

Adult Health Interventions at Scale and Children's Schooling: Evidence from Antiretroviral Therapy in Zambia

Adrienne M. Lucas, Margaret Chidothe, and Nicholas L. Wilson*

Draft: August 2015
Please do not cite without permission

Abstract

Approximately one in five children in Zambia in 2007 lived with an HIV positive adult. We identify the effect of adult antiretroviral therapy (ART) availability on children's educational outcomes by combining data on the expansion of ART availability in Zambia with two nationally representative household surveys that include HIV testing. Through a triple difference specification, we find that the availability of ART increased the likelihood that children in households with HIV positive household heads started school on time and were the appropriate grade-for-age. The mechanisms were likely decreased opportunistic infections in the household and related care giving duties. The results were similar if we instead used the HIV status of the father or mother of the child.

Keywords: HIV/AIDS, education, ARTs, Zambia

JEL Codes: I15, I18, J13, O15, O18

*Lucas: Department of Economics, Lerner College of Business and Economics, University of Delaware, and NBER. alucas@udel.edu. Wilson: Department of Economics, Reed College. Chidothe: Department of Economics, Wellesley College. For useful comments and suggestions, we thank Jim Berry, Kristin Butcher, Marcus Goldstein, Pinar Keskin, Isaac Mbiti, Patrick McEwan, Manisha Shah, Kartini Shastry, Matt White, and seminar participants at Swarthmore College, Temple University, the University of Delaware, the University of South Florida, the International Health Economics Association World Congress, and the Northeast Universities Development Consortium Conference.

1 Introduction

In the southern cone of Africa more than 10 percent of prime aged adults are HIV positive and 20 percent of children live with an HIV positive adult, creating a public health crisis with multigenerational effects (UNAIDS 2015). HIV has no cure. Instead, the international response has been to treat those already infected and try to prevent additional infections. The primary treatment response has been the subsidized distribution of adult antiretroviral therapy (ART) to infected adults. Epidemiological studies have shown that the adherence to the prescribed ART regime increases adult health (Wools-Kaloustian et al. 2006; Hammer 1997), and this improved adult health could have important benefits for children. For example, Pitt and Rosensweig (1990), Yamano and Jayne (2005), and Evans and Miguel (2007) found that the ill health of others in the household impeded children’s educational access and attainment through care giving duties, labor substitution, and money available for nutrition and school expenses. In this paper we focus on the impacts of the at-scale provision of ART on the schooling of children living in households with infected adults. Even though the national and international response to HIV/AIDS has been to provide free or subsidized ART, the rigorous empirical estimation of the effect of adult ART (and corresponding improvement in adult health) on children’s schooling has been hampered by both a lack of data and compelling sources of exogenous variation in exposure to treatments. This study will provide the first estimates of the effect of a large scale subsidized adult ART program on children’s schooling.

We identify the effect of the availability of adult ART on children’s schooling through the timing of free ART availability that varied by location and variation in adult HIV status, a triple difference specification. Zambia, the focus of our study, has one of the highest HIV/AIDS prevalence rates in the world and one of the most successful ART distribution campaigns in sub-Saharan Africa. Prior to the availability of ART in Zambia, one in seven adults aged 15-49 was HIV positive and one in five children of primary school age was living

with a mother, father, or household head who was HIV positive (DHS 2002). In 2003 ART was effectively unavailable and by 2007 40 percent of households were within 10km of a treatment facility that distributed free ART. We combine unique clinic level data on the dates of initial ART availability and geographic coordinates of the facilities that provided ART with two nationally representative household surveys that include HIV testing modules. Our triple difference is then the interaction of a clinic ever providing free ART (spatial variation), whether the clinic distributed free ART prior to the date of the household survey (temporal variation), and the HIV status of adults in the household (variation in HIV status). This triple difference identifies the effect of adult ART availability on children's educational outcomes in households with HIV positive adults, net of any location, time, or location by time variation that is common to both HIV positive and HIV negative households (e.g. general development changes).

We find that expanded ART availability increased the likelihood that primary school aged children who lived with an HIV positive household head enrolled in school on time and were the correct grade for age, a proxy for timely school progression. We do not find any evidence that ART availability differentially increased the likelihood of children being enrolled in school beyond the first year. The results are similar if the reference adult is the mother or father. While our labor market participation measures are coarse, we find that this increase is not likely due to changes in the extensive margin of the adult labor supply. In contrast, we find substantial decreases in illness among children under 5, indicating that one potential mechanism is a decrease in opportunistic infections in the household or related care giving duties.

One strand of the literature on HIV/AIDS has focused on the detrimental relationship between adult HIV and adults' and children's outcomes. Using propensity score matching in South Africa, Levinsohn et al. (2013) found that HIV positive adults were less likely to be employed. Both Akbulut-Yuksel and Turan (2013) and Fortson (2011) found that children

in households with an HIV positive mother or in regions with a high with HIV prevalence had less schooling than expected.

Another strand focuses on the effects of the free or subsidized provision of ART and has taken three approaches. The first type used smaller scale clinic- or employer-based studies and focus on HIV positive adult recipients of ART with variation coming from the timing of the initiation of treatment. Graff Zivin et al. (2008) and Thirumurthy et al. (2008) used longitudinal data on individuals in Western Kenya and found that the initiation of ART increased recipients' labor supply and that children in household's with HIV positive adults increased their weekly school attendance by over 20 percent. Habyarimana et al. (2010) used a similar strategy with longitudinal data from a diamond company in Botswana and found that the initiation of ART decreased worker absenteeism. The second approach relied on temporal and spatial variation in ART availability, effectively difference-in-differences, but considered the effect on the whole population regardless of HIV status (e.g. Bendavid et al. 2012, Friedman 2014, Baranov and Kohler 2014). The third approach uses a strategy similar to the current paper with the HIV status of individuals or other adults in the household as an additional source of variation. Baranov et al. 2015 used HIV status to limit their analysis to HIV negative households and found that ART availability increased the intensive labor supply in three rural districts in Malawi. Lucas and Wilson (2013) and Lucas and Wilson (2015) used a similar identification strategy to the current paper and found that the availability of adult ART increased the weight of children under 5 years old in households with likely HIV positive adults and the weight of likely HIV positive women.

Our paper adds to the existing literature on a number of margins. First, we have longer run outcomes (e.g. grade progression and enrollment decisions) that were not available in previous studies. Second, because we are using a national household survey we are able to estimate the effect over all HIV positive households, even those who did not seek, were not yet eligible given their disease progression, or did not adhere to treatment. Third, our estimates

are the net effect on HIV positive households, eliminating any changes in outcomes that are common across all households. Fourth, the ART distribution and expansion model in Zambia is common to a number of other countries supported by the United States President's Emergency Plan for AIDS Relief (PEPFAR), and our estimates present a likely scenario for similar PEPFAR supported countries.

2 Background

2.1 HIV/AIDS in Zambia

The HIV/AIDS epidemic is one of the most pressing public-health challenges faced by developing nations, especially those in the southern cone of Africa where more than 10 percent of the population aged 15 to 59 are afflicted with the disease (UNAIDS 2015). HIV is a virus, primarily transmitted through heterosexual intercourse in sub-Saharan Africa (Dunkle et al. 2008). The initial symptoms of HIV are similar to a mild flu. This disease then remains with infected individuals, causing a slow decline in health as the immune system weakens and the disease progresses to AIDS. The rate of clinical progression from initial HIV infection to AIDS has been observed to vary between individuals, from 2 weeks up to 20 years (Navarro 2000). In the absence of treatment, the median time of progression from HIV to AIDS is 9 to 10 years (UNAIDS 2000). Estimates of the median survival time upon the manifestation of AIDS is about one year (Lee et al. 2001; Morgan et. al. 2002).

HIV/AIDS does not have a cure. During the period under study, The WHO standard followed in Zambia was to provide ART at the start of a patient's descent into AIDS, at approximately a CD4 T-cell count of 200 to 350 cells per micro liter of blood (Stringer et al. 2006, WHO 2006). Since this was a previously untreated population, the average CD4 count of those treated was likely much lower. ART is a drug cocktail therapy that impedes the course of HIV/AIDS and has been shown to improve the health status of HIV positive

patients (Hammer 1997; Wools-Kaloustian et al. 2006). In a previously untreated population in South Africa, Médecins Sans Frontières (2003) found that after 12 months of treatment, the mean weight gain was 10.0 kg and patients reported a decrease in pain and discomfort and an increase in the ability to care for oneself and engage in typical activities. Further, the incidence rate of tuberculosis among the treated declined by two thirds. In 2005, the average price for the most common ART drug combinations was US\$268 per treated person per year (WHO 2006). In Zambia, this expense was paid by donors and not the individual recipients.

In Zambia the first reported AIDS case was in 1984 (WHO 2005). Small scale state provision of subsidized ART began in Zambia in 2002 at the University Teaching Hospital in Lusaka and at the Ndola Central Hospital in Ndola. Even with partial subsidization, the annual cost of treatment totaled at least US\$2000, one and a half times an urban nurse's salary, almost four times a cleaner's salary, and more than four times the per capita GDP of Zambia (International HIV/AIDS Alliance 2004). In addition a limited number of private companies, in particular the mining industry, provided ART to their employees at a subsidized rate.¹

The official commitment to the provision of universal free ART to adults occurred in June 2004 (WHO 2006). Since this announcement, both the Global Fund to Fight AIDS, Tuberculosis and Malaria and the United States President's Emergency Plan For AIDS Relief (PEPFAR) have donated hundreds of millions of dollars annually to increase ART availability.

The scale-up of ART provision in Zambia was dramatic. In 2003, less than 10 percent of those needing ART were receiving treatment and only 3 sites were open in the entire country. In 2005, 25 percent of those requiring treatment were receiving it from 110 different clinics (WHO 2006). Even though some private companies continued to provide treatment to their

¹Our clinic data do not include clinics that only served specific corporations. Therefore, individuals who received ART through their employers prior to the wider availability of ART will be misclassified as not receiving ART.

employees, over 95 percent of those treated were receiving treatment in the public sector (WHO 2006).

The scale-up of treatment facilities started with the most advanced hospitals (Zambia Ministry of Health 2008).² Each province had at least one such facility, but many households were not within a reasonable treatment distance. The program was then extended to smaller primary care facilities like district hospitals and health centers. By the end of 2007, 64 percent of the 440,000 people in Zambia needing ART had access to it, and a third of all health facilities in the country were able to offer treatment (Zambia Ministry of Health 2008). During our period of study, almost all individuals who were treated received the “first-line” ART treatments that are cheaper and easier to administer than later stage treatments (WHO 2006).³ Even though the ART was free to recipients, some clinics continued to charge user fees. By early 2006 all of these point of service user fees for HIV treatment had been eliminated (WHO 2006).

Since ART has been shown to be more effective if provided to someone who was well nourished, ART clinics in Zambia provided nutritional advice and counseling to those receiving ART. Since these two actions coincided, we cannot separately identify their effects. As this coupling is often standard practice in ART provision, one would expect a similar program in other settings.⁴

²In our triple difference specification we include interaction terms that control for time varying differences between locations that did and did not receive ART in addition to controls for any time invariant differences between districts. See Section 3 for additional details.

³Most of the ART treatment during the period of our study was for adults. In 2005, about 8% of the recipients of ART in the public sector were children (WHO 2006). We will not be able to rule out this direct treatment of children as the cause of our results, but given the magnitude of the adults versus the children treated, the direct treatment is likely not the dominant channel. Further, during the period of ART scale-up, ART regimens were also used for the prevention of mother-to-child transmission (PMTCT). Even the earliest beneficiaries of PMTCT would not be old enough to appear in the schooling data that we use for the analysis. A 2009 study of Cameroon, Cote d’Ivoire, South Africa, and Zambia found that fewer than 50% of infants born to HIV positive mothers at health centers that provided PMTCT completed the full course of treatment (UNICEF 2009), and a WHO report based on data from 2008 deemed that Zambia had made “no progress” towards the millenium development goal of reducing the under 5 mortality rate (WHO 2010). Even if additional younger siblings survived, the effect of this survival on older siblings is uncertain, but the survival is unlikely to generate an increased likelihood of school attendance.

⁴A more comprehensive food assistance program that included supplemental nutrition assistance was started in February 2009, after our window of study (Tirivayi and Groot 2014).

2.2 Education in Zambia

Primary school in Zambia starts at age 7, lasts 7 years, and is not compulsory (UNESCO 2010). Secondary education spans grades 8-12, and students are typically aged 15-19 years old (Zambian Ministry of Education 2011).

In 2002 Zambia introduced the Free Basic Education (FBE) program that eliminated the school fees for grades 1-7 (Zambian Ministry of Education 2011).⁵ School uniforms were no longer compulsory, but many schools continued to require them. Further, some schools continued to administer supplementary fees for school development projects, and parents were still responsible for books, other supplies, transportation, and food. Therefore, despite the elimination of formal fees, both other schooling related expenses and the need to work to earn money continued to be a barrier to schooling for some children (Robson and Sylvester 2007). According to official statistics, approximately 7 percent of students in primary school in 2005 repeated a grade (UNESCO 2010). Children continue on to a subsequent grade based on the assessment of their current teachers in consultation with their parents.

3 Empirical Strategy

We exploit the scale-up in the availability of free ART in a triple difference specification to identify the effect of adult ART availability on children’s schooling outcomes. The primary conceptual difficulties in identifying the effects of adult ART are the non-random placement of treatment centers and adherence to treatment. Within a country, or even between countries, regions that were earlier recipients of ART could be richer or have a higher population densities, attributes that could affect children’s schooling independent of ART availability. Further, not all infected adults might seek or adhere to treatment, resulting in clinic-based estimates differing from the effects at scale. Our triple difference strategy overcomes both

⁵While not contemporaneous to the increased provision of ARTs, this program did occur between the our first household survey (2001) and our second household survey (2007). Our triple difference specification removes any policy changes that uniformly affected households regardless of HIV status.

of these difficulties by identifying the effect of adult ART availability off of the differences between HIV positive and HIV negative individuals and using household instead of clinic based surveys. Our estimates are the effect of the scale up of ART, not necessarily the adherence to ART.

To identify the effect of ART at scale, we rely on variation in geography, survey timing relative to initial ART provision, and adult HIV status. The household data are a nationally representative repeated cross section collected in 2001 and 2007 that we combine with unique data on the start date and geographic coordinates of each ART service provider. More details on the data appear in Section 4. Formally, we estimate the effect with a triple difference specification

$$\begin{aligned}
Y_{ijt} = & \alpha + \beta (HIV_{ijt} * ART_j * post_t) + \gamma_1 HIV_{ijt} + \gamma_2 ART_j + \gamma_3 post_t \\
& + \gamma_4 (HIV_{ijt} * ART_j) + \gamma_5 (HIV_{ijt} * post_t) + \gamma_6 (ART_j * post_t) \\
& + \mathbf{X}'_{ijt} \mathbf{\Gamma} + \varepsilon_{ijt}
\end{aligned} \tag{1}$$

where Y_{ijt} is the outcome of interest (e.g. enrolled in school, being the correct grade for age) for individual i in geographic cluster j at time t , HIV_{ijt} is the likely HIV status of the reference adult (e.g. household head) for child i , ART_j is a dummy variable that takes the value of 1 if the household is within 10km of an ART treatment center in 2007, and $post_t$ is a dummy variable that takes a value of 1 if the household was surveyed in 2007.⁶ \mathbf{X}'_{ijt} contains additional control variables: dummy variables for the month of survey, female, living in an urban location, the age group of the reference adult, interactions between the reference adult age group and $post_t$, the age of the child, the district, and the interactions between district dummy variables and $post_t$. The coefficient of interest is β , the effect of having a clinic that distributes ART near a household with an HIV positive reference adult. Because our control variables jointly vary by location and survey timing, this effect is net of any other temporal

⁶For reasons of privacy and consent, exact HIV status cannot be assigned to all adults. The algorithm for attaching likely HIV status to each adult is discussed in the Data Section.

or spatially varying attributes that might be common across likely HIV positive and likely HIV negative households (e.g. a change in the price of copper that might differentially affect districts in the “post” period).

One of our main education outcomes of interest is whether the child is the correct grade-for-age. This measure combines timely entry and progressing through one grade each year. Students who start school after the official age of entry of seven will never be grade-for-age, while even those who start on time could be retained in a grade, causing them to no longer be grade-for-age. While not perfect, we believe this measure is a decent proxy for a child’s likelihood of completing primary school, and does not simply represent a delay in eventual educational attainment. Both Shephard and Smith (1989) and National Center for Education Statistics (1997) found that students who were not grade-for-age had lower achievement outcomes and higher drop out rates. Further, Oreopoulos, Page, and Stevens (2006) used grade-for-age among children aged 7 to 15 as a proxy for “children’s long-run success.” (page 737) While the cited studies focused on the United States, the likelihood of dropping out as children become older could be even larger in African countries as older children are both more complementary to and easily substitutes for adult labor, increasing the opportunity cost of school as children age. Further, most salient to girls, the likelihood of pregnancy and marriage increases with age. As evidence of the difficulty in completing primary school for older students, Lucas and Mbiti (2012) found that the removal of school fees for primary school in Kenya had a smaller effect on older primary school children, especially girls.

The availability of ART treatment could affect the schooling outcomes for children living in households with HIV positive adults in at least six ways. First, children will not be kept home to care for an ill family member. Second, children would be less likely to be substitutes for adult labor in employment, household production, or child care.⁷ Third, an increase in

⁷Dillon (2013) found that children in Mali were substitutes for adult labor in child care and household production when a household adult experienced a negative health shock.

income could provide money necessary for school supplies, uniforms, transportation, and other school expenses. Fourth, increased household income or increased productivity of household enterprises through improved health could increase children’s nutritional intake and food security, and thus increase school attendance and outcomes (FAO 2003; see Glewwe and Miguel 2008 for a summary of the literature on relationship between children’s nutrition and schooling outcomes).⁸ Fifth, children would be exposed to fewer opportunistic infections. Finally, children who are less worried about the health status of their parents might be able to focus more on their studies. Our reduced form effect is the sum of all of the potential channels through which the presence of an ART treatment center might affect the children in a household with an HIV positive adult. Additional specifications attempt to parse out some of the potential mechanisms.

4 Data

For our analysis we combine individual survey data from two rounds of the Zambian Demographic Health Survey (DHS) with unique data on the geographic location of all health facilities in Zambia as of 2006 as well as the month and year in which these facilities started offering free ART if this date occurred prior to June 2008.

The Zambian DHS are a nationally representative household survey with data on individual level demographic, economic, health, and education outcomes. We use two rounds of this repeated cross section. The DHS-IV survey was collected from November 2001 to June 2002, prior to the availability of free ART, and the DHS-V was collected April to October 2007, after the partial scale-up of free ART. For each child within a surveyed household the data contain gender, age, sex, school enrollment status, and current grade as well as the

⁸Based on a 2004 cross section of households in Northern Province, Zambia prior to the widespread availability of ART, 24 percent of households with an HIV positive adult reported eating at most one meal per day, approximately twice as high as the percentage of households unaffected by HIV/AIDS. Further, households with an HIV positive adult reported a 9 percentage point larger decline in the amount of land under cultivation between 1997 and 2002 than unaffected households (Curry et al. 2006).

gender of, age of, and relationship to the household head. If the child’s mother or father are in the household, they are similarly identified. Further, for each child under the age of 60 months, the adult respondent was asked whether the child had diarrhoea, fever, or cough in the two weeks preceding the survey. At the household level the data contain the district of residence and a normalized wealth measure based on household assets.

As part of both the DHS-IV and DHS-V a subsample of females aged 15-49 and males aged 15-59 were tested for HIV. Due to privacy concerns and incomplete testing coverage, we are not able to match each adult with his or her HIV status.⁹ Instead, we use an individual’s likely HIV status based on the portion of individuals who tested positive for HIV in a respondent’s gender by age group by province by urban status cell (e.g. 30-35 year old females in rural Northern Province). These values are calculated separately for each of the two survey rounds.^{10,11} For all children we assign the likely HIV status of their household head, their mothers, and their fathers, if these individuals are identified in the household roster. Our primary specifications use the household head as the reference adult as all children in the sample have a household head, but not all have a mother and/or father in the household for reasons that could be related to the presence or absence of adult ART therapy.¹² For about 60 percent of children their household head is their father, with mother as the second most likely person (12 percent). Thirty-three percent do not live with their

⁹In the DHS-IV about 75 percent of eligible individuals were tested with the response rate appearing to be unbiased in relation to patterns of HIV infection (Dzekedzeke 2002). In the interest of respondent privacy, the HIV test results in the DHS-IV lack unique identifiers. In the DHS-V, 75 percent of respondents in the relevant age ranges consented to be tested and can be linked to the test results through unique identifiers, 18 percent refused to be tested, and the remainder were unavailable (Tembo-Mwanamwenge and Kasongo 2009). The reason for a missing test is not provided at the individual level. For consistency across the two samples and within each sample, we apply the same procedure to all individuals.

¹⁰Since patients taking ART are less infectious than those who are in the final stages of AIDS, one concern is that ART availability altered the HIV prevalence. We do not find evidence of this. The HIV prevalence at the cell level and portion of respondents who were within the treatment radius of an ART clinic is positively correlated, but once we condition on HIV prevalence in 2001 and province, urban, and female dummy variables, we do not find a statistically significant relationship between ART availability and HIV prevalence.

¹¹Our data have 481 different populated cells with an average of 27 adults in each cell.

¹²We use a broad definition of father to include both biological fathers and men married to the child’s mother in order to increase the sample size.

mothers, 44 percent do not live with their fathers, and 30 percent live with neither a mother nor father, but only 4 percent report both parents being deceased. Robustness checks control for these different family structures.

To determine the availability of ART for a household we combine unique data on the location and date of ART availability of all health facilities that dispensed ART prior to 2008 with the locations of DHS sample cluster centroids. We calculate whether a household was within 10 km of a ART treatment facility prior to the 2007 DHS survey, effectively calculating an “ever ART” measure for the entire sample.¹³

Table 1 contains summary statistics, separately by DHS survey round. According to the data, 7 percent of the sample was within the 10km treatment radius of an ART treatment facility in the 2001. While technically available, ART was prohibitively expensive for most people. Therefore, in our specifications we do not consider this availability as a part of the free ART scale-up. Seventeen to 19 percent of children in our sample lived with an HIV positive household head, with moms, when present, somewhat more likely to be HIV positive than dads, when present. Data were not collected on initiation of treatment. Women were asked whether they visited a clinic for themselves or their children in the last 12 months. The likelihood of visitation decreased between the two surveys, but health generally increased over this period making trips for childhood illnesses less likely. Children were more likely to be attending school and be the correct age for their grade in the 2007 survey round.

5 Results

We first estimate the effect of adult ART provision on children’s schooling outcomes, then explore a number of potential mechanisms.

¹³For privacy concerns, DHS sample cluster centroids are displaced in a random fashion, potentially leading to attenuation bias in our estimates.

5.1 Schooling

Table 2 presents evidence of the effect of adult ART availability on three schooling measures through the estimation of Equation 1 as a linear probability model.¹⁴ In all columns the sample is limited to children of primary school age who have a household head in the HIV testing age range. In each column the coefficient of interest is the one on the triple interaction of HIV positive * ART ever * post, the differential effect of ART availability on children in households with likely HIV positive household heads. The HIV status of the household head is calculated as explained in Section 4.

According to column 1, ART availability did not differentially affect the likelihood that a child in households with an HIV positive household head attended any school during the current school year, an extensive measure of schooling, as the coefficient is positive but statistically insignificant. In 2007, government schools were free and over 80 percent of the sample reported being enrolled in school. Therefore, this lack of effect is not surprising given the high enrollment rate and low cost of attending at least a minimal amount of school, and our large standard error does not rule out a change in enrollment. In contrast, ART availability increased the likelihood that children in households with HIV positive household heads were the correct grade for their age, a measure of the intensive margin of schooling that combines timely entry and progression. Based on the magnitude of the coefficient, for a child in a household with a household head who was HIV positive with certainty, the likelihood of being grade for age increased by 49.4 percentage points. None of our demographic cells have a value of 1 for likely HIV status. Within our sample, a change from the median value of head HIV status to 0 would lead to an expected increase in likelihood of being grade for age by 8 percentage points, and a change from the 10th to 90th percentile would result in an expected 19 percentage point change.

¹⁴The appendix table 2 shows the general trends in schooling using a simple difference-in-differences strategy, removing the triple interaction term from Equation 1 as well as any measure of HIV status. That table shows the education was generally increasing over the period as measured by both school attendance and being grade-for-age.

While these estimates might appear large, recall that they include all direct and indirect benefits that might accrue to children in households with HIV positive household heads due to the availability of adult ART.

As noted, being grade for age is the result of starting school on time at age 7 as well as progressing through one grade each year. Unfortunately, our data do not contain either of these measures. We present results for the effect of ART availability on timely entry only for those who should have been in their first year of school at the time of the survey in column 3. As with grade-for-age, we find a positive and statistically significant relationship between this measure of schooling and our regressor of interest. Scaling this coefficient, comparing the median HIV status to zero implies a change in the probability of timely entry of 15 percentage points.

While the other coefficients in the table are not of direct interest to the research question, they show that children in households with HIV positive household heads were more likely to be attending school and be the correct grade for age. In Zambia, as with other countries of sub-Saharan Africa, HIV rates increase with education, and these coefficients likely reflect that relationship (Fortson 2008). Further, children from locations that ever received ART were more likely to be attending school and be the correct grade-for-age. Since our identification strategy leverages temporal, spatial, and HIV status differences, these time invariant characteristics do not affect the validity of our strategy.

We tested for differences by child gender across all three schooling outcomes and while the point estimates are larger for boys in all cases, we fail to reject that the coefficients are equal for boys and girls (results not presented).

5.2 Mechanisms

Adult ART could have improved children's schooling through a number of channels. First, we test for the impact of adult ART on the labor supply of adults who were the household

heads of the children in our sample. Specifically we estimate Equation 1 with a household head as the unit of observation, limiting the sample to household heads of a primary school aged child, and a measure of labor supply as the outcome of interest. In Columns 1 and 2 of Table 3 we do not find any statistically significant relationship between the provision of ART and the likelihood that the household head was working at the time of the survey (column 1) or had worked in the last 12 months (column 2). In fact, none of the lower level coefficients have a statistically significant relationship with these outcomes, potentially an indictment of the quality of these measures. In results not presented, we further find no evidence of a statistically significant relationship with working full time or working for pay. In contrast, Thirumurthy et al. (2008), in a clinic based study in Kenya, found that the onset of ART did increase the labor supply of treated individuals as did McLaren (2010) for Black men in South Africa based on a difference-in-differences analysis. Our results are too imprecise to rule out similar results. Further, our data on labor force participation are only coarse measures of the extensive margin of labor supply with over 80 percent of household heads reporting in 2001 that they were currently working or had worked in the last 12 months. Additionally, because of the structure of the DHS, the labor supply questions only cover about half of all household heads in our sample. We used the same method to test the labor supply of mothers, for whom the sample coverage is larger, and fathers for whom the sample cover is worse, and similarly find no statistically significant relationship.

We further tested for the effect of ART availability on household wealth measured in two ways. First, we use the normalized measure of household wealth, with a mean of 0 and standard deviation of 1, calculated by the DHS based on reported assets. We limit the sample to one observation per household that has at least one child of primary school age. As with our measures of working, we find no statistically significant effect on household wealth (Column 3). Given the long term nature of wealth accumulation and the relatively short exposure to ART availability, this result could be different with a longer exposure to ART.

Second, we created an indicator variable that takes the value of 1 if the floor of the household dwelling was improved, i.e. not earth, mud, or dung, as a potentially shorter run estimate of a change in wealth. As with the standardized wealth measure, we found a positive and statistically insignificant relationship with our regressor of interest (Column 4).

Next we tested for the effect of ART on illnesses. Unfortunately the DHS survey do not ask questions on the health of primary school aged children. Instead, respondents were asked whether each child under 5 years old had diarrhea, a fever, or a cough in the two weeks prior to the survey. These younger children would be subject to the same home disease environment as the primary school aged children. Susceptibility to illness could reflect an underlying nutrition deficit as well as increased intra-household disease transmission due to an adult with a weakened immune system. Table 4 contains the results of separate estimates for each of these measures. The top of each column indicates the dummy variable used as a dependent variable in a re-estimation of Equation 1 as a linear probability model. While the coefficients are negative, we do not find a statistically significant relationship between increased ART availability and the likelihood of diarrhea or cough for children with HIV positive household heads (columns 1 and 3). In contrast, we find a large, statistically significant decrease in the incidence of fever, consistent with household heads bringing less illness into the household and children having a higher level of nutrition and being better able to fend off illness.¹⁵ Further solidifying these illness results, Lucas and Wilson (2013) used a similar strategy and found an increase in weight among children under age 5, indicating a healthier home environment.¹⁶ The decrease in household illness and improved nutrition could have increased the school attendance of primary school aged children through an improvement in their own health or decrease in caregiving duties.

¹⁵An alternative explanation could be an increase in vaccination due to increased clinic exposure. In results not presented, children were not differentially likely based on the HIV status of the household head and clinic proximity to have received their BCG vaccine to protect against tuberculosis, polio vaccine, measles vaccine, or DPT vaccine to protect against diphtheria, pertussis, and tetanus. Further, they were not differentially likely to have a health card.

¹⁶Lucas et al. (2015) confirm the improved adult health with ART availability.

5.3 Alternative Adults

Our primary specifications focused on the household head to alleviate concerns about ART potentially altering the likelihood that a mother or father was present in the household. In Table 5 we provide estimates analogous to Table 2 but using the HIV status of either the child’s mother or father. Recall from Table 1 that the mother was the household head for about 12 percent of the sample and fathers were the household heads for about 58 percent of the sample. Therefore, for some households the same HIV status would appear in both the household head and mother or father estimations. Almost all of the fathers (97 percent) are also household heads and 18 percent of the mothers are household heads.

Column 1 contains the estimates for the likelihood of school attendance with a separate panel for each parent. In contrast with the estimates for household heads, in which we did not find a statistically significant relationship, the interaction of availability of ART with mother’s HIV status has a positive and statistically significant relationship with the likelihood of attending school (Panel A). When we consider being the correct grade for age (column 2), the results are of similar magnitude to the result with household head’s status, but the result is statistically insignificant using mother’s status while remaining statistically significant for father’s status. Similarly, the point estimate in column 3 is similar to the household head analog, but only statistically significant for mother’s status. Columns 4 to 6 contain the estimates for reported childhood illness. Consistent with a story of physical proximity and opportunistic infections, the point estimates are statistically significant for diarrhea for both parents and cough for fathers, estimates that were not statistically significant when using the status of the household head. On average in our sample, primary school aged children live in households of 6.4 people, 2.5 adults and 3.9 children.

These differences by relationship of the child to the adult could be the result of differing levels of personal and economic interactions between the child and the adult, differential economic and household responsibilities and responsibilities by gender, other factors potentially

related to HIV that would cause a child to reside with either a father or mother, or differential treatment adherence by gender. Conditional on receiving and adhering to treatment, the effect of ART on men versus women should biologically be the same. Whether women and men were equally likely to seek and adhere to treatment is an open question. In 2005 women in sub-Saharan Africa were more likely than men to seek treatment with 55 percent of the infected population estimated to be women while over 60 percent of those receiving ART were women (WHO 2006). On the other hand, women did not always correctly adhere to the treatment. Zulu (2005) found that among those surveyed in Zambia, 76 percent of women did not always exactly follow their prescribed regimen and 21 percent shared their regimen with a non-tested husband. We cannot empirically test adherence but plan to explore other potential mechanisms with available data.

6 Robustness

Table 6 contains additional estimates of our coefficients of interest, controlling for additional programs and covariates that could have biased on initial results. Column 1 repeats the estimates from Table 2 for ease of comparison.

One concern with our estimation is the presence of concurrent programs. In Column 2 we include controls for the availability of prevention of mother-to-child transmission (PMTCT) of HIV or voluntary counseling and testing (VCT) services, two additional HIV services that were scaled up during our time frame of interest but not colinearly with ART availability. Our point estimates remain quite similar. Also, during the time of our study, bed net availability increased, and one concern is that our results are reflecting an increase in their use, instead of an effect of ART. While HIV positive individuals were not specifically targeted to receive bed nets, one could imagine that because of clinic contact they might be more likely to use a bed net. Our results remain robust to the inclusion of a dummy variable for bed net use (results not shown).

An additional concern is that we are conflating teacher HIV status with household adult HIV status. We used data from the round two of the Zambia Southern and Eastern Africa Consortium for Monitoring and Education Quality (SACMEQ) data collected in 2003 to calculate the gender ratio of teachers in each province. Then based on this gender ratio, we used the Zambia DHS from 2002 to estimate the average HIV status of teachers in each province. In the results in Column 3, we included this HIV status as an additional triple interaction term as an additional regressor. Our results are robust to this inclusion with the expectation of timely entry. While the point estimate is still the large, the increase in the standard error and decrease in the point estimate renders the coefficient statistically insignificant.

A final concern is orphan status. In column 4 we include dummy variables for a deceased mother, deceased father, and both parents being deceased. Our findings are robust to this inclusion.

7 Discussion and Conclusions

This study uses the 2001 and 2007 Zambia DHS surveys of households combined with uniquely collected administrative data on availability of antiretroviral therapy (ART) to identify the effect of subsidized adult ART therapy at scale on educational outcomes of children in households with infected adults.

We find that availability of adult ART resulted in educational gains for primary school aged children in households with HIV positive adults. Provision of free ART increased the likelihood that children in households with HIV positive household heads were grade-for-age and entered school at the correct age. We do not find an effect on the likelihood of being enrolled in school, our proxy for the extensive margin of schooling. One potential mechanism driving this result is that children in the household are healthier, potentially indicating fewer opportunistic infections in the household. Therefore, in addition to directly

benefiting adults, ART provision to adults in a household assists children already in school, but does not appear to alter likelihood that children are enrolled in school. When cost benefit analyses of ARTs are conducted these additional indirect benefits are often not included. Improved schooling outcomes for students is an additional benefit to be considered when assessing the cost effectiveness of ART provision. Additional estimations will continue to test potential mechanisms as well as better understand differentials in effects based on the child's relationship to the reference adult.

References

- AKBULUT-YUKSEL, M., AND B. TURAN (2013): “Left behind: intergenerational transmission of human capital in the midst of HIV/AIDS,” *Journal of Population Economics*, 26, 1523–1547.
- BARANOV, V., D. BENNETT, AND H.-P. KOHLER (2015): “The Indirect Impact of Antiretroviral Therapy: Mortality Risk, Mental Health, and HIV-Negative Labor Supply,” Mimeo.
- BARANOV, V., AND H.-P. KOHLER (2014): “The Impact of AIDS Treatment on Savings and Human Capital Investment in Malawi,” Mimeo.
- CURRY, J., E. WIEGERS, A. GARBERO, S. STOKES, AND J. HOURIHAN (2006): “Gender, HIV/AIDS and Rural Livelihoods: Micro-Level Investigations in Three African Countries,” Research Paper 2006/10, UNU-WIDER.
- DILLON, A. (2013): “Child Labour and Schooling Responses to Production and Health Shocks in Northern Mali,” *Journal of African Economies*, 22(2), 276–299.
- DUNKLE, K. L., R. STEPHENSON, E. KARITA, E. CHOMBA, K. KAYITENKORE, C. VWA-LIKA, L. GREENBERG, AND S. ALLEN (2008): “New heterosexually transmitted HIV infections in married or cohabiting couples in urban Zambia and Rwanda: an analysis of survey and clinical data,” *Lancet*, 371, 2183–2191.
- FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS HIV/AIDS PROGRAMME (2003): “Mitigating the Impact of HIV/AIDS on Food Security and Rural Poverty,” Discussion paper, FAO, Rome.
- FORTSON, J. (2008): “The Gradient in sub-Saharan Africa: Socioeconomic Status and HIV/AIDS,” *Demography*, 45(2), 303–322.
- (2011): “Mortality Risk and Human Capital Investment: The Impact of HIV/AIDS in sub-Saharan Africa,” *Review of Economics and Statistics*, 93(1), 1–15.
- GLEWWE, P., AND E. A. MIGUEL (2008): “The Impact of Child Health and Nutrition on Education in Less Developed Countries,” in *Handbook of Development Economics*, ed. by T. P. Schultz, and J. Strauss. Elsevier.
- HABYARIMANA, J., B. MBAKILE, AND C. POP-ELECHES (2010): “The Impact of HIV/AIDS and ARV Treatment on Worker Absenteeism: Implications for African Firms,” *Journal of Human Resources*, 45(4), 809–839.
- LEVINSOHN, J., Z. M. MCLAREN, O. SHISANA, AND K. ZUMA (2013): “HIV Status and Labor Market Participation in South Africa,” *The Review of Economics and Statistics*, 95(1), 98–108.
- LUCAS, A. M., AND I. M. MBITI (2012): “Does Free Primary Education Narrow Gender Differences in Schooling Outcomes? Evidence from Kenya,” *Journal of African Economies*, 21(5), 691–722.

- LUCAS, A. M., AND N. L. WILSON (2013): “Adult Antiretroviral Therapy and Child Health: Evidence from Scale-up in Zambia,” *American Economic Review: Papers and Proceedings*, 103(3), 456–61.
- (2014): “Can Antiretroviral Therapy At Scale Improve the Health of the Targeted in Sub-Saharan Africa?,” Mimeo.
- MCLAREN, Z. (2010): “The Effect of Access to AIDS Treatment on Employment Outcomes in South Africa,” .
- MÉDECINS SANS FRONTIÈRES (2003): “Antiretroviral Therapy in Primary Health Care: Experience of the Khayelitsha Programme in South Africa,” Discussion paper, World Health Organization, Switzerland.
- NATIONAL CENTER FOR EDUCATION STATISTICS (1997): “Dropout Rates in the United States,” Statistical Analysis Report NCES 97-473, U.S. Department of Education Office of Educational Research and Improvement.
- OREOPOULOS, P., M. E. PAGE, AND A. H. STEVENS (2006): “The Intergenerational Effects of Compulsory Schooling,” *Journal of Labor Economics*, 24(4), 729–760.
- ROBSON, S., AND K. B. SYLVESTER (2007): “Orphaned and Vulnerable children in Zambia: the impact of the HIV/AIDS epidemic on basic education for children at risk,” *Educational Research*, 49(3), 259–272.
- SHEPARD, L. A., AND M. L. SMITH (eds.) (1989): *Flunking Grades: Research and Policies on Retention*. The Falmer Press.
- TEMBO-MWANAMWENGE, M., AND W. KASONGO (2009): “Prevalence of HIV and Syphilis,” in *Zambia Demographic and Health Survey 2007*, ed. by T. D. R. C. U. o. Z. Central Statistical Office, Ministry of Health, and M. I. Inc. CSO and Macro International Inc., Calverton, MD.
- THIRUMURTHY, H., J. G. ZIVIN, AND M. GOLDSTEIN (2008): “The Economic Impact of AIDS Treatment Labor Supply in Western Kenya,” *The Journal of Human Resources*, XLIII(3), 511–552.
- TIRIVAYI, N., AND W. GROOT (2014): “The Impact of Food Transfers for People Living with HIV/AIDS: Evidence from Zambia,” .
- UNAIDS (2015): “AIDSinfo Online Database,” .
- UNESCO (2010): “World Data on Education,” .
- UNICEF (2009): “Children and AIDS: Fourth Stocktaking Report,” .
- WORLD HEALTH ORGANIZATION (2005): “Zambia Summary Country Profile for HIV/AIDS Treatment Scale-up,” .

——— (2006): *Progress on Global Access to HIV Antiretroviral Therapy: A Report on 3 by 5 and Beyond*. The World Health Organization, Geneva.

——— (2010): “PMTCT Strategic Vision 2010-2015,” .

ZULU, K. (2005): “Fear of HIV serodisclosure and ART success: the agony of HIV positive married women in Zambia,” Poster Exhibition: The 3rd IAS Conference on HIV Pathogenesis and Treatment. Abstract no. TuPe11.9C03.

Afya Mzuri (2012), “HIV and AIDS,” <http://www.afyamzuri.org/dziwani/hiv-aids/120-hiv-aids>, retrieved 4/15/2014.

Bell, Clive, Shantayanan Devarajan, and Hans Gersbach. 2006. “The Long-run Economic Costs of AIDS: A Model with an Application to South Africa.” *World Bank Economic Review* 20:55-89.

Bloom, David, and Ajay Mahal. 1997. “Does the AIDS Epidemic Threaten Economic Growth?” *Journal of Econometrics* 77:105–24.

Canning, David. 2006. “The Economics of HIV/AIDS in Low-Income Countries: The Case for Prevention.” *Journal of Economic Perspectives* 20:121-142.

Chapoto, Antony, and T.S. Jayne. 2008. “Impact of AIDS-Related Mortality on Farm Household Welfare in Zambia.” *Economic Development and Cultural Change* 56 (2):327-374.

Cuddington, John. 1993. “Further Results on the Macroeconomic Effects of AIDS: The Dualistic, Labor-Surplus Economy.” *The World Bank Economic Review* 7(3): 403-417. DHS. 2007. *Guide to DHS Statistics*. DHS. Calverton.

Duflo, Esther and Christopher Udry. 2004. “Intrahousehold Resource Allocation in Cote d’Ivoire: Social Norms, Separate Accounts and Consumption Choices.” Working Paper no. 10498, NBER, Cambridge, Mass.

Hammer, S. 1997. “A Controlled Trial of Two Nucleoside Analogues Plus Indinavir in Persons with Human Immunodeficiency Virus Infection and CD4 Cell Counts of 200 Per Cubic Millimeter or Less.” *New England Journal of Medicine* 337 (11):725-733.

Hoddinott, John and Lawrence Haddad. 1991. “Household Expenditures, Child Anthropometric Status and the Intrahousehold Division of Income: Evidence from the Cote d’Ivoire,” *Papers* 155, Woodrow Wilson School - Development Studies. Princeton, NJ.

International HIV/AIDS Alliance. 2004. “Antiretroviral Treatment in Zambia: A study of the experiences of treatment users and health care workers.” International HIV/AIDS Alliance. Photocopied.

Larson, Bruce, Matthew P. Fox., Sydney Rosen, Margaret Bii, Carolyne Sigei, Douglas Shaffer, Fredrick Sawe, Monique Wasunna, and Jonathon L. Simon. 2008. “Early effects of antiretroviral therapy on work performance: Preliminary results from a cohort study of Kenyan agricultural workers.” *AIDS* 22: 421-425.

Mahal, Ajay, David Canning, Kunle Odumosu, and Prosper Okonkwo. 2008. “Assessing the economic impact of HIV/AIDS on Nigerian households: a propensity score matching approach.” *AIDS*, 22 (1): 95-101.

Mahmoud, Toman, and Rainer Thiele. 2009. “Does AIDS-Related Mortality Reduce Per-Capita Household Income? Evidence from Rural Zambia.” *Special Report on AIDS in Africa*, Kiel Institute for the World Economy. Kiel Institute for the World Economy. Kiel.

Mishra, Vinod, Martin Vaessen, J Ties Boerma, Fred Arnold, Ann Way, Bernard Barrere, Anne Cross, Rathavuth Hong and Jasbir Sanghaa . 2006. "HIV Testing in National Population." Review of Economics and Statistics .The President and Fellows of Harvard College and the Massachusetts Institute of Technology.

Morgan, D., C. Mahe, B. Mayanja and J.A. Whitworth. 2002. "HIV-1 infection in rural Africa: is there a difference in median time to AIDS and survival compared with that in industrialized countries?" AIDS 16: 597-603.

Navarro, V. 2000. "Assessment of the World Health Report 2000." Lancet, 356:1598-1601.

Nattrass, Nicoli. 2008. "Gender and Access to Antiretroviral Treatment in South Africa." Feminist Economics 14: 419-36.

Nelson, K.E., and C. Masters. 2007. "Infectious disease epidemiology: theory and practice." Williams. New York. 789-894.

Scandlyn, Jean. 2000. "When AIDS became a chronic disease." Western Journal of Medicine 172 (2): 30-133.

Stringer, J., Zulu, I., Levy, J., Stringer, E., Mwango, A., Chi, B., Mtonga, V., Reid, S., Cantrell, R., Bulterys, M., Saag, M., Larlink, R., Mwinga, A., Ellerbrock, T., Sinkala, M. 2006. "Rapid scale-up of antiretroviral therapy at primary care sites in Zambia: Feasibility and early outcomes. " Journal of the American Medical Association, 296(7), 782-793.

UNAIDS. 2002. Zambia Epidemiological Factsheet on HIV and AIDS. UNAIDS Geneva.

UNAIDS (2007). Report on the Global AIDS Epidemic. Joint United Nations Programme on the HIV/AIDS, Geneva.

UNAIDS (2008). Report on the Global AIDS Epidemic. Joint United Nations Programme on the HIV/AIDS, Geneva.

UNAIDS (2010). Report on the Global AIDS Epidemic. Joint United Nations Programme on the HIV/AIDS, Geneva.

WHO (2010). Antiretroviral Therapy for HIV Infection in Adults and Adolescents: Recommendations for a Public Health Approach. World Health Organization. Geneva.

Wools-Kaloustian, K. et al (2006). Viability and effectiveness of large-scale HIV treatment initiatives in sub-Saharan Africa: experience from western Kenya. AIDS, 20,41-48.

Zambian Ministry of Education. 2011. "Looking towards the future of education: A stocktaking report." Ministry of Education, Lusaka. Photocopied

Zambia Ministry of Health. 2008. Assessing the Scale up of HAART. Ministry of Health. Lusaka.

Zambia Ministry of Health. 2010. Republic of Zambia Biennial Report. Ministry of Health, Lusaka. Photocopied.

Zivin, Graff, Harsha Thirumurthy and Markus Goldstein. 2008. "AIDS treatment and intrahousehold resource allocation: Children's nutrition and schooling in Kenya." Journal of Public Economics 92: 908-1015.

Zulu K.P. (2005) Fear of HIV serodisclosure and ART success: the agony of HIV positive married women in Zambia.. Poster Exhibition: The 3rd IAS Conference on HIV Pathogenesis and Treatment: Abstract no. TuPe11.9C03

Table 1: Summary Statistics

	2001	2007
ART Available within 10km	0.07 (0.26)	0.46 (0.50)
Likelihood of HIV+ Household Head	0.17 (0.11)	0.19 (0.08)
Likelihood of HIV+ Mom	0.21 (0.11)	0.21 (0.09)
Likelihood of HIV+ Dad	0.16 (0.11)	0.19 (0.08)
Mom Visited Clinic in Prior 12 Months	0.74 (0.44)	0.54 (0.50)
Mom Ever Tested for HIV	0.09 (0.28)	0.43 (0.49)
Age	11.76 (3.36)	11.67 (3.28)
Attending School	0.67 (0.47)	0.82 (0.39)
Grade for Age	0.27 (0.44)	0.43 (0.49)
Household Has a Bednet	0.31 (0.46)	0.71 (0.45)
Bednet Used Previous Night	0.16 (0.37)	0.29 (0.45)
Dad is Household Head	0.60 (0.49)	0.57 (0.49)
Mom is Household Head	0.12 (0.32)	0.13 (0.33)
Someone Else is Household Head	0.28 (0.45)	0.30 (0.46)
Orphan	0.02 (0.16)	0.04 (0.18)
Household Wealth (normalized measure based on assets)	0.07 (1.05)	0.01 (1.03)
Illness in Prior Two Weeks		
Diarrhea	0.21 (0.41)	0.16 (0.37)
Fever	0.45 (0.50)	0.18 (0.39)
Cough	0.39 (0.49)	0.26 (0.44)

Notes: Standard deviations appear in parenthesis. Source: Calculations based on 2001 and 2007 Zambia DHS. The unit of observation is a primary school aged child with four exceptions. Household wealth is at the household level for households with a primary school aged child. The four illness measures are for children aged 0-5.

Table 2: Effect of Adult ART on Children's Schooling

	Attended School During Current School Year (1)	Grade for Age (2)	Timely Entry (3)
HIV+ * ART Ever * Post	0.178 (0.150)	0.518*** (0.156)	0.763** (0.388)
HIV+	0.138* (0.079)	0.209** (0.085)	0.391** (0.186)
ART Ever	0.065* (0.035)	0.115*** (0.041)	0.090 (0.060)
Post	0.138*** (0.051)	0.178*** (0.060)	0.304* (0.180)
HIV+ * ART Ever	-0.115 (0.092)	-0.251** (0.117)	-0.352 (0.227)
HIV+ * Post	-0.205 (0.127)	-0.292** (0.143)	-0.528 (0.338)
ART Ever * Post	-0.070 (0.047)	-0.146** (0.057)	-0.169* (0.101)
Observations	12,128	12,128	1,933
Rquared	0.19	0.22	0.24

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors clustered at the statistical enumeration level appear in parenthesis. The sample is limited to children in expected grades 1-7 with a valid HIV approximation for their household head. All columns are linear probability models and include child age, household head age group, district, year of survey, month of survey, urban, and female dummy variables and household head age group times post and district dummy variables times post.

Table 3: Mechanisms - Labor and Wealth

	Household Head		Household Wealth (3)	Improved Floor Material (4)
	Currently Working (1)	Worked in the Last 12 Months (2)		
HIV+ * ART Ever * Post	-0.158 (0.183)	-0.192 (0.132)	0.353 (0.469)	0.073 (0.211)
HIV+	-0.022 (0.093)	0.000 (0.073)	0.337 (0.233)	0.104 (0.098)
ART Ever	-0.047 (0.041)	-0.033 (0.028)	0.274** (0.113)	0.122** (0.047)
HIV+ * ART Ever	0.175 (0.151)	0.146 (0.104)	-0.417 (0.351)	-0.169 (0.140)
HIV+ * Post	0.162 (0.130)	0.157 (0.102)	0.134 (0.358)	0.164 (0.174)
ART Ever * Post	-0.005 (0.047)	0.022 (0.034)	-0.226* (0.132)	-0.089 (0.058)
Observations	4,304	4,304	6,918	6,869
Rsquared	0.19	0.19	0.68	0.51

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors clustered at the cluster level appear in parenthesis. The sample is limited to households with at least one child aged 7 to 14 and a valid HIV approximation for their household head. Columns 1 and 2 are linear probability models. Column 3: the dependent variable is a normalized measure of wealth with mean 0 and standard deviation of one across all households. All columns include household member age group, district, year of survey, month of survey, urban, and female dummy variables and household member age group times post and district dummy variables times post.

Table 4: Mechanisms - Illnesses

	Diarrhea (1)	Fever (2)	Cough (3)
HIV+ * ART Ever * Post	-0.157 (0.146)	-0.395** (0.169)	-0.240 (0.191)
HIV+	0.04 (0.082)	-0.229** (0.097)	-0.055 (0.089)
ART Ever	-0.035 (0.023)	-0.070*** (0.026)	-0.021 (0.029)
HIV+ * ART Ever	-0.014 (0.091)	0.241** (0.112)	0.139 (0.113)
HIV+ * Post	0.191 (0.125)	0.331** (0.144)	0.065 (0.145)
ART Ever * Post	0.063** (0.030)	0.096*** (0.037)	0.048 (0.047)
Observations	10,372	10,372	10,372
Rsquared	0.08	0.15	0.08

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors clustered at the cluster level appear in parenthesis. The sample consists of children aged up to age 5 with a valid HIV approximation for their household head. All columns are linear probability models. The dependent variable is an indicator variable equal to one if the child had the illness at the top of the column in the two weeks prior to the survey. All columns include child age, household head age group, district, year of survey, month of survey, urban, and female dummy variables and household head age group times post and district dummy variables times post.

Table 5 - HIV Status of Alternative Adults

	Attends School (1)	Grade for Age (2)	Timely Entry (3)	Diarrhea (4)	Fever (5)	Cough (6)
<i>Panel A: Mother</i>						
HIV+ * ART Ever * Post	0.207 (0.174)	0.252 (0.253)	0.698* (0.418)	-0.354** (0.151)	-0.351** (0.171)	-0.112 (0.194)
Observations	9,585	9,585	1,699	11,379	11,379	11,379
Rsquared	0.21	0.24	0.28	0.08	0.14	0.08
<i>Panel B: Father</i>						
HIV+ * ART Ever * Post	0.040 (0.208)	0.510** (0.250)	0.554 (0.498)	-0.413** (0.171)	-0.491*** (0.188)	-0.362* (0.208)
Observations	7,842	7,842	1,395	8,503	8,503	8,503
Rsquared	0.21	0.25	0.27	0.08	0.15	0.08

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors clustered at the cluster level appear in parenthesis. The sample is limited to children aged 7 to 14 with a valid HIV approximation for their household adult as listed in the panel. All columns are linear probability models and include child age, household member age group, district, year of survey, month of survey, urban, and female dummy variables and the following interactions: household member age group times post, and district dummy variables times Post. Columns 4-6 are for children aged 0 to 5.

Table 6 - Additional Specification Checks

	Preferred Specification (Table 3)	Including Other HIV Services	Including Triple Teacher HIV Interaction	Including Orphan Status
	(1)	(2)	(3)	(4)
<i>Panel A: Attended School</i>				
HIV+ * ART Ever * Post	0.178 (0.150)	0.214 (0.155)	0.122 (0.140)	0.168 (0.145)
Observations	12,128	12,128	12,128	12,128
Rsquared	0.19	0.23	0.19	0.19
<i>Panel B: Grade for Age</i>				
HIV+ * ART Ever * Post	0.518*** (0.156)	0.478** (0.230)	0.400*** (0.148)	0.495*** (0.157)
Observations	12,128	12,128	12,128	12,128
Rsquared	0.22	0.22	0.22	0.22
<i>Panel C: Timely Entry</i>				
HIV+ * ART Ever * Post	0.763** (0.388)	0.847** (0.390)	0.560 (0.435)	0.773* (0.400)
Observations	1,933	1,933	1,933	1,933
Rsquared	0.24	0.24	0.24	0.24

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors clustered at the cluster level appear in parenthesis. Panels A and B: The sample is limited to children or primary school age with a valid HIV approximation for their household head. Panel C: Sample limited to children of grade 1 age. Each panel is a separate dependent variable. All estimates are linear probability models and include child age, household member age group, district, year of survey, month of survey, urban, and female dummy variables and the following interactions: household member age group times post, and district dummy variables times Post. Column 1 from Table 2. Column 2 includes for controls for PMTCT and VCT availability within 10km of the household. Column 3 includes a triple interaction with the average HIV status of teachers in the province. See text for additional details on its calculation. Column 4 includes three additional dummy variables: whether the mother of the child is deceased, whether the father of the child is deceased, and whether both parents are deceased.

Appendix Table - Trends in Children's Schooling

	Attended School During Current School Year (1)	Grade for Age (2)	Timely Entry (3)
ART Ever	0.049* (0.026)	0.060** (0.030)	0.030 (0.052)
Post	0.139*** (0.031)	0.063* (0.037)	0.080 (0.063)
ART Ever * Post	-0.051** (0.024)	-0.005 (0.035)	-0.004 (0.052)
F-test that coefficients on Post and ART Ever X Post sum to 0			
F statistic	13.57	2.67	1.43
p-value	0.00	0.11	0.24
Observations	12,128	12,128	1,933
Rsquared	0.16	0.20	0.19

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors clustered at the cluster level appear in parenthesis. The sample is limited to children aged 7 to 14 with a valid HIV approximation for their household head. All columns are linear probability models and include child age, household head age group, district, year of survey, month of survey, urban, and female dummy variables and household head age group times post and district dummy variables times post.