Child development impact of water scarcity: Evidence from Ethiopia

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Anita Staneva*[a], Muhammed A. Usman[b], Fabrizio Carmignani[a]

[a]Griffith University, Griffith Business School, Australia
[b]Center for Development Research (ZEF), University of Bonn

Abstract

This paper examines the effect of water scarcity on child health and cognitive development using nationally representative data from Ethiopia. The empirical strategy utilizes an instrumental variable approach that exploits variation in water availability across Ethiopian regions. We find that children living in households without access to improved water sources are more likely to be stunted, wasted and anemic, and they are more likely to experience a cognitive deficit. Children of families with a lack of water are more likely to be exposed to unhealthy home environment. Our findings are consistent with the idea that water collection time crowd out other activities for families and young children.

Keywords: water scarcity, cognitive skills, stunting

1. Introduction

Resource constraints in many developing countries, including household burdens for collecting water, have been long-standing policy concerns (Koolwal and Van de Walle, 2013). The

*Corresponding author: Griffith University, Griffith Business School, Department of Accounting, Finance and Economics. Email: a.staneva@griffith.adu.au.

water available to rural communities is often either unsafe or insufficient to meet basic health needs (Usman et al., 2019). Searching for water sources is a daily chore for over 2 billion women and children across the globe, who spend more than six hours each day hauling water from various sources to their homes (UNICEF, 2016). It is predominately girls that will leave school to assist in water collection, as females carry out most domestic chores within the family (Spears and Lamba, 2013).[1] The spread of diseases caused by poor water supply and sanitation services remains a major health problem. Young children who are consistently exposed to unprotected water sources that have been contaminated by fecal matters are often affected by life-threatening diarrhea and other water-related diseases (Usman et al., 2019). Another important aspect is poor nutrition. In 2018, one-third of children under-five in Africa were chronically undernourished (stunted; short for their age) while an estimated seven percent were acutely undernourished (wasted; low weight for their height) (World Health Organization and others, 2019). In addition, poor nutrition in early life is associated with impaired cognitive development and linked to lower human capital attainment, life expectancy and lower socio-economic status in adulthood (Currie and Almond (2011), Hoddinott et al. (2013)).

While increasing attention is being paid to water scarcity problems and deforestation, the interaction between natural resource scarcity and human capital development has, in large part, been overlooked. Motivated by the importance of early life experience in driving children's life chances, in this paper we examine the impact of water scarcity on children's health and cognitive development using data from the 2016 Ethiopia Demographic and Health Survey (DHS) and 2016-17 Young Lives School Survey. The Ethiopia DHS data allows us to identify health outcomes, such as anemia, and anthropometric indicators (e.g., height for age, weight for age, and height-for-weight). Relatedly, the Young Lives School Survey data

[1] Hence, they are more likely to end up in early marriages, be at risk of domestic violence and continue living in a poverty; unable to ever earn an income that gives them the choice or access to improved health care.

provides information on children's cognitive performance, measured by maths, English, and Amharic test scores. The empirical identification strategy utilizes an instrumental variable approach that exploits variation in water accessibility across Ethiopian localities. In Ethiopia, rainfall and water availability are highly variable, and the region has long been subject to harsh climate conditions. Access to water varies substantially not only between urban and rural areas but also by season.[2] In particular, in 2015, the country experienced the worst drought in decades, affecting nearly 10 million people (Seaward, 2016). The El Niño weather system represented a significant shock leaving hundreds of thousands of farmers with failed crops and dead livestock, and led Ethiopia to a sharp increase in humanitarian requirements.

We find that water scarcity and poor sanitation conditions have an adverse effect on child development. Specifically, we found evidence of a loss of cognitive ability in addition to the health and malnutrition negative consequences of water scarcity. We find that children who attend schools without access to improved water sources have lower levels of cognitive development.

Our findings are important for several reasons. First, although much of the existing literature has studied the health outcomes in developed countries, early-life missed opportunities for cognitive development and access to education in a country, where disease and malnutrition are widespread, may be especially important. Identifying children who are likely to lag behind and need additional support has important policy implications. The importance of access to education is reflected within the Sustainable Development Goals (SDG 4) of the commitment to ensure that all children can complete a course of primary education (United Nations, 2015). In addition, the UN's Sustainable Development Goal for water and sanitation, Goal 6, calls for universal and equitable access to safe and affordable drinking water by 2030, and the first step is providing everyone with a basic service within

[2]The country is very vulnerable to water-related climate shocks like water scarcity, drought and floods. A modest 5% decrease in rainfall could cause a 10% decrease in agricultural productivity and reduce the GDP derived from the basin by 5% (McCartney et al., 2010).

a 30-minute round trip (UNICEF, media). Second, our article extends the literature by providing further evidence on possible mechanisms through which water access could affect child health and cognition by investigating household constraints, domestic violence and time use activities. As a result, we found that women spend on avarage more than XX mine in water gathering and too little time on other productive tasks, including time-spend with their children. Finally, there is growing interest in how water, sanitation and hygiene (WASH) interventions might support strategies to reduce stunting in sub-Saharan Africa. Because childhood cognitive skills, health and poor nutrition predict their later outcomes, our results imply that safe, reliable, and easily accessible water is crucial for the preservation of good health and human capital development. A key challenge in achieving the SDG 6 is that in Ethiopia many people are still lacking access to safe in-house and school water connections. According to our data around 45% of children report that no available water source in school facilities.

The remainder of the article is organized as follows. Section 2 discusses the relevant literature. Section 3 introduces the data and sample construction. Section 4 discusses the results. Conclusions and policy implications are presented in Section 6.

2. Related Literature on early child health and cognitive skills

The empirical evidence on the impact of improved water and sanitation on child health is examined in several studies (see Esrey et al. (1990), Cameron (2009), Usman et al. (2019)). Jalan and Ravallion (2003) find that child health (specifically the prevalence and severity of diarrhea are better for Indian children living in villages with access to piped water than for those in observationally similar families in villages lacking such infrastructure. Using cross-country data, Fay et al. (2005) argue that access to basic infrastructure (piped water, sanitation, and electricity) reduces infant and under-five child mortality and incidence of stunting in children. However, Ravallion (2007) questions the robustness of Fay et al. (2005)

findings based on the methodology. Using an alternative estimator and augmenting their data set to include female schooling, Ravallion (2007) finds little evidence that better infrastructure lowers child mortality or stunting. Rocha and Soares (2015) find that negative rainfall shocks lead to a higher infant mortality and worse health at birth. Similarly, Usman et al. (2019) show that the probability of child diarrhoea is 18 percentage points lower in households with uncontaminated stored drinking water than in households with contaminated water.

A series of papers have addressed the relationship between weather shocks and health outcomes. Deschenes and Moretti (2009), for example, find a strong impact of temperature fluctuations on mortality and birth weight in the US. Regarding rainfall, there has been a growing body of research exploring different settings and potential channels. Maccini and Yang (2009) look at rural Indonesia and find long-term beneficial effects of rainfall incidence during the first year of life for women (on health, education and labor market outcomes), with no effect for men. Authors interpret the correlation between rainfall and health outcomes as working through higher agricultural production and lower food prices. Kim (2010) finds a puzzling positive relationship between rainfall and mortality during the growing season in West Africa, while Kudamatsu et al. (2012) show that both increased rainfall and droughts in the growing season are associated with higher infant mortality. These various papers interpret the negative correlation between rainfall and child health as being associated with the increased labor supply of mothers as a response to better agricultural conditions, or direct effect of excessive rain on agricultural production (Rocha and Soares, 2015).

Less examined, however, is the impact of water provision on children's cognitive development, education and risk of living in a domestic violence family. Dehydration can negatively impact children's cognitive abilities (Trinies et al., 2016). For instance, in a randomized control study Trinies et al. (2016) find little evidence of associations between dehydration among children and cognitive performance in Zambia. A smaller body of research has explored the cognitive effects of dehydration from intervention and cross-sectional studies in the United Kingdom and Israel, suggesting that drinking water is associated with an improved attention, short-term memory, visual search, and mood (Edmonds and Burford (2009), Bar-David et al. (2005)). Freeman et al. (2012) conduct a cluster-randomized trial of school-based WASH program on pupil's absence in Kenya, and find no overall effect of the intervention on school absence. Spears and Lamba (2013) find that exposure to drought in utero is associated with being 2 percentage points less likely to recognize numbers in childhood. Lieberman et al. (2005) uses more extreme conditions to generate dehydration – undertaking a military exercise for 53 h in hot conditions, during which participants slept for an average of three hours. Unsurprisingly, they report overwhelmingly adverse impact on cognitive function.

There are various potential mechanisms that can explain the link between variations in water supply and socio-economic outcomes. For instance, a regular rainfall is seen as beneficial for agricultural production and improved nutrition and health.[3] Different aspects of WASH have been plausibly linked to all four 'pillars' of the food and nutrition security framework (Cumming et al., 2016). Lack of clean water, the focus of this paper, features at various levels in these frameworks with varying degrees of connectivity to health outcomes. It may directly impact households depending of agriculture through reduced nutrient intake which can lead to malnutrition (WHO, 2012). Lack of water supply combined with poor sanitation also increases the risk of infectious diseases, such as diarrhea and respiratory infections (Rocha and Soares, 2015). Finally, adequate water intake is crucial to sustain vital physiological and cognitive functions, including transportation of oxygen, nutrients, and waste products (Benton, 2011). Higher water intake correlates with greater ability to maintain task performance when inhibitory demands are increased (Khan et al., 2015). Children in particular are to be at higher risk of dehydration as they are often dependent

[3] The causes of stunting and malnutrition are interlinked – ranging from biological, socio-economic and environmental factors.

upon adults for the provision of fluid.

The findings of this paper complement these studies and also add to the literature on the effect of poverty on children's cognitive development and educational attainment.[4] We also add on the mechanisms linking water scarcity to health and cognitive outcomes.

3. Data and descriptive analysis

Our data come from the 2016 Ethiopia Demographic and Health Survey (DHS) and 2016-17 Youth Lives School Survey (YLSS). The DHS is used to estimate the health impact of water scarcity and the YLSS allows us to identify a child's cognitive development. The recent DHS data was collected from January 2016 to June 2016 in nine geographic regions and two administrative cities of Ethiopia. The survey collects a wide range of information on demographic and health indicators of all household members with specific emphasis on maternal and child health issues.[5] Included in the analyses were all children aged 0-59 months as well as their mothers or caregivers.

The anthropometric indicators mostly used for monitoring malnutrition among children, and utilised in our analysis are: stunting (low height-for-age) and wasting (low weight-for height). Stunting and wasting were defined using the new WHO (2006) child growth standards. A child is stunted if the height-for-age Z-score is below 2 standard deviations (SD) compared with the median of the WHO child growth standards. Stunting is a cumulative indicator of slow physical growth and reflects long term malnutrition (Glewwe et al., 2001). Similarly, a child is wasted if the weight-for-height Z-score is below -2 SD compared to the

[4]There is a large literature exploring the effect of poverty and low income on the development of children. Brooks-Gunn and Duncan (1997) reviewed evidence from numerous national longitudinal data sets for the US focusing on the consequences of poverty across a range of outcomes for children, and the pathways through which poverty might operate. Much of the evidence that they described points towards the negative effect of poverty on child development.

[5]The sampling frame is a complete list of 84,915 Enumeration Areas (EA), with each EA comprised of 181 households. Sampling was stratified and conducted at two levels. Each region was stratified into urban and rural, producing 21 strata. Sample EAs were selected independently from each stratum in two stages by using proportional allocation and implicit stratification (Tekile et al., 2019).

median of the WHO child growth standards. These indices were pre-existing variables in the DHS dataset. Finally, anemia was measured in terms of hemoglobin level in grams/deciliter. We categorized children as anemic if they fall within the moderate and severe anemia levels.[6]

The 2016 YLSS survey examines school effectiveness through multiple outcome measures, including students' learning progress in maths, English and Amharic test. The Survey involved the administration of two linked maths and English tests, administered at the beginning and the end of Grade 7 and Grade 8 school years.[7] The maths cognitive test comes from series of tests of reasoning, applying knowledge and conceptual understanding to solve problems, knowing facts, concepts and mathematical procedures. The English language tests were included in the school survey as a reflection of the status of English in Ethiopia as a 'transferable skill' (Graddol 2010). The test somewhat diverges from the school curriculum in Grade 7 and Grade 8, and covers content that students at upper primary grades should be familiar with after learning English as a second language from Grade 1 and will need for secondary school. It focuses on the following four skill domains: i) word identification;[8] ii) word meaning and contextual vocabulary;[9] sentence construction and comprehension;[10] and reading and comprehension.[11] Finally, Amharic test focuses on everyday expressions and phrases used in interaction with other Amharic speakers.[12] To facilitate interpretation of the

[6]Mild anemia: Number of children whose hemoglobin count is between 10.0 and 10.9 g per deciliter (g/dl). Severe anemia: Number of children whose hemoglobin count is less than 7.0 g per deciliter (g/dl).

[7]In the case of the mathematics and English tests, each item follows a multiple choice format with a single correct answer, so that each item score is dichotomous, being either correct or incorrect.

[8]This domain aims to identify simple vocabulary which students are likely to have been exposed to, with particular focus on language relating to their everyday environment and to education.

[9]This domain aims to identify the meaning of less-familiar words through their contextualised use in a sentence, or via a synonym/antonym.

[10]This tasks requires completing sentences correctly, using appropriate grammatical concepts and/or combining sentences

[11]Students are required to read a range of texts (stories, posters, factual passages) and comprehending direct facts and implicit inferences.

[12]Amharic is Ethiopia's official federal working language and while it is not the Ethiopian language with the largest number of mother tongue speakers it does serve as a language for business, commerce and government (Rossiter et al., 2017).

results, we transform the cognitive outcomes into z-scores.[13]

Water availability is assessed following several definitions. First, the quantity of water available to a given household is largely affected by travelling time taken to collect water (Cairncross and Cuff, 1987). We define access to water by household's reported time walking to the primary drinking water source (see Whittington et al. (1990); Kremer et al. (2011), Koolwal and Van de Walle (2013)). Walking time to collect water is a preferred definition, since it reflects potential difficulties in terrain (Koolwal and Van de Walle, 2013). There are life risks, especially to children and young girls, in the process of fetching the water including going to the water points in the evening after dark or leaving after dark. There is also the risk of drowning for the children that fetched from the open water sources like the lake, dams, and unprotected springs (Kamya et al., 2021).

Second, besides, water accessibility is measured by a dummy variable 'unimproved water', which indicates whether the household has access to improved drinking water sources based on the WHO and UNICEF definition. In our samples, many households obtained their drinking water from sources such as a river, streams, pond, unprotected springs or well, lake, canal, dam, or irrigation canal which can be easily contaminated. The 2016-17 YLSS survey provides information on sources of drinking water within the school facilities. Specifically, the variable 'unimproved water' takes on the value 1 if student answers that the main source of drinking water at school facilities is unprotected dug well, tanker truck, rainwater, river or stream and also no water available at school and 0 if the main source of drinking water comes from protected dug well, tube well, borehole and piped water. Similarly, in 2016 DHS survey, the 'unimproved water' variable captures households who respond that the main source of drinking water comes from surface and rain water, tanker truck or bottled water. In addition, we use a question from the YLSS survey that specifically asks:'Is there water

[13]To maintain statistical power, in the analysis performed by childs cognitive task, we do not restrict our sample to children with non-missing information on all tests across all five cognitive measures.

available from this water source today?'

In our specification we also include controls for mother and father's level of education, as the level of household awareness of the health benefits of water quality, safe sanitation and good hygiene practices highly depends on the level of education among household members (Usman et al., 2019). We also expect this to have a positive effect on child's health and cognitive outcomes. As the level of education for both primary caretakers were very low, the highest grade completed among the household members was used as a proxy for education. In developing country, such as Ethiopia, income is also important in determining the type of drinking water source used by households (Larson et al. (2006); Briand et al. (2010)). To control for wealth and other unobserved health practices, household asset was used as a proxy for wealth.[14]

To analyse the potential mechanisms behind the health and cognitive effects of water scarcity, we utilise various additional measures from domestic violence module. This module was designed to be administered to women. The specific questions asked each married woman if her husband/partner, ever did any of the following to her: a) 'Say or do something to humiliate you in front of others?' b) 'Threaten to hurt or harm you or someone close to you?' c) 'Insult you or make you feel bad about yourself?' d) 'Push you, shake you, or throw something at you?' e) 'Slap you?' f) 'Twist your arm or pull your hair?' g) 'Punch you with his/her fist or with something that could hurt you?' h) 'Kick you or drag you or beat you up?' i) 'Try to choke you or burn you on purpose?' j) 'Threaten or attack you with a knife, gun, or other weapon?' The variable 'violence' takes on the value 1 if mother answers 'often', 'sometimes', or positively, but not in the last 12 months, otherwise ('never') the value is 0. We also utilise a variable 'afraid' that captures mothers being afraid of husbands most of the

[14]In the DHS data wealth quintiles variable is calculated via principal components analysis, where to assign wealth indicator weights, household assets such as floor type, wall, roof type, water source, sanitation facilities, radio, electricity, television, refrigerator, cooking fuel, furniture, and number of persons per room were used. The index classify the overall scores to wealth quintiles: poorest, poorer, middle, richer, and richest.

time.

Descriptive statistics for the analysis samples by water availability are presented in Tables 1 and 2. In Fig. 1 we also show the average tests scores for boys and girls by water availability at school level. There are pronounced differences between the two groups. The sample identified as having access to 'unimproved water' has a higher incidence of being stunted, wasted and underweight. We observe that boys and girls who have access to improved water at school are performing better in all test scores. For example, average score in second test maths is 19.61 for children with an access to improved water compared to 18.01 for those attending school with unimproved water facilities.

[Insert table 1 & table 2 here]

In Figure 2, we further present graphical evidence on the relationship between time taken to collect water and cognitive score for boys and girls. The specific question asks: 'How long does it take you to collect water at home?' and aims to capture students' time on productive household tasks, other than education. Around 56% of students respond that it takes on average less than 5 minutes to collect water, whereas 26% and 17% report between 5-30 and over 30 minutes collection time, respectively. The figures show a decreasing cognitive skills pattern for both boys and girls. There is a sharp decline in cognitive skill levels for girls who take on average between 5 and 30 minutes to collect water. It is interesting to note that the decline in cognitive functioning is sharper for girls.

[Insert Figure 2 here]

4. Methodology

To investigate whether living in a households or attending schools with unimproved water sources affects health and cognitive outcomes of children, we consider the following model:

$$Y_{if} = \tau TIME_{if} + X_i'\beta + \varepsilon_{if} \tag{1}$$

where Y_{if} represents one of the several health outcomes for child i in a family f; X_{if} is a vector of child and family characteristics (child age in months, gender, parental education, number of siblings in the family, region of residence dummies); and ε_{if} is an idiosyncratic error term. In this specification the coefficient on $TIME_i$ indicator, τ measures the time spend by child's caregiver to get to the nearest water source (one-way walk time), and τ is the parameter of interest.

To estimate the impact of water availability on cognitive development we use the Young Lives School Survey, and modify the above specification by including school fixed effects:

$$Y_{ih} = \gamma W_{ih} + X_{ih}'\gamma + \epsilon_h + w_{ih} \tag{2}$$

where Y_{ih} represents maths, English and Amharic cognitive test score for child i attending school h; W_{ih} is an indicator of child's attending school h with unimproved/improved water source; X_{ih} is a vector of child and school characteristics (child age, gender, parental education, school total revenue (budged), teachers' higher education, regional dummies); and ϵ_h is a school fixed effect while w_{ih} captures unobservables that vary across i and h. The inclusion of the school fixed effects allows to account for unobserved time-invariant school characteristics, which may affect water availability and pupils' outcomes at the same time.

OLS estimation of equations (1) and (2) produces unbiased estimates of the child development so long as ε_{if} (w_{ih}) is i.i.d. There may, however, be unobserved dierences in the rate at which children acquire cognitive skills or develop health issues given water access variable.

The ‘time used by main family member to get to the water source’, and ‘unimproved’ water source available in the premise (type of primary sources from which school supplies their drinking water) may be endogenous due to unobservable heterogeneity among households (i.e., preferences for better water quality).[15] For example, areas with abundant water resources may have a higher prevalence of shallow wells or surface water (Pickering and Davis, 2012). Such sources generally cause a high microbial water contamination that increases the risk of diarrhoeal illness and health complaints compared to piped water or deep groundwater (Wright et al., 2004). In addition, one can expect that a higher household wealth is associated with greater chance of using piped water (Zoungrana, 2021). Such unobservables could affect the health and cognitive outcomes of children estimated via equations (1) and (2). This is clearly the case in cross-section data. To address the issue, we employ Instrumental Variable estimator (IV) and consider the following two-stage specification. Firstly:

$$W_{if} = \boldsymbol{X}'_{if}\beta + Z_{ij} + e_{ij} \tag{3}$$

where treatment W_{if} of each child i in family f (i.e., attending school h) is predicted using vector of child and family characteristics $\boldsymbol{X}'_{if}$(i.e. school characteristics $\boldsymbol{X}'_{ih}$); Z_{ij} is a vector of instrumental variables, and a nonsystematic e_{ij} error term.

In the second stage, we estimate the following health and cognitive outcome:

$$Y_{if} = \hat{W}_{if}\theta + \boldsymbol{X}'_{if}\beta + u_{if} \tag{4}$$

where $\hat{W}_{if}$ is predicted treatment status from equation (3). Our instrumental variable strategy uses the variation within communities/regions in rainfall and drought based on the Climate Hazards Group InfraRed Precipitation with Station rainfall data (see ?; Hirvonen et al.

[15]In the study areas, most households take water from community water sources, and most rural households do not have alternative drinking water sources.

(2020)). In Table 5 we show the aggregated fluctuations in the rainfall, wet days, mean temperature and annual precipitation over time. We use monthly rainfall records for each community between 2000 and 2015 to construct rainfall z-scores for each community in our sample. These z-scores were calculated by subtracting total rainfall during the rainy season in 2015 in the community from the mean of the total rainfall during the rainy season in 2000-2015 in the community and dividing this difference by the standard deviation of the total rainfall during the rainy season in 2000-2015 in the community (see Hirvonen et al. (2020)). In figure X we map the z-rainfall score values together with the DHS survey locations. We use this construct to instrument our main treatment variables of interests – 'unimproved water source', and 'time to nearest water source'. This instrument should be correlated with the availability of drinking water in the premise but not with child development outcomes directly.

5. Results

5.1. Health outcomes

Table 3 reports the OLS and IV results for the DHS sample. Columns 1 to 3 report the linear probability model (OLS), and columns 4 to 6 show the instrumental variable (IV) models which do take into account the endogeneity. All estimates were adjusted for child's age in months and gender, parents with no education, household size, region of residence, and ethnicity (75 ethnic dummies). The longer the time to the nearest water source is, the higher the chances for a child to be stunted, wasted and anemic are. All other things being equal, an additional 30 minutes walk to water source spend by child's caregiver, on average results in a 0.015 percentage points increase in the probability of a child being stunted and anemic. The estimate of wasting is also statistically significant. Overall, these estimates are are in line with the existing literature in sub-Saharan Africa (Pickering and Davis, 2012).

[15] Regarding other covariates, the estimated coefficients have the expected signs. Children with parents who have no qualification are more likely to be stunted, wasted or anemic.

The IV results (columns 4-6), greater in magnitudes, support these findings, thought the impact on stunting is no longer significant. A 30-min increase in one-way walk time to water source is associated with 0.030 and 0.053 percentage point increase in wasting and anemia prevalence.

5.2. Cognitive outcomes

Table 4 presents the impact of unimproved water access on children's cognitive performance. Columns 1 to 3 report the linear probability model (OLS), and columns 4 to 6 show the instrumental variable (IV) models. The estimates reported in Table 4, clearly point to a strong negative correlation between access to unimproved water and subsequent cognitive performance. We find that those who attend school with an access to unimproved water underperformed in all tests scores. For example, children attending school without improved water facilities score on average by 0.85-0.80 standard deviations in maths and English tests, respectively. In comparison, the negative effect of unimproved water access is lower in magnitude on Amharic performance. The estimated deficit in Amharic test relative to that of an otherwise similar child attending school with protected water source is 0.15 standard deviations. To get a sense of how important these estimates are, we compare them to the effect of parent education. For example, having a father with no education is associated with a 0.06 standard deviation disadvantage in child maths performance, relative to having a father with a qualification. The gap in cognitive skills associated with accessing unimproved versus improved water is nearly ten times larger. In addition, parent inputs as measured by children's mother alive in the family result in a significant positive impact on all tests scores. It is predominantly girls that are found to be at a greater cognitive disadvantage from attending in a water scare school. Specifically, the maths and English test performance is 0.19 and 0.06 standard deviations lower, respectively, when compared to boys.

The IV results, significantly greater in magnitudes, support these findings.

6. Potential Mechanisms

We further explore the possible mechanisms through which water availability, and in particular mother's time to collect water, may affect children's health outcomes. Children who live in water scare areas/or have access to unimproved water sources may be more likely to live in a poverty or experience domestic violence in the family. It is well established that adverse circumstances such as poverty and domestic violence may create a stressful home environment, which contributes to child development. For this part of the analysis, we use dependent variables that indicate mother's health outcomes and domestic violence exposure. We analyse the sample of women who participated in the domestic violence module of the survey.

In Tale 6 we report our estimates of maternal health and domestic exposure. Holding other observable factors constant, an additional 30 minutes walk to water source spend by child's mother associates with a higher probability of mothers being exposed to a violent husband. We also observe these women to be underweight and anemic. Specifically, the IV estimates show that women who spend an extra walk to fetch water are 6.6 probability points more likely to be exposed in a violent relationship. Although these variables might be taken as proxies for the quality measures of social interaction and health-related behaviours, we are aware that they measure it far from perfectly. In addition, we should be cautious in our interpretation of these results as there might be a reverse causality between water collection time and health-related behaviours. Nevertheless, our findings indicate that the adverse health outcomes in children may occur alongside with a domestic family exposure. Overall, the evidence suggest that children of families with lack of water are more likely to be exposed to unhealthy home environment.

6.1. Heterogeneity in the estimated effects

In this section we further explore heterogeneity in the estimated effects by focusing on sub-groups of the population. We can expect some heterogeneity in health and cognitive outcomes due to differences in wealth, as it is mainly poor people that are suffering the most from the burden of diseases associated with a lack of clean water supply and sanitation services (Usman et al., 2019). In addition, we test the sensitivity in our domestic violence estimates considering the impact of household wealth. For this purpose, we divide our sample into quartiles based on household's wealth and perform the OLS and IV estimates for the low ('poorest' and 'poorer') and high ('richer' and 'richest') wealth quartile.

The results, reported in Panels A and B, Table 8 for high and low wealth quartiles, respectively, show that women who fall within the highest wealth quartile are less likely to be exposed to a violent relation and no significant correlation we observe in the underweight and anemia outcomes. In contrast, those who are within the lowest wealth quartile are found at a greater disadvantage.

7. Conclusions

In low- and middle-income countries, including Ethiopia, socio-economic conditions are one of the major causes of growth failure in children. Lack of access to clean water and proper sanitation affects various facets of a person's life, including the prevalence of disease and healthy development. This paper presents evidence on the effect of water scarcity on child development. To address the potential endogeneity of water access, we use an instrumental variable approach exploiting the variation in drought and rainfall conditions caused by 2015 El Niño weather system. We emphasize several aspects of our findings. First, under-five children living in households without access to improved water sources are more likely to be stunted, wasted and anemic. Second, we show that there are corresponding patterns of disparities in cognitive performance. All else equal, lack of improved water at school vicinity reduces children's maths and English test performance by 0.80 standard deviations. There are several possible channels for this result. Studies have shown that the gap in early school performance is explained by family differences in socio-economic disadvantage as well as parent and school investment. Our paper contributes to this strand of literature by showing that environmental factors, such as access to improved water has a significant influence on child nutrition and development. In addition, examining the characteristics of the women who experience violence and the contexts in which they live helps to identify some of the common risk factors, if any, for child development.

A number of policy recommendations can be derived from these findings. First, more efforts should be put into increasing the existing coverage of improved water supply. To advance the SDG 4 and 6 goals, the study suggests a need to accelerate the provision of improved water supply and sanitation services in schools as well as in communities where access is inadequate. Moreover, since adult women and school-age children are disproportionately responsible for household water collection, the provision of adequate and safe water sources foremost benefits women and young children. Because it reduces the burden of travelling long distances to fetch water, which in turn increases their time to go to school and to study. Second, the demand for water improvement change may not always originate from the community. The communities may not express their urgent need to have water improvement systems, and in such situations, the demand for change can be provided by scientific organizations and political leadership can drive the change (Prosser et al. (2015); Fogarty et al. (2021)). Improving water security and economic development while reducing poverty in Ethiopia requires a diverse set of actors. Government, private sector, development banks and civil society all have important roles to play in developing effective water security polices and investments (Heijden and Adane, 2017).

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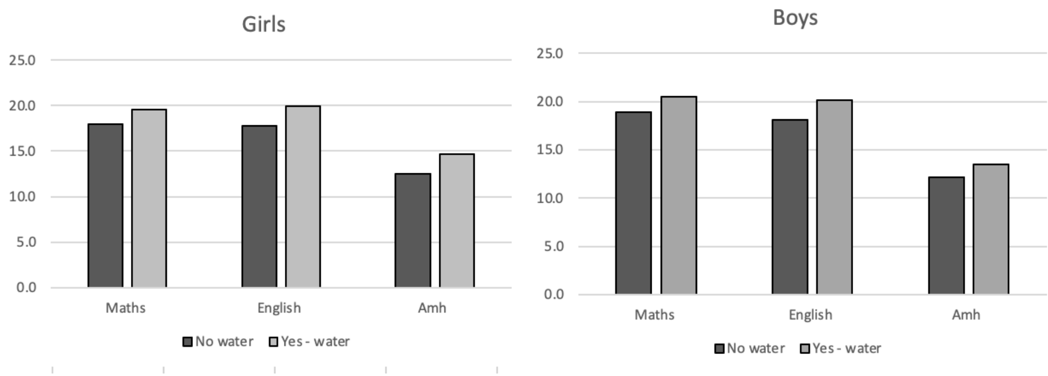
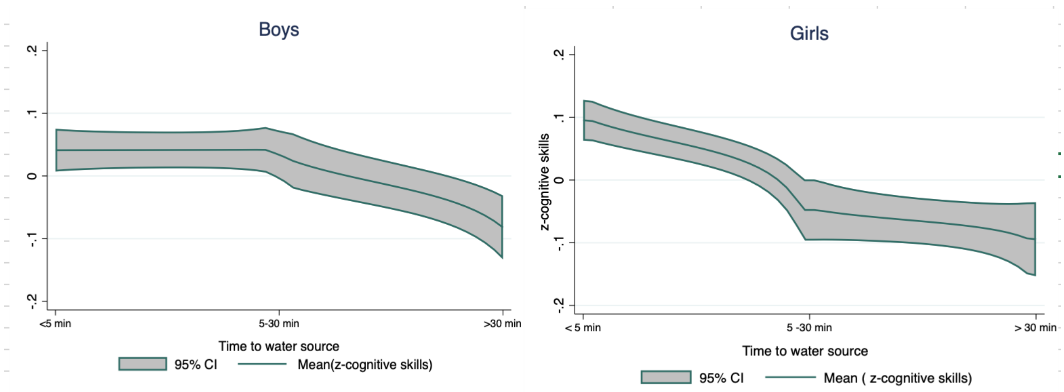
Figure 1: Cognitive skills and water availability at school



Source: Author's projection from the YLSS data.

Figure 2: Time to collect water and cognitive skills



Source: Author's calculations from the YLSS data. We use bivariate kernel regression with a bandwidth of 2 to estimate mean levels of cognitive scores as a function of time to collect water. The gures also include 95% condence intervals.

Table 1: Descriptive Statistics – 2016 DHS data

	Unimproved water		Improved water	
Variables	Mean	Std. Dev.	Mean	Std. Dev.
Child age	28.62	17.38	28.69	17.50
Female	0.49	0.50	0.49	0.50
Stunting	0.38	0.49	0.35	0.48
Severe stunting	0.18	0.39	0.15	0.36
Underweight	0.28	0.45	0.24	0.42
Severe underweight	0.10	0.29	0.07	0.26
Wasting	0.14	0.35	0.11	0.31
Anemia	0.36	0.48	0.30	0.46
Time to water source	2.68	0.90	2.09	0.91
Mother education				
No education	0.84	0.37	0.65	0.48
Primary	0.14	0.35	0.25	0.43
Secondary	0.01	0.12	0.07	0.25
Higher	0.01	0.07	0.04	0.19
Mother working	0.25	0.43	0.39	0.49

Table 2: Descriptive Statistics – 2016-17 YLSS data

	School facility has			
	Unimproved water		Improved water	
	Mean	Std. Dev.	Mean	Std. Dev.
Age	14.71	1.70	14.23	1.47
Female	0.43	0.50	0.53	0.50
Maths1 test score	15.21	5.67	16.89	6.38
Maths2 test score	18.07	6.94	19.61	7.28
English1 test score	18.32	6.73	19.35	6.98
English2 test score	19.97	6.94	20.26	7.17
Amh test score	12.10	5.12	13.84	4.39
Mother education				
Never been to school	0.38	0.49	0.24	0.43
Up to Grade 4	0.14	0.34	0.14	0.35
Up to Grade 8	0.12	0.32	0.20	0.40
Up to Grade 10	0.09	0.28	0.13	0.33
TVET or Diploma	0.03	0.17	0.04	0.19
Up to Grade 12	0.04	0.19	0.07	0.26
University	0.07	0.25	0.06	0.24
I don't know	0.14	0.35	0.13	0.33
Father education				
Never been to school	0.21	0.40	0.14	0.35
Up to Grade 4	0.12	0.32	0.11	0.31
Up to Grade 8	0.13	0.33	0.16	0.36
Up to Grade 10	0.10	0.30	0.14	0.35
TVET or Diploma	0.06	0.23	0.05	0.21
Up to Grade 12	0.07	0.25	0.10	0.30
University	0.16	0.37	0.11	0.32
I don't know	0.17	0.37	0.19	0.40
Time to water source	1.86	0.82	1.50	0.71
School inspection rating				
Level 1	0.09	0.29	0.04	0.19
Level 2	0.33	0.47	0.35	0.48
Level 3	0.22	0.41	0.38	0.49
Level 4	0.03	0.17	0.14	0.35
Never been inspected	0.34	0.47	0.09	0.29

Table 3: The impact of water access on child stunting, wasting and prevalence of anemia, OLS and IV – DHS data

	(1) Stunting	(2) Wasting	(3) Anemia	(4) Stunting	(5) Wasting	(6) Anemia
	OLS estimates			IV estimates		
Time to collect water	0.015***	0.011**	0.015*	0.031	0.030*	0.053**
	(0.005)	(0.004)	(0.008)	(0.020)	(0.018)	(0.026)
Female	-0.021***	-0.023***	0.017*	-0.020***	-0.023***	0.018*
	(0.008)	(0.007)	(0.010)	(0.008)	(0.007)	(0.010)
Child age	0.011***	-0.004***	-0.001	0.011***	-0.005***	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Child age^2	-0.000***	0.000***	0.000	-0.000***	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother - no education	0.041***	0.020**	0.035**	0.043***	0.017	0.020
	(0.010)	(0.009)	(0.016)	(0.012)	(0.011)	(0.015)
Father- no education	0.040***	-0.002	0.027*	0.041***	-0.002	0.018
	(0.010)	(0.009)	(0.015)	(0.010)	(0.009)	(0.013)
R^2	0.074	0.042	0.121	0.070	0.038	0.110
N	8731	8794	9059	8731	8794	9059

Notes: Based on Ordinary Least Squares (OLS) and Instrumental variable (IV) regression methods. Unit of observation is a child 6-59-months. Standard errors clustered at family level, are in parentheses. The specications control in addition for mothers age, household size, ethnicity (75 ethnic dummies), and regional controls. *, **, *** Represents statistically significant at the 10%, 5% and at the 1% level.

Table 4: The impact of school having unimproved water on child cognitive development – 2016 YLSS data

	Maths OLS	English	Amh	Maths IV	English	Amh
Unimproved water	-0.799***	-0.754***	-0.154***	-1.690***	-2.019***	-1.602***
	(0.019)	(0.019)	(0.018)	(0.174)	(0.204)	(0.141)
Child age	0.247***	0.162***	0.098*	0.247***	0.162***	0.114**
	(0.065)	(0.051)	(0.055)	(0.049)	(0.041)	(0.056)
Child age^2	-0.007***	-0.005***	-0.003*	-0.007***	-0.005***	-0.003*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
Girl	-0.194***	-0.061***	0.043	-0.194***	-0.061***	0.045**
	(0.024)	(0.020)	(0.037)	(0.017)	(0.015)	(0.021)
Number of siblings	-0.014***	-0.018***	-0.021***	-0.014***	-0.018***	-0.029***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)
Mother alive	0.092***	0.068*	0.101***	0.092***	0.068**	0.099**
	(0.031)	(0.038)	(0.032)	(0.033)	(0.029)	(0.045)
Father alive	0.035	0.017	0.004	0.035	0.017	0.011
	(0.031)	(0.023)	(0.031)	(0.024)	(0.021)	(0.031)
Mother - no education	0.024	0.001	-0.003	0.024	0.001	-0.021
	(0.031)	(0.021)	(0.035)	(0.022)	(0.019)	(0.030)
Father- no education	-0.061***	-0.087***	-0.068*	-0.061**	-0.087***	-0.074**
	(0.021)	(0.026)	(0.037)	(0.025)	(0.022)	(0.037)
N	11784	11384	3986	11784	11384	3986
R^2	0.239	0.410	0.590	0.239	0.410	0.566

Notes: Based on OLS method. Standard errors clustered at school level, are in parentheses. The specifications control in addition for teacher highest education, school budged and school fixed effects. *, **, *** Represents statistically significant at the 10%, 5% and at the 1% level.

Table 5: Fluctuations in weather conditions in Ethiopia (2000-2015)

Year	Rainfall	Wet days	Temperature	Precipitation
2000	935.2	6.7	22.1	86.2
2005	937.8	6.3	22.4	78.6
2010	1059.5	6.6	22.8	81.3
2015	760.4	5.9	23.0	70.5

Notes: Average rainfall, number of wet days, meant temperature and annual precipitation.

Table 6: Potential association by which water time collection may affect child's health - Mother's outcomes – DHS data

	Violence	Afraid	Underweight	Anemia	Violence	Afraid	Underweight	Anemia
	OLS estimates				IV estimates			
Time to collect water	0.002	0.013***	0.032***	0.019***	0.066**	0.065**	0.111***	0.076**
	(0.006)	(0.005)	(0.003)	(0.006)	(0.032)	(0.027)	(0.013)	(0.033)
Mother age	0.001*	0.000	0.001***	-0.004***	0.002**	0.001	0.002***	-0.003***
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Mother no education	0.004	0.049***	0.031***	0.043***	-0.016	0.033**	0.006	0.027*
	(0.012)	(0.010)	(0.005)	(0.013)	(0.015)	(0.013)	(0.007)	(0.016)
Mother in work	0.024**	0.069***	-0.013***	-0.023*	0.031***	0.074***	-0.003	-0.018
	(0.011)	(0.010)	(0.005)	(0.012)	(0.011)	(0.010)	(0.005)	(0.012)
N	8781	8781	35956	7696	8781	8781	35956	7696
R^2	0.066	0.061	0.066	0.108	0.052	0.049	0.040	0.099

Notes:Based on Ordinary Least Squares (OLS) and Instrumental variable (IV) regression methods. Unit of observation is a mother. Standard errors clustered at family level, are in parentheses. The specications control in addition for household size, whether mother is working, education, ethnicity (75 ethnic dummies), and regional controls. *, **, *** Represents statistically significant at the 10%, 5% and at the 1% level.

Table 7: The impact of water access on child stunting, wasting and prevalence of anemia, OLS and IV – by wealth Quartiles

	(1)	(2)	(5)	(1)	(2)	(5)
	Stunting	Wasting	Anemia	Stunting	Wasting	Anemia
	OLS estimates			IV estimates		
Panel A: High Income						
Time to collect water	0.002	0.002	-0.003	-0.001	0.010	-0.005
	(0.009)	(0.007)	(0.011)	(0.008)	(0.006)	(0.009)
N	4677	4748	4922	4677	4748	4922
R^2	0.098	0.029	0.114	0.077	0.014	0.017
Panel B: Low Income Quartile						
Time to collect water	0.020*	0.016*	0.020	0.035***	0.012*	0.028***
	(0.011)	(0.008)	(0.013)	(0.009)	(0.006)	(0.008)
N	2792	2778	2851	2792	2778	2851
R^2	0.083	0.035	0.065	0.061	0.018	0.022

Table 8: Potential association by which water time collection may affect child's health - Mother's outcomes – by wealth Quartiles

	Violence	Afraid	Underweight	Anemia	Violence	Afraid	Underweight	Anemia
	OLS estimates				IV estimates			
Panel A: High Wealth								
Time to collect water	-0.027***	-0.021***	-0.003	-0.010	0.074	-0.177**	0.045*	0.020
	(0.008)	(0.007)	(0.004)	(0.009)	(0.059)	(0.072)	(0.026)	(0.080)
N	2880	2880	12786	2354	2880	2880	12786	2354
R^2	0.093	0.161	0.063	0.063	0.033	0.102	0.063	0.063
Panel B: Low Wealth								
Time to collect water	0.066***	0.065***	0.038***	0.023*	0.267***	0.265***	0.175***	0.127*
	(0.010)	(0.009)	(0.004)	(0.012)	(0.083)	(0.060)	(0.033)	(0.073)
N	4416	4416	17903	4196	4416	4416	17903	4196
R^2	0.134	0.086	0.066	0.128	0.102	0.156	0.033	0.079