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EFFECTS OF ADULT HEALTH INTERVENTIONS AT SCALE ON CHILDREN'S SCHOOLING: EVIDENCE FROM ANTIRETROVIRAL THERAPY IN ZAMBIA

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Effects of Adult Health Interventions at Scale on Children's Schooling: Evidence from Antiretroviral Therapy in Zambia
Adrienne M. Lucas, Margaret Chidothe, and Nicholas L. Wilson
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ABSTRACT

In 2007, approximately one in five children in Zambia lived with an HIV positive adult. We identify the effect of adult antiretroviral therapy (ART) availability at scale on children's educational outcomes by combining data on the expansion of ART availability with two national 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.

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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 (Hammer 1997; Wools-Kaloustian et al. 2006), and this improved adult health could have important benefits for children. Previous research has shown the effect of ill adult health on 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, i.e. national, 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 provision at scale (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 and location of free ART availability 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 health facility level data on the dates of initial ART availability and geographic coordinates of the facilities that provided ART with two national household surveys that include HIV testing modules. Because we are studying a nationwide program at scale, unfortunately we are somewhat limited by the available data. Due to privacy concerns we are unable to assign exact HIV status to all of the adults in our sample. In the interest of symmetry and to alleviate concerns of selective test refusal, we instead rely on the likely HIV status of the individual based on the HIV status of others in the demographic group. More details on the exact construction of this measure are in the Data Section.[1] We include extensive controls in our primary specifications and numerous robustness checks to ensure that this data limitation is not confounding our estimates.

Our triple difference is then the interaction of a health facility ever providing free ART (spatial variation), whether the health facility distributed free ART prior to the date of the household survey (temporal variation), and the likely HIV status of adults in the household (variation in likely HIV status). This triple difference identifies the effect of adult ART

[1] Formally, for each individual we define their demographic group by gender, age, province, and living in an urban or rural location, the most precise group possible given the privacy concerns.

availability on children's educational outcomes in households with likely HIV positive adults, net of any location, time, or location by time variation that is common to both likely HIV positive and likely HIV negative households (e.g. differential development trends by region). Further, it controls for any differences across time for likely HIV positive and negative households. While we are unaware of any education programs that targeted children in HIV positive households or any programs that targeted households near to health facilities that distributed ART, our use of the interaction of likely HIV status and a time dummy variable and the use of the interaction of being near a health facility that distributed ART and a time dummy variable would control for these possibilities. Finally, we are unaware of any concurrent programs that specifically targeted HIV positive households in locations in which ART was available, other than the specific ART availability.[2] Therefore, our estimates are the effect of adult ART availability on children's educational outcomes.

We find that expanded ART availability increased the likelihood that primary school aged children who lived with a likely 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 two years of primary school, perhaps not surprising given that government primary schools did not charge fees eliminating a common enrollment barrier. 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

[2]During the period under study (2002 to 2007) the social safety net model used in Zambia was cash transfers targeting the most destitute households. Prior to 2007, such schemes operated as pilots to refine the targeting algorithm in only four of the severty-two districts in Zambia (Regional Hunger and Vulnerability Program 2007). Even though HIV status was not part of the selection mechanism, in the robustness section we show that our results are robust to removing these districts from our sample.

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 existing economic literature on HIV/AIDS has focused on the detrimental relationship between adult HIV and adults' and children's outcomes. 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. Focusing on adults only, Levinsohn et al. (2013) used propensity score matching and found that HIV positive adults in South Africa were less likely to be employed.

Another strand of the literature has focused on the effects of the free or subsidized provision of ART and has taken one of three approaches. The first type used smaller scale clinic- or employer-based studies and focused on HIV positive adult recipients of ART with variation coming from the timing of the initiation of treatment. All individuals in these studies had sought treatment and were adhering to 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. McLaren 2010, Bendavid et al. 2012, Friedman 2014, Baranov and Kohler 2014). The third approach used 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 margin of labor supply in three rural districts in Malawi. Lucas and Wilson (2013) and Lucas and Wilson (2016) 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 countries, 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 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.[3]

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

[3] Our health facilities 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.

(WHO 2006). Even though some private companies continued to provide treatment to their 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).[4] 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. e.g. 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).[5] 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 re-

[4] In 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.

[5] Most 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 number of adults versus 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.

ceiving 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.[6]

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).[7] 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.

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

[7] While not contemporaneous to the increased provision of ART, this program did occur between the our first household survey (2002) and our second household survey (2007). Our triple difference specification removes any policy changes that uniformly affected households regardless of HIV status.

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 take-up, retention, 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 of these difficulties by identifying the effect of adult ART availability off of the differences between likely HIV positive and likely HIV negative individuals and using household instead of clinic based surveys. Our estimates are the net effect of the scale up of ART, not necessarily the take-up, retention in care, and 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 repeated cross-sectional household surveys collected in 2002 and 2007 that we combine with unique data on the start date and geographic coordinates of each ART service provider.[8] More details on the data appear in Section 4. Formally, we estimate the effect with a triple difference specification

[8] The first household survey occurred from November 2001 to June 2002. We refer to it as the 2002 survey for simplicity.

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

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.[9] $\mathbf{X}'_{ijt}$ 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 we include dummy variables that jointly vary by location and survey timing, this effect is net of any other temporal 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). Further because we are including dummy variables for the age group of the reference adult and its interaction with post and dummy variables for the child's age, we are controlling for life cycle dynamics. In order for such dynamics to be biasing our results they must be both differential by ART availability and HIV status. Even though we do not think such bias is likely, in our robustness section

[9]For 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.

we include additional controls for birth order.

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.

In addition to being a desirable outcome itself, we believe that grade-for-age, while not perfect, 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 Shepard 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. Child marriage is common in Zambia with 42 percent of marriages occurring prior to the woman reaching age 18 (Child Frontiers 2015). 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.[10]

[10] Both not being grade-for-age and dropping out are common in Kenya, Uganda, and Tanzania where 90 percent of children complete at least 5 years of schooling, yet one third of 13 year olds failed a grade 2 literacy and numeracy test (Jones et al. 2014). Further, age and achievement at grade 6 is negatively correlated (Oduol 2006).

Even in the unlikely case that our measure only captures a delay in eventual educational attainment, this has a cost to the schooling sector in the inefficient use of resources and to students in a delayed start of their working lives and therefore lifetime income.

The availability of ART treatment could affect the schooling outcomes for children living in households with HIV positive adults in at least eight 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.[11] Third, an increase in 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).[12] Fifth, children would be exposed to fewer pathogens because adults with stronger immune systems would be less susceptible to opportunistic infections. Sixth, the availability of ART could reduce HIV related stigma. Seventh, a longer life expectancy for parents could alter their perceived return to educating their children. 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

[11] Dillon (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.

[12] Based 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, approximarely 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 amd 2002 than unaffected households (Curry et al. 2006).

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 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 national household surveys 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, school enrollment status, and current grade as well as the 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.[13] 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.[14,15] For all children we assign the likely HIV status of their household head, their mothers, and their fathers, if these individuals were 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.[16] For about 60 percent of children their household head was their father, with mother as the second most likely person (12 percent). Thirty-three percent did not live with their mothers, 44 percent did not live with their fathers, and 30 percent lived with neither a mother nor father, but only 4 percent reported 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 (if ever) for the health facilities with the locations of

[13] In 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.

[14] Since patients taking ART are less infectious that 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 relationship between HIV prevalence at the cell level and portion of respondents who were within the treatment radius of an ART clinic is not statistically significant once we control for HIV prevalence in 2001 and province, urban, and female dummy variables.

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

[16] We 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 since we cannot always differentiate between the two.

the sample cluster centroids from the DHS.[17] 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.[18] Of all health facilities open in 2008, 242 of them (18 percent) started distributing ART prior to the 2007 survey. These unique health facilities data further provide the start date of other HIV services, i.e. voluntary counseling and testing and prevention of mother to child transmission, that we use in robustness checks.

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 2002 data. 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 any reason 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. Figure 1 shows the national age profile of HIV risk. In our empirical specification we exploit variation between genders, ages, provinces, and urban vs. rural.

[17] Our data include 1,349 health facilities.

[18] For privary concerns, DHS sample cluster centroids are displaced in a random fashion, potentially leading to attentuation bias in our estimates.

5 Results

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

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.[19] 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 were enrolled in school during the current school year, an extensive measure of schooling, as the coefficient is positive but statistically insignificant.[20] In 2007, government schools did not charge fees 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. Further, our large standard error does not rule out a change in enrollment.

[19] The appendix table 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.

[20] Precisely the survey asks whether the child has attended any school in the last year, effectively a measure of 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 51.8 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 20 percentage point change.

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 in column 3 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. 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 12 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).

Table 3 tests for differential effects by grade, replacing the single triple interaction from Equation 1 with separate interactions for each primary grade. Unlike in the overall average in column 1 of Table 2, in column 1 of Table 3 we find that adult ART availability differentially increased the likelihood that students in primary grades 1 and 2 were attending school. Further we are able to reject the equality of coefficients across all primary grades. Therefore, for school enrollment the benefits appear to be concentrated with the youngest cohorts. And while we cannot directly test the mechanism, this finding suggests that the dominant mechanism is not care giving – or at least care giving that is preventing children from being enrolled in school – as this effect would be stronger in the older aged children. Column 2 contains analogous estimates on the effect of being grade for age. In this case, all grade levels are more likely to be grade for age with no clear age pattern, indicating that adult ART availability affects the likelihood of grade progression.

In Table 4 we provide estimates for differential effects by both distance and duration of exposure. In column 1, we replaced the triple interaction of interest in Equation 1 with a series of 5 km distance interactions (i.e. 0 to 5 km, 5 km to 10 km, 10 km to 15 km, and 15 km to 20 km) and included the appropriate double interactions. Based on column 1, the benefit is concentrated within 10 km of a health facility that provided free ART. The coefficients for larger distances are positive, but smaller in magnitude and statistically insignificant. This confirms our use of 10 km in our primary specifications. In column 2, we augmented Equation 1 with an additional triple interaction term replacing the single "post" with the number of months that ART was available. The point estimate on both the original triple interaction term and the new one are positive, as expected, but separately insignificant. The test of joint significance confirms that these regressors are jointly statistically significant.

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 5 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 2002 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 coverage is smaller, 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 did 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 6 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.[21] Further supporting these illness results, Lucas and Wilson (2013) and Lucas and Wilson (2015) used a similar strategy and found an increase in weight among children under age 5 and likely HIV positive women, indicating a healthier home environment. 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 care giving duties.

Because of data limitations we cannot directly test for other mechanisms that might be the channel through which adult ART availability affects children's schooling. Our empirical tests are not meant to be exhaustive, instead pointing out one channel - improved health of

[21] An 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 diptheria, pertussis, and tetanus. Further, they were not differentially likely to have a health card.

young children in the house - through which we think adult ART availability affects children's schooling.

Due to the questions asked in the DHS we cannot know whether members of the household were receiving ART. During the time under study, those receiving ART would have had to make periodic visits to the clinic in order to receive medication. The DHS does inquire of women only whether they "visited a health facility for any reason in the twelve months preceding the interview." (Demographic and Health Surveys 2008) This question is not ideal for a three reasons. First, the question is posed during the family planning section of the survey, priming women to think only of certain kinds of visits. Second, recall from Table 1 that the portion of women who reported visiting a clinic fell by 20 percentage points between the two surveys, with differential changes for other reasons potentially swamping changes due to ART. Finally, respondents might not consider a visit to pick up an ART prescription as a formal visit to a health facility. Nevertheless, we test whether the women were more likely to have indicated that they visited a health facility and find no differential effect by our triple interaction of interest. Additionally we test whether women were more likely to have ever been tested for HIV, finding that women were substantially more likely to have been tested by the 2007 survey, but the effect is not differential by HIV status and ART availability.

5.3 Alternative Adults

Our primary specifications focused on the household head to alleviate concerns about ART altering the likelihood that a mother or father was present in the household. In Table 7 we provide estimates analogous to Table 2 but using the HIV status of either the child's mother or father and the maximum HIV measure across the household head, 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. Almost all of the fathers (97 percent) were also household heads and 18 percent of the mothers were household heads. Therefore, for some households the same HIV status would appear in both the household head and mother or father estimations.

Column 1 contains the estimates for the likelihood of school attendance with a separate panel for each adult. Similar to the estimates for household heads in which we did not find a statistically significant relationship, the interaction of availability of ART with mother's, father's, or adult maximum HIV status has a positive and statistically insignificant relationship with the likelihood of attending school. 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 and adult maximum status. Similarly, the point estimate in column 3 is similar to the household head analog, but only statistically significant for mother's and adult maximum 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 or adult maximum. 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 by gender, other factors potentially related to HIV that would cause a child to reside with either a father or mother, or differential treatment take-up and adherence by gender. Unfortunately, we cannot empirically differentiate these possibilities. 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.

Given that the illness results are stronger while the schooling results remain similar when considering adults other than the household head, the mechanism is likely more than just illness in the household. Unfortunately, our data do not allow us to test for further mechanisms such as beliefs or the intensive margin of the labor supply.

6 Robustness

Tables 8 and 9 contains additional estimates of our coefficients of interest confirming that the results with our preferred specifications above were not due to bias. Table 8 contains estimates that control for additional programs and covariates. Table 9 contains estimates that redefine the sample and include alternative measures of HIV status. Columns 1 of both Tables repeat the estimates from Table 2 for ease of comparison. Each panel is a separate dependent variable.

One potential concern with our estimation is the presence of concurrent programs. In Column 2 of Table 8 we include controls for the availability of prevention of mother-to-child transmission (PMTCT) of HIV and 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 Zambian 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.[22] Then based on this gender ratio, we used the HIV data from the 2002 Zambia DHS 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 large, the increase in the standard error and decrease in the point estimate renders the coefficient

[22] Teachers' ages are not available in the SACMEQ data.

statistically insignificant. In all cases the point estimates moved in the expected direction, towards 0.

While average HIV in the community could affect households with HIV positive and HIV negative household heads similarly, it will be correlated with household head HIV status. Therefore, similar to the concerns in Column 3, in Column 4 we include a triple interaction for the average HIV status of geographic region, province by urban/rural. The grade for age finding is similarly sized and statistically significant, but the finding for timely entry is smaller and no longer statistically significant.

To be sure we are not capturing differences in family structure or adult life cycle dynamics, we control for alternative family structures in Columns 5 and 6. For 3 percent of our sample, both parents are deceased with 7 percent having a deceased mother and 14 percent a decreased father. In Column 5 we included dummy variables for a deceased mother, deceased father, and both parents being deceased. Recall that in our primary specifications we control for the age group of the reference adult, its interaction with post, and the age of the child, likely alleviating many of the concerns that our results are biased by life cycle dynamics. As an additional check, in Column 6 we include a set of dummy variables for birth order.[23,24] Our findings are robust to both of these inclusions.

In Table 9 we limit the sample in three separate ways to further test for the robustness

[23]Due to the structure of the DHS data the birth order was not reported for all of the respondents in our primary sample. For these individuals, we approximate their birth order based on their age relative to the ages of other children in the household and include an additional dummy variable to indicate an approximated birth order.

[24]To further confirm that we are not conflating changes that might have occurred in the likelihood of being age for grade by birth order with ART availability we re-estimate Equation 1 replacing all incidences of HIV status with birth order. The coefficient on the triple interaction is both economically and statistically insignificant with a point value of -0.004 and standard error of 0.006. Therefore, we conclude that our results are not being driven by birth order effects.

of our findings. In 2003 Zambia's Ministry of Community Development and Social Services (MCDSS) started a Social Cash Transfer (SCT) scheme in Kalomo district that was designed to pilot a cash transfer to the most destitute 10 percent of households in the targeted communities (Schubert 2005). By 2007 the program was operating in Chipata, Katete, Kazungula, and Monze districts (Regional Hunger and Vulnerability Program 2007; Seidenfeld and Handa 2011). The amount of the transfer was designed to allow each household to purchase a 50 kg bag of maize per month, enough to increase household consumption from one meal to two meals per day (Regional Hunger and Vulnerability Program 2007). The program did not specifically target HIV positive households, relying instead on perceived destitution. In order to ensure that our results are not being driven by this program, we provide estimates in Column 2 that eliminate these districts from the analysis. The point estimates are quite similar to the estimates over the full sample.

Even though we control for time invariant and time varying heterogeneity by both district and ART availability, in Column 3 we limit our sample to households that were within 10 km of a health facility to ensure that we are not misappropriating access to health care as access to ART. In Column 4 we remove Lusaka Province, the capital of Zambia, to alleviate concerns that our results are driven by or substantially different for Lusaka Province. The point estimates are remarkably similar to the original point estimates.

In the final two columns of Table 9 we use two alternative HIV measures. First in Column 5 we used a binary HIV measure defined as HIV status above or below the median HIV status in the sample. This replaces all instances of HIV in Equation 1. The point estimates under this specification match the significance of the original estimates, but are smaller in magnitude. The point estimates are similar to those from column 1 when considering the

25th to 75th percentage change in HIV status. In Column 6 we use replace all instances of HIV in Equation 1 with actual HIV status if it is known, using the binary HIV status from Column 5 in the case of a missing test result or inability to link an individual due to privacy concerns, additionally controlling for the use of this imputation. The results for both grade for age and timely entry are similar to those in Column 5, but the timely entry results are no longer statistically significant.

Therefore, we find our results robust to the alternative estimates presented.

7 Discussion and Conclusions

This study uses the 2002 and 2007 Zambia DHS repeated cross section 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 likely infected adults.

We find that availability of adult ART resulted in educational gains for primary school aged children in households with likely 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 overall effect on the likelihood of being enrolled in school, our proxy for the extensive margin of schooling, but children in primary grades 1 and 2 were more likely to be enrolled. 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 older 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. Further, our findings confirm the importance of intergereratioanl spillovers of public health interventions and considering the entire household when increasing children's schooling outcomes.

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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 Clinc 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 2002 and 2007 Zambia DHS. The unit of observation is a primary school aged child with five exceptions: Household wealth is at the household level for households with a primary school aged child and the four illness measures are for children aged 0-5.

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

	Enrolled (1)	Grade for Age (2)	Timely Entry (3)
HIV+ * ART Ever * Post	0.178	0.518***	0.763**
	(0.150)	(0.156)	(0.388)
HIV+	0.138*	0.209**	0.391**
	(0.079)	(0.085)	(0.186)
ART Ever	0.065*	0.115***	0.090
	(0.035)	(0.041)	(0.060)
Post	0.138***	0.178***	0.304*
	(0.051)	(0.060)	(0.180)
HIV+ * ART Ever	-0.115	-0.251**	-0.352
	(0.092)	(0.117)	(0.227)
HIV+ * Post	-0.205	-0.292**	-0.528
	(0.127)	(0.143)	(0.338)
ART Ever * Post	-0.070	-0.146**	-0.169*
	(0.047)	(0.057)	(0.101)
Observations	12,128	12,128	1,933
Rsquared	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 dummy variables for child age, household head age group, district, month of survey, urban, female, household head age group times post, and district dummy variables times post.

Table 3: Effect of Adult ART on Children's Schooling - Analysis By Grade

	Enrolled (1)	Grade for Age (2)
Primary 1	0.531*** (0.166)	0.592*** (0.165)
Primary 2	0.448*** (0.157)	0.641*** (0.175)
Primary 3	0.219 (0.143)	0.388** (0.176)
Primary 4	0.087 (0.156)	0.441** (0.185)
Primary 5	-0.024 (0.161)	0.575*** (0.144)
Primary 6	-0.009 (0.143)	0.622*** (0.187)
Primary 7	-0.009 (0.156)	0.410** (0.186)
Test of equality of coefficients		
F Statistic	8.50	2.29
p-value	0.00	0.06
Observations	12,128	12,128
Rsquared	0.19	0.22

Notes : * significant at 10%; ** significant at 5%; *** significant at 1%. The coefficients presented are those from the interaction of HIV*ART*post*relevant grade level, primary 1 through 7. 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 dummy variables for child age, household head age group, district, month of survey, urban, female, household head age group times post, and district dummy variables times post.

Table 4: Effect of Adult ART on Children's Schooling - Distance and Timing Gradients

	Grade for Age	
	(1)	(2)
0 to 5 km	0.664***	
	(0.166)	
5 to 10 km	0.979**	
	(0.422)	
10 to 15 km	0.238	
	(0.343)	
15 to 20 km	0.514	
	(0.407)	
HIV+ * ART Ever * Post		0.371
		(0.235)
HIV+ * ART Ever * Months of ART		0.005
		(0.007)
Test Coefficients are Jointly Equal to 0		
F-statistic		5.52
p-value		0.01
Observations	12,128	12,128
Rsquared	0.22	0.22

Notes : * significant at 10%; ** significant at 5%; *** significant at 1%. In column 1 the coefficients presented are those from the interaction of HIV*ART*post where the distance band is substitiuted for ART. 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 dummy variables for child age, household head age group, district, month of survey, urban, female, household head age group times post, and district dummy variables times post.

Table 5: Mechanisms - Labor and Wealth

	Household Head		Household Wealth	Improved Floor Material
	Currently Working	Worked in the Last 12 Months		
	(1)	(2)	(3)	(4)
HIV+ * ART Ever * Post	-0.158	-0.192	0.353	0.073
	(0.183)	(0.132)	(0.469)	(0.211)
HIV+	-0.022	0.000	0.337	0.104
	(0.093)	(0.073)	(0.233)	(0.098)
ART Ever	-0.047	-0.033	0.274**	0.122**
	(0.041)	(0.028)	(0.113)	(0.047)
HIV+ * ART Ever	0.175	0.146	-0.417	-0.169
	(0.151)	(0.104)	(0.351)	(0.140)
HIV+ * Post	0.162	0.157	0.134	0.164
	(0.130)	(0.102)	(0.358)	(0.174)
ART Ever * Post	-0.005	0.022	-0.226*	-0.089
	(0.047)	(0.034)	(0.132)	(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 statistical enumeration area level appear in parenthesis. The sample is limited to households with at least one child in expected grades 1-7 and a valid HIV approximation for their household head. Columns 1, 2, and 4 are linear probability models. Column 3: the dependent variable is a normalized measure of wealth with mean 0 and standard deviation of 1 across all households in the full DHS survey. All columns include dummy variables for household member age group, district, month of survey, urban, female, household member age group times post, and district dummy variables times post.

Table 6: Mechanisms - Illnesses

	Diarrhea (1)	Fever (2)	Cough (3)
HIV+ * ART Ever * Post	-0.157	-0.395**	-0.240
	(0.146)	(0.169)	(0.191)
HIV+	0.04	-0.229**	-0.055
	(0.082)	(0.097)	(0.089)
ART Ever	-0.035	-0.070***	-0.021
	(0.023)	(0.026)	(0.029)
HIV+ * ART Ever	-0.014	0.241**	0.139
	(0.091)	(0.112)	(0.113)
HIV+ * Post	0.191	0.331**	0.065
	(0.125)	(0.144)	(0.145)
ART Ever * Post	0.063**	0.096***	0.048
	(0.030)	(0.037)	(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 statistical enumeration area 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 dummy variables for child age, household head age group, district, month of survey, urban, female, household head age group times post, and district dummy variables times post.

Table 7 - HIV Status of Alternative Adults

	Attends School	Grade for Age	Timely Entry	Diarrhea	Fever	Cough
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Mother						
HIV+ * ART Ever * Post	0.207	0.252	0.698*	-0.354**	-0.351**	-0.112
	(0.174)	(0.253)	(0.418)	(0.151)	(0.171)	(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
Panel B: Father						
HIV+ * ART Ever * Post	0.040	0.510**	0.554	-0.413**	-0.491***	-0.362*
	(0.208)	(0.250)	(0.498)	(0.171)	(0.188)	(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
Panel C: Maximum across Head, Mother, and Father						
HIV+ * ART Ever * Post	0.157	0.412**	0.837**	-0.195	-0.348**	-0.152
	(0.153)	(0.175)	(0.377)	(0.140)	(0.157)	(0.183)
Observations	12,267	12,267	1,949	10,634	10,634	10,634
Rsquared	0.19	0.22	0.24	0.08	0.14	0.08

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors clustered at the statistical enumeration level level appear in parenthesis. Each panel uses the likely HIV status of a different household member. Panel A: Mother. Panel B: Father. Panel C: Maximum HIV status across household head, mother, and father. A non-missing HIV status for any of these adults is sufficient to be included in this panel. Columns 1-2: The sample is limited to children in expected grade 1-7 with a valid HIV approximation for their household adult as listed in the panel. Column 3: The sample is limited to children who should be grade 1 with a valid HIV approximation for their household adult as listed in the panel. Columns 4-6: The sample is limited to children aged 0 to 5 with a valid HIV approximation for their household adult as listed in the panel. All columns are linear probability models and include dummy variables for child age, household member age group, district, month of survey, urban, female, household member age group times post, and district dummy variables times post.

Table 8 - Specification Checks - Concurrent Programs and Covariates

Dependent Variable as Indicated in Each Panel	Preferred Specification (Table 2)	Additional Covariates				
		Other HIV Services	Teacher HIV Status	Average HIV Status	Orphan Status	Birth Order
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Attended School						
HIV+ * ART Ever * Post	0.178	0.214	0.122	0.057	0.168	0.145
	(0.150)	(0.155)	(0.140)	(0.143)	(0.145)	(0.147)
Observations	12,128	12,128	12,128	12,128	12,128	12,128
Rsquared	0.19	0.23	0.19	0.19	0.19	0.19
Panel B: Grade for Age						
HIV+ * ART Ever * Post	0.518***	0.478**	0.400***	0.431***	0.495***	0.472***
	(0.156)	(0.230)	(0.148)	(0.154)	(0.157)	(0.156)
Observations	12,128	12,128	12,128	12,128	12,128	12,128
Rsquared	0.22	0.22	0.22	0.22	0.22	0.23
Panel C: Timely Entry						
HIV+ * ART Ever * Post	0.763**	0.847**	0.560	0.282	0.773*	0.678*
	(0.388)	(0.390)	(0.435)	(0.440)	(0.400)	(0.391)
Observations	1,933	1,933	1,933	1,933	1,933	1,933
Rsquared	0.24	0.24	0.24	0.24	0.24	0.26

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 a triple interaction with average HIV status in the geographic region. Column 5 includes three additional dummy variables: whether the mother of the child is decreased, whether the father of the child is deceased, and whether both parents are deceased. Column 6 includes dummy variables for birth order.

Table 9 - Specification Checks - Sample and HIV Status

Dependent Variables as Indicated in Each Panel

					Alternative HIV Measure	
	Preferred Specification (Table 2)	Removing Social Cash Transfer Districts	Sample Limited to Households within 10km of a Health Facility	Removing Lusaka Province	Above or Below Median	Actual When Available
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Attended School						
HIV+ * ART Ever * Post	0.178	0.161	0.202	0.129	0.060	0.057
	(0.150)	(0.159)	(0.160)	(0.155)	(0.042)	(0.044)
Observations	12,128	11,067	9,170	10,709	12,128	12,128
Rsquared	0.19	0.19	0.184	0.197	0.19	0.187
Panel B: Grade for Age						
HIV+ * ART Ever * Post	0.518***	0.508***	0.542***	0.485***	0.142**	0.140**
	(0.156)	(0.166)	(0.185)	(0.164)	(0.056)	(0.062)
Observations	12,128	11,067	9,170	10,709	12,128	12,128
Rsquared	0.22	0.23	0.22	0.23	0.22	0.22
Panel C: Timely Entry						
HIV+ * ART Ever * Post	0.763**	0.733*	0.795*	0.810**	0.210*	0.139
	(0.388)	(0.409)	(0.463)	(0.398)	(0.123)	(0.114)
Observations	1,933	1,766	1,428	1,707	1,933	1,933
Rsquared	0.24	0.25	0.24	0.25	0.24	0.24

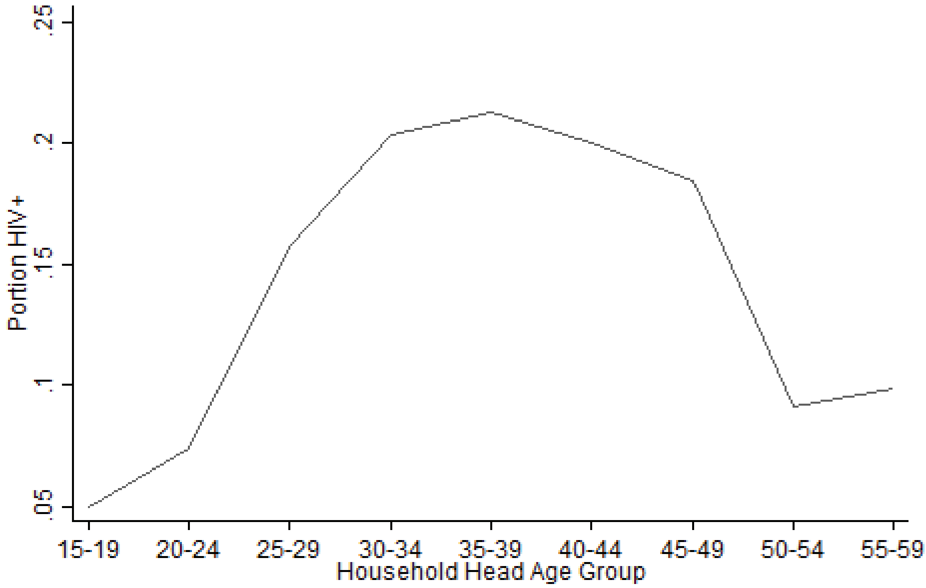
Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors clustered at the cluster level appear in parenthesis. Panels A and B: The sample is limited to children or primary school age with a valid HIV approximation for their household head. Panel C: Sample limited to children 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 removes the 4 districts with cash transfer schemes. Column 3 limits the sample to households within 10 km of a health facility. Column 4 removes observations in Lusaka province. Column 5 replaces all instances of the HIV measure with one that is an indicator for above or below median HIV likelihood. Column 6 replaces all instances of the HIV measure with an individual's test result if available or the same measure as in Column 5 if not.

Appendix Table - Trends in Children's Schooling

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

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

Figure 1: Age Profile of HIV Status



Authors calculations based on data from Zambia DHS