	(0.149)
Household size	0.002	0.002	-0.014*	-0.014*	-0.015*	-0.016*
	(0.013)	(0.013)	(0.008)	(0.008)	(0.008)	(0.008)
Urban (=1)	-0.042	-0.035	0.018	0.036	0.093*	0.094
	(0.127)	(0.127)	(0.055)	(0.055)	(0.056)	(0.058)
Access to cooking fuels	0.162***	0.160***	0.003	-0.019	-0.082	-0.078
	(0.060)	(0.061)	(0.053)	(0.053)	(0.053)	(0.053)
Constant	4.223***	4.190***	-1.274***	-1.038***	-1.062***	-1.248***
	(0.599)	(0.599)	(0.185)	(0.184)	(0.186)	(0.197)
Observations	14470.000	14470.000	14470.000	14470.000	14470.000	14470.000
Household FE	yes	yes	—-	—	—	—
Region-specific time trends	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes

Notes:All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A5: Grade progression - Ethiopia and India

	Ethiopia						India					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
WASH	0.149**						0.064					
	(0.061)						(0.086)					
Water		0.075						-0.264				
		(0.064)						(0.182)				
Sanitation		0.072						0.062				
		(0.059)						(0.086)				
Cumm. water access			0.123***						0.031			
			(0.020)						(0.039)			
watar access =4				0.095						0.158		
				(0.081)						(0.221)		
watar access =5				0.179**						0.169		
				(0.083)						(0.179)		
watar access =6				0.427***						0.193		
				(0.091)						(0.169)		
Cum. san. access					0.131***						0.022	
					(0.020)						(0.023)	
sanitation access =1						0.271**						0.333***
						(0.120)						(0.112)
sanitation access =2						0.341***						0.326***
						(0.111)						(0.123)
sanitation access =3						0.466***						0.408***
						(0.107)						(0.133)
sanitation access =4						0.564***						0.084
						(0.114)						(0.136)
sanitation access =5						0.775***						0.334**
						(0.121)						(0.153)
Child sex	0.000	0.000	-0.272***	-0.282***	-0.274***	-0.273***	0.000	0.000	-0.211***	-0.210***	-0.208***	-0.202***
	(.)	(.)	(0.048)	(0.048)	(0.048)	(0.048)	(.)	(.)	(0.055)	(0.055)	(0.055)	(0.054)
Age in years	-0.063	-0.063	0.143***	0.142***	0.148***	0.148***	0.108	0.108	0.260***	0.260***	0.261***	0.266***
	(0.087)	(0.088)	(0.046)	(0.046)	(0.046)	(0.046)	(0.068)	(0.068)	(0.057)	(0.057)	(0.057)	(0.057)
Mother's education	0.077***	0.078***	0.063***	0.063***	0.059***	0.058***	0.064**	0.064**	0.063***	0.063***	0.061***	0.065***
	(0.027)	(0.027)	(0.008)	(0.008)	(0.008)	(0.008)	(0.028)	(0.028)	(0.007)	(0.007)	(0.008)	(0.008)
Wealth index	-0.604*	-0.545	0.720***	0.922***	0.696***	0.694***	-0.579*	-0.492	0.549***	0.539**	0.506**	0.497**
	(0.321)	(0.353)	(0.216)	(0.213)	(0.212)	(0.213)	(0.324)	(0.326)	(0.209)	(0.212)	(0.224)	(0.222)
Household size	0.011	0.011	-0.008	-0.009	-0.012	-0.012	-0.008	-0.008	-0.014	-0.014	-0.014	-0.014
	(0.018)	(0.018)	(0.012)	(0.012)	(0.012)	(0.012)	(0.017)	(0.017)	(0.011)	(0.011)	(0.011)	(0.011)
Urban (=1)	-0.233	-0.228	0.358***	0.381***	0.521***	0.517***	0.075	0.073	-0.198***	-0.197***	-0.242***	-0.195**
	(0.185)	(0.186)	(0.079)	(0.081)	(0.077)	(0.078)	(0.169)	(0.169)	(0.076)	(0.076)	(0.090)	(0.094)
Access to cooking fuels	0.428***	0.424***	0.312***	0.288***	0.274***	0.274***	0.061	0.050	0.006	0.007	-0.001	0.012
	(0.084)	(0.084)	(0.079)	(0.079)	(0.080)	(0.080)	(0.079)	(0.079)	(0.072)	(0.072)	(0.072)	(0.072)
Constant	-0.600	-0.641	-1.046***	-0.853***	-1.217***	-1.163***	0.175	0.388	-1.416***	-1.419***	-1.261***	-1.509***
	(0.526)	(0.528)	(0.230)	(0.230)	(0.230)	(0.242)	(0.466)	(0.485)	(0.359)	(0.336)	(0.289)	(0.310)
Observations	7038	7038	7038	7038	7038	7038	7423	7423	7423	7423	7423	7423
Household FE	yes	yes	—-	—	—	—	yes	yes	—-	—	—	—
Region-specific time trends	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes:All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$,

Table A6: Table: School dropout - Combined Countries

	Fixed Effects		**Random Effects**			
	(1)	(2)	(3)	(4)	(5)	(6)
Access to both improved water and sanitation	-0.014*					
	(0.008)					
Access to safe drinking water		0.002				
		(0.010)				
Access to sanitation		-0.008				
		(0.008)				
Number of rounds with water access (0-5)			-0.002			
			(0.002)			
watar access catagories =4				-0.006		
				(0.008)		
watar access catagories =5				-0.004		
				(0.008)		
watar access catagories =6				-0.002		
				(0.008)		
Number of rounds with sanitation access (0-5)					-0.001	
					(0.002)	
sanitation access catagories =1						-0.021*
						(0.011)
sanitation access catagories =2						-0.023**
						(0.011)
sanitation access catagories =3						-0.023**
						(0.010)
sanitation access catagories =4						-0.015
						(0.011)
sanitation access catagories =5						-0.017
						(0.011)
Child sex	0.000	0.000	0.002	0.002	0.002	0.002
	(.)	(.)	(0.004)	(0.004)	(0.004)	(0.004)
Age in years	0.019*	0.019*	0.018***	0.018***	0.018***	0.018***
	(0.011)	(0.011)	(0.004)	(0.004)	(0.004)	(0.004)
RECODE of momedu (Mother's education)	-0.010***	-0.010***	-0.004***	-0.004***	-0.004***	-0.004***
	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)
Wealth index (including concrete block)	0.046	0.033	-0.053***	-0.057***	-0.055***	-0.052***
	(0.035)	(0.037)	(0.019)	(0.019)	(0.019)	(0.019)
Household size	-0.000	-0.000	-0.000	-0.000	0.000	0.000
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Urban/rural residence	0.002	0.001	0.004	0.003	0.004	0.001
	(0.017)	(0.017)	(0.006)	(0.006)	(0.006)	(0.007)
Access to adequate cooking fuels	-0.013*	-0.012	-0.011*	-0.010	-0.009	-0.009
	(0.008)	(0.008)	(0.006)	(0.006)	(0.006)	(0.006)
Constant	-0.276**	-0.276**	-0.092***	-0.096***	-0.094***	-0.082***
	(0.117)	(0.117)	(0.029)	(0.029)	(0.029)	(0.029)
Observations	10381.000	10381.000	10381.000	10381.000	10381.000	10381.000
Household FE	yes	yes	—-	—	—	—
Region-specific time trends	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes

Notes:All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A7: Wash and School dropout - Ethiopia and India

	Ethiopia						India					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Access to WASH	-0.017						-0.012					
	(0.011)						(0.012)					
Access to water		0.003						-0.003				
		(0.011)						(0.026)				
Access to sanitation		-0.003						-0.012				
		(0.012)						(0.012)				
Cumm. water access			-0.005**						0.005			
			(0.002)						(0.004)			
Watar access =4				-0.008						0.006		
				(0.009)						(0.026)		
Watar access =5				-0.006						0.012		
				(0.009)						(0.022)		
Watar access =6				-0.010						0.016		
				(0.008)						(0.021)		
Cumm. san. access					-0.002						-0.001	
					(0.002)						(0.003)	
Sanitation access =1						0.003						-0.034**
						(0.017)						(0.013)
Sanitation access =2						-0.013						-0.030**
						(0.016)						(0.015)
Sanitation access =3						-0.013						-0.030**
						(0.015)						(0.014)
Sanitation access =4						-0.011						-0.015
						(0.016)						(0.016)
Sanitation access =5						-0.010						-0.023
						(0.016)						(0.017)
Child sex	0.000	0.000	0.014**	0.015***	0.015***	0.015***	0.000	0.000	-0.009	-0.009	-0.009	-0.010
	(.)	(.)	(0.006)	(0.006)	(0.006)	(0.006)	(.)	(.)	(0.006)	(0.006)	(0.006)	(0.006)
Age in years	0.041***	0.041***	0.016***	0.016***	0.016***	0.016***	0.000	0.000	0.020***	0.020***	0.019***	0.019***
	(0.014)	(0.014)	(0.006)	(0.006)	(0.006)	(0.006)	(0.016)	(0.016)	(0.006)	(0.006)	(0.006)	(0.006)
Mother's education	-0.003	-0.003	-0.003***	-0.003***	-0.003***	-0.003***	-0.017***	-0.017***	-0.005***	-0.005***	-0.005***	-0.005***
	(0.004)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)
Wealth index	0.072	0.033	-0.006	-0.019	-0.019	-0.016	0.033	0.034	-0.083***	-0.083***	-0.074***	-0.072**
	(0.052)	(0.057)	(0.028)	(0.028)	(0.029)	(0.029)	(0.046)	(0.047)	(0.027)	(0.027)	(0.029)	(0.028)
Household size	-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Urban (=1)	0.021	0.020	-0.010	-0.014	-0.018**	-0.019**	-0.006	-0.006	0.015*	0.015*	0.018*	0.012
	(0.025)	(0.025)	(0.009)	(0.009)	(0.009)	(0.009)	(0.022)	(0.022)	(0.009)	(0.009)	(0.011)	(0.011)
Access to cooking fuels	-0.011	-0.007	0.007	0.009	0.010	0.010	-0.013	-0.013	-0.012	-0.012	-0.012	-0.013
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
Constant	-0.348***	-0.348***	-0.062*	-0.072**	-0.069**	-0.069**	-0.035	-0.032	-0.080*	-0.065	-0.051	-0.024
	(0.107)	(0.108)	(0.033)	(0.032)	(0.033)	(0.034)	(0.086)	(0.088)	(0.043)	(0.040)	(0.033)	(0.036)
Observation	4554.000	4554.000	4554.000	4554.000	4554.000	4554.000	5827.000	5827.000	5827.000	5827.000	5827.000	5827.000
Household FE	yes	yes	—-	—	—	—	yes	yes	—-	—	—	—
Region-specific time trends	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes:All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, and family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$,

Table A8: Access to WASH and education outcomes

	Years Completed			**Grade progression**			**School dropout**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Combined	Ethiopia	India	Combined	Ethiopia	India	Combined	Ethiopia	India
WASH	0.101**	0.149***	-0.011	0.164***	0.198***	0.073	-0.011	-0.023*	0.004
	(0.039)	(0.052)	(0.061)	(0.062)	(0.068)	(0.121)	(0.011)	(0.013)	(0.019)
Water	0.078	0.112**	-0.252*	0.096	0.161**	-0.498*	-0.001	-0.006	0.004
	(0.050)	(0.057)	(0.141)	(0.068)	(0.070)	(0.271)	(0.012)	(0.013)	(0.044)
Sanitation	0.101***	0.156***	-0.002	0.118*	0.135**	0.084	-0.004	-0.010	0.001
	(0.038)	(0.049)	(0.062)	(0.060)	(0.069)	(0.120)	(0.011)	(0.014)	(0.018)
Observations	10618	5550	5068	10621	5516	5105	7169	3518	3651
Household FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Region-round trends	yes	yes	yes	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: All models include region-specific linear time trends and robust standard errors clustered at the child level. Controls include child age and gender, parental education, household size, number of working males and females, number of dependent males and females, Dad's education, caregiver's subjective well-being, land ownership, family socioeconomic status, and access to cooking fuel. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

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