AIDS Treatment Scale-Up and Child Schooling in Sub-Saharan Africa

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Abstract

Antiretroviral therapy (ART) dramatically reversed the sharp rise in AIDS-related mortality in sub-Saharan Africa. Economic theory predicts that longer life expectancy increases human capital investment by raising expected returns to schooling. What has been the impact of expanding ART availability on child education? To identify ART scale-up at the sub-national level, I employ a novel method based on trends in regional HIV prevalence rates among adults who were most likely to benefit from access to ART in terms of survivorship. Through a reduction in AIDS mortality, ART scale-up may be positively correlated with HIV prevalence rates for this sub-population, and thus, contrary to findings from studies using data pre-dating 2005, the relationship between HIV prevalence and child schooling could be positive. Indeed, my results suggest that the successful implementation of ART helped to increase current school enrollment among children 7 to 14 years old, non-orphans and orphans alike, and to decrease the number of years that children were falling behind grade-for-age. I find little evidence that intrahousehold allocation of labor, attitudes towards HIV-positive teachers, or public goods provision can explain the results, but allocation of public spending at the country-level may be an important channel.

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1 Introduction

Antiretroviral therapy (ART) revolutionized the clinical treatment of AIDS. While it does not destroy HIV-producing cells in the human body, ART stops the virus from replicating and thereby lowers the viral load in an infected individual. A lower viral load has two significant benefits: first, AIDS patients can ward off opportunistic infections that would have led to death, and second, the rate of transmitting HIV between couples or from mother to child decreases. Since ART became available, population-level studies from demographic surveillance sites in South Africa, Malawi, and Uganda have shown substantial reductions in adult mortality (Bor et al., 2013; Jahn et al., 2008; Mills et al., 2011). The effectiveness of antiretroviral drugs in preventing mother-to-child transmission of HIV is also well documented (see WHO, 2006), and although behavioral disinhibition may lessen its effectiveness in the general population, ART has been shown to suppress rates of new infection (i.e. incidence) in controlled settings (Cohen et al., 2011).

Economic theory predicts that changes in life expectancy influence investment in human capital, namely education. Intuitively, returns to schooling increase with life expectancy because an individual with a longer life span has more time to enjoy a higher wage rate than his or her counterpart with similar educational attainment but shorter life expectancy. On the margin, the latter individual has less to gain from an additional year of schooling and therefore would leave school for employment at a younger age. Studies based on large-scale interventions that have extended life expectancy find evidence supporting higher investment in education (e.g. Jayachandran and Lleras-Muney, 2009; Lucas, 2010), and Fortson (2011) shows a significant decline in educational attainment among adults living in regions where adult HIV prevalence rates had grown most rapidly before ART became widely accessible in sub-Saharan Africa.[1]

Aside from extending life expectancy, ART may affect child schooling through numerous alternate channels. Adults on ART may take up household duties that children would have had to fulfill; with fewer responsibilities at home, children have time to attend school and are more likely to progress through school on-time. Adults receiving ART may also be able to generate income, which would pay for school fees and supplies, and HIV-positive teachers may be strong enough to resume teaching. Parents may be more willing to send their children to school as stigma towards

[1] In line with "common convention" and Easterly (2009), I will refer to 'sub-Saharan Africa' as 'Africa' in the reminder of the paper.

HIV-positive teachers subsides. ART roll-out may be a marker of international health aid, which could free up government funds for education or for other public goods. Higher government spending on education could manifest in upgraded facilities, higher or more reliable pay for teachers, or an overall greater supply of teachers. Public goods (e.g. electricity, sanitation, and piped water) may reduce time and energy spent on housework. Unprotected water sources and poor sanitation can lead to more cases of acute illnesses, which prevent children from attending school, or impair nutritional absorption, which impedes the child's physical and cognitive development.

In this paper, I employ a new method to identify ART scale-up at a sub-national level, and I show suggestive evidence that, among children 7 to 14 years old, ART scale-up helped to increase school attendance and to decrease the number of years that children were falling behind grade-for-age. The method draws on the idea that we can infer ART scale-up from trends in HIV prevalence rates among adults who were most likely to benefit from access to ART. More specifically, with additional assumptions that I elucidate in section 4, ART scale-up and trends in HIV prevalence rates are positively correlated for this sub-population through a reduction in AIDS mortality. Typically, one would expect that schooling outcomes deteriorate in places where the fraction of "sick people" (or HIV prevalence) is higher. However, ART can allow people with HIV to live almost normal life expectancies (e.g. Mills et al., 2011), and HIV prevalence could actually be higher when access to HIV treatment expands.

Is there "proof of concept" that ART scale-up can increase HIV prevalence? Using longitudinal data from a demographic surveillance site in rural South Africa, researchers documented a "dramatic increase in HIV prevalence after scale-up of antiretroviral treatment" between 2004 and 2011 (Zaidi et al., 2013). The authors show that the increase in HIV prevalence is driven by ART recipients and concentrated among adults 25-49 years old. The study challenges the notion that rising HIV prevalence is, strictly speaking, a cause for alarm because the trend could be driven by lower AIDS mortality rather than higher rates of new infection.

Two recent studies in the economics literature find that access to ART increased investment in child education. With two rounds of data on rural households - some of which had members who began ART before the first round and others began ART in-between rounds - in western Kenya, Zivin et al. (2009) show that children 8 to 18 years old from households in which a member began ART "early" (i.e. before the first survey) experienced larger gains in 'hours at school during

the previous 7 days' than other children in the sample. These gains cannot be attributed to a reduction in children's participation in the labor market. Studying the same population, d'Adda et al. (2009) document that the amount of time girls 14 to 18 years old spent collecting water and boys 8 to 13 years old spent on housework in the past week declined after an adult household member initiated ART. While less time spent on non-market labor may be a channel through which ART affects school attendance, the authors did not directly test the hypothesis. Using three survey rounds[2] of the Malawi Longitudinal Study of Families and Health, Baranov and Kohler (2012) find that household expenditure on child's education increased among those living near an ART facility relative to those living farther from the facility.[3] Moreover, higher spending on education, unlike spending on health care, was not exclusive to households with HIV-positive members.

By evaluating access to ART at a sub-national region level across seven high-HIV-prevalence countries, this paper complements the existing literature and makes four contributions. First, studying ART scale-up by region rather than by individual ART receipt may better capture general equilibrium effects on households that are not directly impacted by ART. Second, looking across several African countries, I can address the generalizability of the results from previous papers, which are based on geographically focused areas because of data constraints. Despite our differences in methodology, the results collectively point toward improvements in child schooling with ART scale-up, even among households in which no adult needed ART. The third contribution of this study is that, with a larger sample size, I am able to investigate whether orphans have been included or excluded from such improvements. I find that orphans from regions with more successful ART roll-out are doing better in terms of school attendance and advancement in school relative to their counterparts from regions with less successful roll-out. Lastly, in my analysis of potential channels, I do not find strong evidence that intrahousehold allocation of labor, HIV/AIDS attitudes, or public goods provision serve as critical links between regional ART scale-up and schooling. However, budgetary allocations at the national level may be an important avenue for future research.

My findings suggest that, in addition to reversing AIDS mortality among prime-aged adults, ART scale-up may dynamically benefit society through child education. However, it remains unclear whether people are, in fact, achieving higher levels of educational attainment that translate to higher

[2]The three survey rounds correspond to years 2006, 2008, and 2010. ART became available in the districts shortly before the 2008 round.

[3]Distance is defined as the negative of log distance by road.

productivity and improved wellbeing. Also, since ART roll-out largely began in the mid-2000s, studies have thus far only been able to show short-run effects rather than medium-run or long-run effects.

The paper is organized as follows: in section 2, I highlight essential facts about ART scale-up in Africa during the 2000s. In section 3, I describe the data, sample, and construction of the key variables, such as HIV prevalence and grade-for-age. I detail the empirical strategy and regression models in section 4. The main results are presented in section 5. Section 6 consists of two parts - I test the sensitivity of the results in subsection 6.1, and I discuss potential channels that the data supports or does not to support in subsection 6.2. Finally, in section 7, I conclude with suggestions for future work.

2 Background: ART scale-up in sub-Saharan Africa during the 21st century

I briefly summarize key events in the effort to scale up ART during the 2000s, and readers who seek a more detailed account are referred to Duh (2013).

Between 1999 and 2004, development assistance to Africa marked for HIV/AIDS (which includes but is not exclusive to HIV treatment) reached unprecedented levels in the history of global health policy. Three of the largest funders for HIV programs launched during this period: (1) World Bank's Multi-country HIV/AIDS program, which began in 1999; (2) The Global Fund to Fight AIDS, Tuberculosis, and Malaria (GFATM), which started in 2002; and (3) the U.S. President's Emergency Plan for AIDS Relief (PEPFAR), which released its initial disbursement in 2004. Altogether, between 1998 and 2008, HIV/AIDS commitments increased by over 40-fold[4] and rose to nearly 50% of total aid for health, population and reproductive health, and social programs to Africa in 2008 (see Figure 1).

Implementation, rather than fundraising, has been a bigger challenge for ART scale-up. Many countries lacked adequate infrastructure and personnel, and the AIDS epidemic weakened health systems that were already struggling (Case and Paxson, 2011). In 2003, the World Health Organization (WHO) launched the 3 by 5 Initiative; "3 by 5" stood for "3 million people [on ART] by

[4]HIV/AIDS donor aid commitments summed to $110 million in 1998 and $5.07 billion in 2008 (OECD CRS).

2005." The goal was ambitious, and the initiative spurred countries to formulate concrete plans to roll-out ART. At the end of 2005, countries submitted "country summary profiles for HIV/AIDS treatment scale-up" that detailed their progress as of December 2005. The goal of 3 million on ART was achieved in 2007 (WHO, 2008), and in 2012, 9.7 million were reportedly receiving ART (UNAIDS, 2013).

Not surprisingly, there is considerable heterogeneity in how quickly countries have been able to expand ART coverage depending on factors such as diplomatic relationships with OECD countries[5], prior experience with implementing large-scale health interventions (e.g. DOTS for Tuberculosis), and sheer size of the country. However, by 2008, many countries in Eastern and Southern Africa had reached 40% of the projected number of HIV-positive people with CD4 cell counts below 200 cells per cubic millimeter, i.e. "ART eligible" individuals in the final stage of the HIV infection (see Figure 2). Thus, in this study, I refer to the years 2003 through 2005 as the pre-ART period and 2009 through 2012 as the post-ART period.

3 Data: Demographic and Health Surveys

The data comes from the Demographic and Health Surveys (DHS), which are nationally representative household-based surveys focusing on reproductive and population health. The MEASURE DHS project is run by ICF International, a publicly traded consulting company based in the United States, and funded by the U.S. Agency for International Development (USAID). Since 1984, DHS has conducted 307 surveys across 90 countries in sub-Saharan Africa, North Africa/West Asia/Europe, Central Asia, South & Southeast Asia, Australasia, and Latin America & Caribbean. When possible, surveys are fielded every five years in a given country.

In 2001, DHS began testing survey respondents for HIV. Adults 15-49 years old from households that had been randomly selected for the men's questionnaire were asked to participate in the HIV testing module. During the interview, the surveyor collected blood specimens using dried blood spot tests[6], which involved pricking the finger of each participant. The participant was informed that he (or she) would not learn the results of the test[7], but DHS provided referrals to free Voluntary

[5]For example: in 2003, PEPFAR designated 15 "focus countries" (including Ethiopia, Kenya, and Rwanda but not Lesotho, Malawi, or Zimbabwe) that received the bulk of aid.

[6]For Zambia 2001/02, an intravenous blood sample was taken instead of the dried blood spot test.

[7]DHS wanted to minimize reasons for respondents to refuse testing, such as fear of learning their HIV status.

Counseling and Testing (VCT) services. The blood specimen was sent to a lab for testing.

Sub-national HIV prevalence rates are calculated using these test results, and household-survey-based HIV prevalence rates have advantages and disadvantages. In the past, HIV prevalence rates were computed using information from antenatal care clinics; this means that the samples consisted of women who had unprotected sex, and HIV prevalence was likely overstated. In principle, the HIV prevalence rates based on DHS data are representative of the population, but non-responses - largely attributable to refusals or absences - could bias the estimates upwards or downwards. Rates of non-responses are sizable and range from 1.5% (Rwanda 2010) to 33% (Malawi 2004). Duh (2013) finds that non-testers in the DHS were more likely to be HIV-positive than testers, which is consistent with other papers on self-selection for HIV testing (e.g. Arpino et al., ming). However, imputing the HIV status for non-responders did not substantially change regional HIV prevalence rates, and correcting for non-responders in the HIV prevalence rates had a negligible impact on the main results for utilization of maternal and child health services in Duh (2013).

My sample consists of children 7 to 14 years old from seven African countries: Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. These seven countries were selected for two reasons: first, each of the seven countries has two survey rounds with HIV testing so that I could study changes in regional HIV prevalence rates, and second, these seven countries are comparable in levels of schooling and HIV prevalence rates prior to ART scale-up. Figure 3 shows trends in school attendance rates from 2003-05 [pre-ART period] to 2009-12 [post-ART period] across 11 countries, all of which are located in sub-Saharan Africa and have at least two survey rounds with HIV testing in the DHS.[8] From left to right, the countries are ordered from lowest to highest rate of school attendance in the pre-ART period. There is a clear jump from Senegal to Tanzania; in Tanzania, the fraction of children 7 to 14 years old who attended school in the current school year was above 80% whereas, in Senegal, stood below 60%. Not only are the baseline levels in school attendance dramatically different, but there is also a clear divide in pre-ART national adult HIV prevalence

[8]As of March 2014, there are 17 countries with two or more rounds of HIV testing in the DHS: Benin (2006, 2011/12), Burkina Faso (2003, 2010), Cameroon (2004, 2011), Cote d'Ivoire (2005, 2011/12), Ethiopia (2005, 2011), Guinea (2005, 2012), Kenya (2003, 2008/09), Lesotho (2004, 2009), Malawi (2004, 2010), Mali (2001, 2006), Niger (2006, 2012), Rwanda (2005, 2010), Senegal (2005, 2010/11), Tanzania (2003/04, 2007/08, 2011/12), Uganda (2004/05, 2011), Zambia (2001/02, 2007), and Zimbabwe (2005/06, 2010/11). For Benin and Uganda, the HIV datasets were not publicly available for at least one round. The first two countries to field the HIV testing module, Mali and Zambia, lack information on the post-ART period. The first round available for Niger is 2006, which I consider to be the post-ART period.

rates. More than 3% of adults 15- 49 years old were living with HIV in Tanzania, Cameroon, Rwanda, Malawi, Lesotho, Zimbabwe, and Kenya; in contrast, less than 2% of prime-aged adults in Burkina Faso, Ethiopia, Guinea, and Senegal were HIV-positive.

Why focus on children 7 to 14 years old? According to UNESCO[9], the starting age of compulsory schooling is 6 or 7 years, which coincides with the starting age of primary school. I chose age 7 as a cut-off to avoid counting children who may not yet attend school because of government regulations. As the child gets older, school attendance becomes an individual rather than household decision. Age 14 is around the ending age of compulsory schooling. Also, a number of surveys, including the DHS, consider individuals who are 15 to 49 years old to be prime-aged adults, and 15 year-olds are eligible for other questions in the survey. Thus, one might worry about a "survey effect" for youths aged 15 or older.

One important detail is that the sample includes children 7 to 14 years old who are alive at the time of interview, and the sample composition might change if ART increases survival among mothers and children with HIV. In the absence of HIV treatment, children born with HIV typically die by age five (Newell et al., 2004). Since I am looking at effects of ART scale-up in the short-run, babies who were affected by increasing access to HIV treatment may not have reached school starting age by 2009-2012. However, I check whether observable household characteristics of children ages 7 to 9, who may have been affected by ART roll-out around their birth, systematically differed from children ages 11 to 13. As shown in Panel A of Appendix Table 1, I do not find evidence that children 7 to 9 years old were more selected on observable dimensions, such as highest educational attainment of an adult household member or female-headed household, in the post-ART period relative to children 11 to 13 years old.

There are three key outcomes in my analysis: (1) did the child attend school during the current school year; (2) is the child behind grade-for-age; and (3) if the child is behind, how many years does he or she lag in grade-for-age? Current school attendance is binary and equals 1 if the child attended school at some point during the academic year. I define grade-for-age based on the child's years of completed schooling and country-specific starting ages for compulsory schooling (or primary school) from UNESCO. The starting age is 6 years old in Cameroon, Kenya, Lesotho, Malawi, and Zimbabwe; in Rwanda and Tanzania, the starting age is 7 years old. Without knowing the child's

[9]UNESCO stands for the United Nations Educational, Scientific and Cultural Organization.

birth month and year, we might wrongly count a child as being behind when, in fact, his (or her) birthday had just passed during the academic year. Thus, if the legal starting age is 6 years old, I consider an 8-year-old child who has completed one year of schooling to be on-time, and if the legal starting age is 7 years old, then a 9-year-old child who has completed one year of schooling is on-time. If the child is ahead in school by more than three years, grade-for-age is recoded as missing. 'Years behind grade-for-age' can take on integer values between -3 and 7; conditional on the child being behind grade-for-age, the number of years must be strictly greater than zero and would range from 1 to 7. Assuming that the child's age is accurately reported, this definition understates the true number of children who were behind grade-for-age. However, it improves upon more arbitrary definitions that have been employed in the literature.[10]

Table 1 reports the sample means. Columns 1 and 2 show the means for children 7 to 14 years old in the pre-ART period (2003-2005) and post-ART period (2009-2012), respectively. The difference in means is displayed in column 3, and stars indicate that the difference is statistically significant at the 5% level.

One can see from the grand sample means that baseline school attendance rates are high, and improvements in schooling outcomes are most pronounced among children 11 to 14 years old. Figure 4 plots school attendance rates by age: attendance peaks at age 11, and in the post-ART period, there was an uptick in attendance among 13 and 14 years-old children. In light of our definition for "grade-for-age," it is not surprising that the fraction of children who are behind rises with age. However, since we observe a greater decline in the probability of falling behind grade-for-age among older children, students in the post-ART period were likely to have been advancing through school in a more timely manner than their pre-ART counterparts. The pattern is evident in Figure 5, which plots the share of children behind grade-for-age by age (solid lines) and, conditional on being behind, the average number of years behind grade-for-age (dashed lines).

The rest of Table 1 compares children in the pre-ART and post-ART periods on observable characteristics. The post-ART sample is younger and more likely to be female. Fewer children come from urban areas, but on the basis of access to electricity and type of flooring, these children are materially better off. Regarding educational attainment among adults in the household, I note

[10]Fortson (2011) assumes that a child should have completed one year of schooling by 8 years old: Years behind grade-for-age = Age - (Years completed + 7).

two concurrent trends - on one hand, as seen by the drop in uneducated adults and adults who never finished primary school, educational attainment has increased; on the other hand, as seen by the decrease in adults who went beyond a secondary education, highly educated individuals may be less likely to have children. In the post-ART period, there are fewer orphans, and adults in the household are far more likely to have an inclusive attitude towards female teachers with HIV. Whereas 70% of children lived in households in which all adults felt that HIV-positive female teachers[11] should be allowed to teach in the pre-ART period, the share of children in households with inclusive attitudes jumped by 19 percentage points to 89.2% in the post-ART period. Before ART scale-up, the average child lived in a region where 7.9% of adults 15-49 years old and 2% of adults 15-19 years old tested HIV-positive. Approximately five years later, the average child lived in a region where fewer prime-aged and young adults were infected with HIV. However, we cannot reject that, for the average child, HIV prevalence did not change among adults in the birth cohorts most impacted by HIV treatment.

Overall, the sample means reflect that material circumstances improved for the average child 7 to 14 years old, and changes in schooling were most dramatic among relatively older children.

4 Inferring ART scale-up from trends in HIV prevalence rates

The empirical strategy of this paper relies on the notion that, since HIV infections do not immediately kill their hosts and can take several years to progress to AIDS, short-term effects of ART scale-up can vary across subgroups of the population when the average illness severity differs by subgroup. Focusing on specific subgroups can help to inform where HIV treatment had been most effective in prolonging life. In subsection 4.1, I decompose a change in HIV prevalence for a fixed birth cohort. I show that, conditional on new infection rates and changes in the population size of HIV-negative cohort members, we would expect a positive correlation between ART scale-up and the trend in HIV prevalence through a decrease in AIDS-related deaths. I argue that adults born between 1965 and 1975 (adults around 30-40 years old in the pre-ART period and 35-45 years old in the post-ART period) were most likely to benefit from access to ART in terms of survival; thus, following members of the birth cohorts 1965-1975 can be informative about the success of ART

[11] The question in the DHS specifically asks about female teachers only; see subsection 6.2 for the exact wording on the questionnaire [in English].

roll-out in the region. To pin down cross-regional variation in new infections, I examine changes in the HIV prevalence rates of adults 15-19 years old. In subsection 4.2, I present the regression models for analysis. To evaluate whether ART scale-up may have encouraged school attendance, I use a logit model with region fixed effects; to study the extent to which ART scale-up affected timely progression through school, I employ a linear model with region fixed effects.

4.1 Decomposition of a change in HIV prevalence for a fixed birth cohort

The HIV prevalence rate for a designated subgroup is defined as the number of HIV-positive individuals belonging to this group divided by the total number of people in the group. A person can acquire HIV through a transmission of bodily fluid (usually blood, semen, or breast-milk) from someone who has the virus. Since a cure for AIDS has not yet been discovered, HIV is an absorbing state such that death is the only way that the number of people living with HIV for a given cohort would drop. Allowing for migration, the number of HIV-positive individuals in a geographic area could increase with in-migration and decrease with out-migration. Thus, the number of HIV-positive individuals belonging to birth cohort k at time $t+1$ can be written as

$$HIV_{t+1}^k = HIV_t^k + Infect_t^k - AIDS_t^k + \left(InHIVMigrate_t^k - OutHIVMigrate_t^k\right), \qquad (1)$$

where HIV_t^k is the number of HIV-positive individuals at the beginning of the previous year (i.e. t), $Infect_t^k$ is the number of new infections during year t, $AIDS_t^k$ is the number of deaths among HIV-positive individuals - likely because of AIDS - during year t, $InHIVMigrate_t^k$ is the number of HIV-positive in-migrants during year t, and $OutHIVMigrate_t^k$ is the number of HIV-positive out-migrants during year t. The size of the population of birth cohort k at time $t+1$ can also be written as

$$Pop_{t+1}^k = Pop_t^k - Deaths_t^k + \left(InMigrate_t^k - OutMigrate_t^k\right), \qquad (2)$$

where Pop_t^k is the size of the population at the beginning of the previous year (t), $Deaths_t^k$ is the total number of deaths among HIV-positive and HIV-negative individuals during year t, $InMigrate_t^k$ is the total number of in-migrants during year t, and $OutMigrate_t^k$ is the total number of out-migrants during year t. $AIDS_t^k$ is a subset of $Deaths_t^k$, and $InHIVMigrate_t^k$ and $OutHIVMigrate_t^k$ are

subsets of $InMigrate_t^k$ and $OutMigrate_t^k$ respectively. For notational ease, I have suppressed the index for geographic region.

Combining equations 1 and 2, we can express the change in HIV prevalence from t to $t+1$ as

$$\begin{aligned}\frac{HIV_{t+1}^k}{Pop_{t+1}^k} - \frac{HIV_t^k}{Pop_t^k} &= \frac{Infect_t^k}{Pop_t^k} - \frac{AIDS_t^k}{Pop_t^k} + \frac{InHIVMigrate_t^k - OutHIVMigrate_t^k}{Pop_t^k} \\ &+ \left(\frac{Deaths_t^k}{Pop_t^k} - \frac{InMigrate_t^k - OutMigrate_t^k}{Pop_t^k}\right)\frac{HIV_{t+1}^k}{Pop_{t+1}^k}.\end{aligned} \tag{3}$$

All else equal, the HIV prevalence rate of birth cohort k increases with more new infections, decreases with more AIDS-related deaths, increases with net in-migration of HIV-positive individuals, and increases with more deaths from non-AIDS causes among HIV-negative individuals or with net out-migration. Conditional on new infections, net migration, and non-AIDS deaths, a region with lower AIDS mortality would see a smaller decline in HIV prevalence over time relative to an identical region with higher death rates from AIDS. In other words, since ART reduces AIDS mortality, one could expect to see a positive correlation between ART scale-up and the change in HIV prevalence rate for a given place and birth cohort, holding fixed other factors on the right-hand side of equation 3.[12]

Equation 3 illustrates that, at face value, trends in HIV prevalence rates are difficult to interpret because we may not know which component(s) is(are) responsible for the change. A decline in HIV prevalence may be attributable to fewer new infections (because of a successful HIV prevention campaign), higher AIDS mortality (because HIV patients could not access treatment), net out-migration of HIV individuals (because a neighboring district offered more generous support for

[12] If we separated out deaths and net migration for HIV-positive and HIV-negative individuals, then equation 3 could be rewritten as

$$\begin{aligned}\frac{HIV_{t+1}^k}{Pop_{t+1}^k} - \frac{HIV_t^k}{Pop_t^k} &= \frac{Infect_t^k}{Pop_t^k} - \frac{AIDS_t^k}{Pop_t^k}\left(1 - \frac{HIV_{t+1}^k}{Pop_{t+1}^k}\right) + \frac{InHIVMigrate_t^k - OutHIVMigrate_t^k}{Pop_t^k}\left(1 - \frac{HIV_{t+1}^k}{Pop_{t+1}^k}\right) \\ &+ \left(\frac{NonAIDSdeaths_t^k}{Pop_t^k} - \frac{InNonHIVMigrate_t^k - OutNonHIVMigrate_t^k}{Pop_t^k}\right)\frac{HIV_{t+1}^k}{Pop_{t+1}^k},\end{aligned}$$

where $NonAIDSdeaths_t^k$ is the number of deaths among HIV-negative individuals, $InNonHIVMigrate_t^k$ is in-migration of HIV-negative individuals, and $OutNonHIVMigrate_t^k$ is out-migration of HIV-negative individuals in period t for adults belonging to cohort k. Note that

$$\begin{aligned}Deaths_t^k &= AIDS_t^k + NonAIDSdeaths_t^k, \\ InMigrate_t^k &= InHIVMigrate_t^k + InNonHIVMigrate_t^k, \\ OutMigrate_t^k &= OutHIVMigrate_t^k + OutNonHIVMigrate_t^k.\end{aligned}$$

people living with HIV), fewer deaths from non-AIDS causes (because success in another health initiative increased the size of the HIV-negative population), or net in-migration of HIV-negative individuals. The problem is that, while HIV prevalence rates are observable, we do not observe the individual factors on the right-hand side of equation 3. In the absence of reliable data on these factors, I propose that focusing on well chosen sub-populations can help to disentangle them.

How do we choose a sub-population that would be informative about ART roll-out? Extending the life expectancy of people living with HIV is the first-order benefit of ART in the general population. However, in a pooled sample of all adults 15-49 years old, one may not see dramatic differences in mortality rates between places with and without ART for two reasons: first, an HIV-positive individual can be asymptotic for several years after seroconversion, and second, people - particularly older individuals - die from non-AIDS causes as well. In the span of five years, who is most likely to benefit from HIV treatment in terms of survival? To answer this question, the age-profile of mortality in an area with high HIV prevalence can help, and previous studies have documented that "excess HIV mortality" is most stark among prime-aged adults (20-60 years old), particularly adults 25-45 years old (e.g. Ardington and Case, ming; Bor et al., 2013; Oster, 2010). I choose to follow adults 30-40 years old at the onset of the study from the early to late 2000s. These adults belong to the birth cohorts of 1965 to 1975, and I call them the "high [ART] impact cohort." If members of the "high impact cohort" are likely to die without ART, then AIDS mortality would be a dominant factor in the trend in HIV prevalence rates for this cohort. Drawing from our discussion above, we would observe a positive correlation between ART scale-up and changes in HIV prevalence among adults of the "high impact cohort" so long as new infections, migration, and deaths from non-AIDS causes are held fixed.

How can we control for new infections, net migration, or non-AIDS deaths? For non-AIDS deaths and net migration, I strategically choose a cohort and level of geographic aggregation to minimize their contributions to the changes in HIV prevalence rates. In the absence of AIDS, the age profile of the log odds of mortality resembles a check-mark with a long right tail. Conditional on surviving past age five, mortality linearly rises with age. Thus, I select a cohort for which a sizable number have advanced HIV infections but not so many are dying from other causes. Regarding migration, I choose a level of aggregation that is fine enough to detect sub-national variation in disease prevalence or program roll-out, but broad enough such that migration is limited. For example: Malawi has

3 regions and 28 districts. Migration across districts is common, but people who migrate across regions encounter barriers with language, religion, tribes, and staple foods.[13]

Variation in new infection rates across geographic space can be threat to my empirical strategy because both low AIDS mortality and high new infections can positively affect trends in HIV prevalence. We could misattribute a small decline in HIV prevalence to low AIDS mortality when, in fact, the region had a surge in new HIV infections. How can we get a measure of new infections in the region? Since young adults who are beginning to become sexually active are unlikely to be HIV-positive, changes in their HIV prevalence rates are largely driven by new infections.[14] Thus, I can control for trends in HIV prevalence of adults 15-19 years old to pin down regional differences in new infections. One must assume that new infection rates of young adults and adults in the "high impact cohort" are sufficiently similar. This assumption is reasonable because members of the "high impact cohort" are not so much older than young adults; moreover, cultural factors like marriage traditions and family structure may be both geographically correlated and influential on sexual behavior.[15]

4.2 Empirical models for ART scale-up and school attendance or grade-for-age

How does my empirical strategy translate to estimation with the available data? To study current school attendance, I use a logit model, and for behind grade-for-age, I employ linear models. All models include region fixed effects such that the coefficient estimate on regional HIV prevalence is identified off of within-region changes rather than levels.

An important caveat to keep in mind is that, since HIV prevalence is an outcome of an unobserved input (e.g. ART coverage), its coefficient estimate is biased. An in-depth discussion about the interpretation of the coefficient can be found in Duh (2013). Essentially, for a linear model, one could think of HIV prevalence as a noisy measure of ART coverage, and its coefficient estimate is attenuated; since ART coverage is serially correlated, the attenuation bias could be quite large.

[13] Another strategy to address migration would be to exclude communities for which migration is the norm, e.g. communities deeply reliant on mining.

[14] Without ART, the overwhelming majority of children born with HIV die by age five (Newell et al., 2004).

[15] I plot regional HIV prevalence of the "high impact cohort" against regional HIV prevalence of young adults in levels (Appendix Figure 1a) and in changes (Appendix Figure 1b). Unsurprisingly, regions with higher HIV prevalence of the "high impact cohort" also have higher HIV prevalence of young adults, but there is no correlation between changes in regional HIV prevalence of the "high impact cohort" and changes in regional HIV prevalence of young adults.

Omitted variable bias (as an illustrative example: regions with higher HIV prevalence also have better quality schools such that children are more likely to attend school and to advance on-time) counters the attenuation bias.[16]

Because the baseline school attendance rate among children 7 to 14 years old is close to 1, one might think that the probability of attending school does not linearly increase (or decrease) with HIV prevalence. Thus, a linear model would be misspecified, and instead, researchers often opt for probit or logit models. I report the main results for all three specifications, and based on goodness-of-fit[17], my preferred specification is a logit model with region fixed effects:

$$Pr\left(School_{irt}\right) = \Lambda\left(\beta_1 \text{HIV of high impact cohort}_{rt} + \beta_2 \text{HIV of young age group}_{rt} + X_{irt}^{'}\alpha + \gamma_r + \delta_t\right), \tag{4}$$

where $\Lambda\left(\cdot\right)$ represents the logistic function and i indexes an individual child, r for sub-national region, and t for time. The outcome variable ($School_{irt}$) is binary and equals 1 if the child attended school at some point during the [school] year. The key explanatory variable is the regional HIV prevalence rate among adults belonging to the "high impact cohort," i.e. birth years 1965-1975. I control for the regional HIV prevalence rate among adults aged 15-19 years old to proxy for new infections, and the vector X_{irt} stands for additional covariates including indicators for the child's age,child's sex, child's sex interacted with age indicators, urban residence, highest educational attainment of household members at least 20 years old, and type of flooring as a measure of household wealth. Region and time fixed effects are captured by γ_r and δ_t respectively. According to our empirical strategy described in the previous subsection, we would interpret a positive marginal effect on "HIV of high impact cohort" (or $\beta_1 > 0$) as suggesting a positive effect of ART scale-up on school attendance.

Equation 4 can be interpreted as the estimating equation from a latent variable model in which the unobserved outcome is the child's propensity to attend school. Let $School_{irt}^{*}$ stand for the child's

[16] For the purpose of mitigating the omitted variable bias, adding covariates could worsen the problem; if we blindly include explanatory variables, the sign on the coefficient estimate could flip. Thus, I avoid over-controlling, and since the attenuation bias with serial correlation in ART coverage could be large, I take the view that the magnitude of the estimates errs on the low side but is not a strict lower bound.

[17] Admittedly, the choice based on the R^2 is somewhat arbitrary, but the qualitative interpretation would not differ by model.

propensity to attend school, and suppose that I can model this propensity as

$$School^{*}_{irt} = b_1 \text{HIV of high impact cohort}_{rt} + b_2 \text{HIV of young age group}_{rt} + X^{'}_{irt}a + g_r + d_t + e_{irt}. \quad (5)$$

I observe that

$$School_{irt} = \begin{cases} 1 & \text{if } School^{*}_{irt} > \overline{School} \\ 0 & \text{otherwise,} \end{cases}$$

meaning that the child attends school if his or her propensity exceeds the threshold $\overline{School}$. If e in equation 5 has a standard logistic distribution, then equation 4 would be correctly specified. If e has a standard normal distribution, then the probit is preferred to the logit model. In practice, the results are very similar.

To examine the child's progression through school after ART began to scale up, I can employ ordinary least squares (OLS) as a descriptive tool of a conditional expectation or as a reduced form regression from the latent variable model. For the former, the conditional expectation of being behind grade-for-age is:

$$\begin{aligned} E\left[Behind_{irt} | HIV_{rt}, X_{irt}\right] &= \varphi_1 \text{HIV of high impact cohort}_{rt} \\ &\quad + \varphi_2 \text{HIV of young age group}_{rt} + X^{'}_{irt}\omega + \rho_r + \tau_t, \end{aligned} \quad (6)$$

where$Behind_{irt}$ is a binary variable that equals 1 if the child is behind grade-for-age as defined in section 3. The indexes and covariates in X_{irt} are the same as previously detailed for school attendance in equation 4. Region and time fixed effects are captured by ρ_r and τ_t. Conditional on being behind, the expected number of years that the child lags grade-for-age is given by:

$$\begin{aligned} E\left[\text{Years behind}_{irt} | HIV_{rt}, X_{irt}, Behind_{irt} = 1\right] &= \theta_1 \text{HIV of high impact cohort}_{rt} \\ &\quad + \theta_2 \text{HIV of young age group}_{rt} + X^{'}_{irt}\xi + \rho_r + \tau_t, \end{aligned} \quad (7)$$

where Years behind$_{irt}$ takes on positive integer values between 1 and 7. In the tables of results, I report φ_2 and θ_2, and negative estimates are consistent with the claim that ART scale-up helped to improve timely progression through school.

Alternatively, if we take the latent variable model seriously, then we might prefer to run the reduced form regression which does not separate the extensive and intensive margins, i.e. 'being behind grade-for-age' and 'if behind, number of years behind grade-for-age.' To see this, recall that $School^*_{irt}$ represents the child's unobserved propensity to attend school, and the child is absent for school when his or her propensity is below the threshold:

$$Absent_{irt} = \begin{cases} 1 & \text{if } School^*_{irt} < \overline{School} \\ 0 & \text{otherwise.} \end{cases}$$

Assume that the conditional probability of being absent can be represented by a linear model such as

$$E\left[Absent_{irt}|ART_{rt}, X_{irt}\right] = Pr\left(Absent_{irt} = 1|ART_{rt}, X_{irt}\right) = a_0 + a_1 ART_{rt} + X'_{irt}d,$$

where ART_{rt} is the regional ART coverage rate (assumed to be observed in this exercise) and X_{irt} is a vector of K characteristics. I also presume that past values of ART and X are known when ART_{rt} and X_{irt} have been revealed. The degree to which the child has fallen behind grade-for-age is a cumulative measure of past absences since he or she started school:

$$\text{Years behind}_{irt} = \sum_{j=1}^{t-1} Absent_{irj}.$$

Therefore, the conditional expectation of years behind grade-for-age can be written as the expression

$$\begin{aligned} E\left[\text{Years behind}_{irt}|ART_{rt}, X_{irt}\right] &= E\left[\sum_{j=1}^{t-1} Absent_{irj}|ART_{rt}, X_{irt}\right] \\ &= \sum_{j=1}^{t-1} E\left[Absent_{irj}|ART_{rt}, X_{irt}\right] \\ &= \sum_{j=1}^{t-1} \left(a_0 + a_1 ART_{rt} + X'_{irt}d\right) \\ &= a_0\left(t-1\right) + a_1 \sum_{j=1}^{t-1} ART_{rj} + \sum_{k=1}^{K} d_k \sum_{j=1}^{t-1} x^k_{irj}. \end{aligned} \tag{8}$$

Equation 8 tells us that, ideally, we would like to control for past values of ART and X, and how far

back in history depends on the child's age. Thus, it would make sense to run separate regressions by age. Supposing that the histories of ART and X may be written as multiplicative functions of time and the current values, i.e. $\sum_{j=1}^{t-1} ART_{rj} = f(t) \cdot ART_{rt}$ and $\sum_{j=1}^{t-1} x_{irj}^k = g^k(t) \cdot x_{irt}^k$, then the reduced form equation that we can take to the data is:

$$E\left[\text{Years behind}_{irt} | ART_{rt}, X_{irt}\right] = \alpha_0 + \alpha_1 ART_{rt} + \sum_{k=1}^{K} \delta_k x_{irt}^k, \tag{9}$$

where $\alpha_0 = a_0(1-t)$, $\alpha_1 = a_1 \cdot f(t)$, and $\delta_k = d_k \cdot g^k(t)$.

In the body of the paper, I present the results using the linear regression model as a descriptive tool of conditional expectations, as shown in equations 6 and 7. The reason is that numerous simplifying assumptions underlie the reduced form equation, and with the current data, those assumptions are largely not testable. For interested readers, the results based on equation 9 are included in the Appendix.

5 Results

Implementing the empirical strategy and regression models in section 4, I present two main results. In regions with more successful ART scale-up (as proxied by the change in HIV prevalence of the 'high impact cohort' from the pre- to post-ART periods), children were more likely to attend school, and if behind grade-for-age, they lagged by fewer years. I observe improvements in child schooling for orphans and non-orphans alike.

5.1 Baseline results: HIV and non-HIV households

Tables 2a and 2b show the effect of ART scale-up on attending school and on falling behind grade-for-age. Across the columns, I separately analyze children 7 to 14 years old from all households (column 1), children from households in which eligible adult members agreed to test for HIV (column 2), children from households in which at least one adult member tested positive for HIV (column 3), and children from households in which no adult tested positive for HIV (column 4). An "HIV household" refers to a household with one or more adult members living with HIV according to DHS's biomarker test (as opposed to self-reported HIV status, which is not in my data). In Table 2a, panels A, B,

and C report the results using a linear probability model, probit model, and logit model.[18] All models include controls for child's age, child's sex, age-sex interaction terms, highest educational attainment among household members 20 years or older, type of flooring, urban residence, time trend, urban-specific time trend, and region fixed effects. As mentioned in subsection 4.2, a non-linear model may serve as a better approximation of the underlying data generating function than the linear probability model given that school attendance rates tend to be high, and in subsequent discussions, I refer to the results in panel C corresponding to the logit model.

The results in Table 2a suggest that school attendance for children 7 to 14 years old increased in regions where ART more successfully scaled up. When the regional HIV prevalence rate of the high impact cohort increased by 1 percentage point, the probability of attending school rose by 0.4 percentage points or by 0.5%. Moreover, the positive effect of ART scale-up on school attendance is evident for both children from HIV households and children from non-HIV households. It's worth noting that the magnitudes of the marginal effects from the probit and logit models (panels B and C) are larger than that of the marginal effect from the linear probability model (panel A), as one would expect since the outcome is capped at 1, i.e. 100%. Using regional HIV prevalence of adults 15-49 years old rather than HIV prevalence of the 'high impact cohort,' the effect of ART scale-up remains positive; however, while the estimates are statistically significantly different from zero at the 10% level, I cannot reject at the 5% level (see Appendix Table 2).

In Table 2b, panels A and B show the results for two different outcomes - the probability of being behind grade-for-age and, conditional on being behind grade-for-age, the number of years - and, again, children from regions with more successful ART scale-up were more likely to advance in school on-time than their counterparts in less successful regions. Across the columns, the estimating sample changes, and the mean of the outcome variable in the pre-ART period is shown in brackets below the standard errors. Although I cannot reject that children from regions with more successful ART scale-up were not less likely to fall behind grade-for-age, those who were behind lagged by a fewer years. An increase of regional HIV prevalence of the 'high impact cohort' by 1 percentage point predicts a reduction in the number of years that a child was behind grade-for-age by 2.54 years or 1.16%. Although the point estimate for non-HIV households (column 4) is double in magnitude relative to the estimate for HIV households (column 3), the standard errors are large such that one

[18] For the probit and logit models, the table displays the average marginal effects.

cannot reject that the coefficients are equal. For HIV households, the estimate is not statistically distinct from zero, and noting the small sample size, the non-significant result could be a power issue.

Together, the results in Tables 2a and 2b illustrate that ART scale-up helped to increase school attendance, and although children were not less likely to have fallen behind in school, they were not as far behind as their counterparts in regions lacking access to ART.

5.2 Orphans

As shown by Case et al. (2004), orphans are a vulnerable group because they are less likely to have strong advocates in household resource allocation decisions. To evaluate whether orphans have been excluded from improvements in schools discussed in subsection 5.1, I analyze children whose mother and/or father were not confirmed to be alive at the time of interview.[19] As reported in Table 1, nearly one-fifth of children in the pre-ART period were missing one or both parent(s) because of death or unknown survival status. By the post-ART period, the fraction of orphans had decreased from one-fifth to one-sixth. The three listed categories of orphanhood – maternal, paternal, and double – were constructed to be mutually exclusive. By far, paternal orphans are most common at 12.2% and 10.6% of children in the pre-ART and post-ART periods respectively. Although there are more [unweighted] observations of double orphans[20] than maternal orphans in the estimating sample, the share of maternal orphans is slightly higher than that of double orphans at 3.9% versus 3.5% in the pre-ART period and 3.2% versus 2.9% in the post-ART period.

The results in Table 3a suggest that ART scale-up helped to increase school attendance among orphans and non-orphans alike. In column 1, I replicate the results from column 1 of Table 2a but with one difference: in Table 3a, Kenyan children are excluded because information about the survival status of their parents is not available in Kenya 2003. In columns 2 through 5, I focus on maternal orphans (children who are missing mothers), paternal orphans (children who are missing fathers), double orphans (children who are missing mothers and fathers), and non-orphans (children for whom mother and father are known to be alive). Again, in the subsequent discussion, I focus

[19] Under this definition, children whose mother and/or father are away from home and have unconfirmed survival status would be classified as orphans. The results are robust to a stricter definition of orphanhood in which the mother and/or father were reported "not alive."

[20] "Double orphans" refer to children who are missing both parents.

on the average marginal effects from a logit model that are shown in panel C.

Consistent with the estimates in Table 2a, the probability of attending school rose by 0.5 p.p. or 0.6% in regions where regional HIV prevalence of the 'high impact cohort' increased by 1 p.p. For maternal orphans, the point estimate remains around 0.5; however, because the standard error gets much larger, the estimate is not statistically significantly different from zero. For double orphans, the point estimate increases by 54% (0.48 p.p. to 0.74 p.p.).

In Table 3b, I examine whether orphans are less likely to have fallen behind grade-for-age in regions with more successful ART scale-up. Rather than reporting different specifications, panels A and B show the results for outcomes on the extensive and intensive margins: in panel A, is the child behind grade-for-age, and in panel B, conditional on being behind, how many years does he or she lag in grade-for-age? Again, the results in Table 3b are consistent with those previously seen in Table 2b. While ART scale-up may not have reduced the probability that a child was behind grade-for-age, children from regions with ART were behind by fewer years than their counterparts in regions without ART.[21] Double orphans appear to be an exception: the result in column 2 of panel A indicates that double orphans were less likely to be behind in regions with ART scale-up.

Altogether, Tables 3a and 3b confirm that orphans living in regions where ART scaled up during the mid-2000s have also experienced increases in 'school attendance' and decreases in the 'degree to which children are behind in school.' The results are neither exclusively driven by orphans nor have orphans been excluded from the observed advances in child schooling.

6 Discussion

In section 5, we saw that, with ART scale-up, children from households with and without HIV-positive adult members were more likely to attend school and, while not less likely to be behind grade-for-age, children were not as far behind grade-for-age. Moreover, orphans have been included in these improvements in schooling associated with ART scale-up. In this section, I first address potential threats to validity, such as differential pre-existing trends in regions with more and less successful ART scale-up efforts. I then investigate possible mechanisms through which ART scale-up affects schooling.

[21] In light of the smaller sample sizes for maternal and double orphans, we may lack statistical power, but the signs of the estimates indicate improvements across groups.

6.1 Robustness checks

6.1.1 Pre-existing trends in regions where ART eventually scaled up

Were regions where ART eventually scaled up trending differently in schooling outcomes prior to 2005? Using surveys rounds from the late 1990s and early 2000s, I can compare trends in school attendance or years behind grade-for-age across regions before ART scale-up efforts ramped up. I study whether changes in regional HIV prevalence rates of the 'high impact cohort' - which proxy for ART scale-up - predicts outcomes before ART became widely accessible in Africa. I focus on the period 1998-2006, and the "placebo" refers to the fact that I essentially pretend that ART scaled up in 2000; in reality, ART began rolling out on a large scale after 2004. A statistically significant coefficient on regional HIV prevalence of the 'high impact cohort' suggests that regions with successful ART scale-up were on a different pre-intervention trajectory.

In Table 4a, I juxtapose the results using a sample of children 7 to 14 years old during the actual time period (panel A) versus children 7 to 14 years old during the placebo time period (panel B) for a linear probability model (column 1), probit model (column 2), and logit model (column 3). Each cell reports the average marginal effect of the regional HIV prevalence rate among the 'high impact cohort' on the probability of attending school in the current school year. The mean of the outcome variable, which is binary, is shown in brackets below the standard error. Based on the results shown in Table 4a, I do not find evidence of differential trends in school attendance rates prior to ART scale-up.

Around the turn of the millennium, were children from regions with successful ART scale-up efforts more likely to be behind grade-for-age or further behind grade-for-age? In Table 4b, I again juxtapose the results using a sample of children from the actual time period (panel A) with a sample of children from the placebo time period (panel B); however, across the columns, the outcome variables are the probability of being behind grade-for-age (column 1) and, conditional on being behind, number of years behind grade-for-age (column 2). Each cell reports the coefficient on the regional HIV prevalence rate for the 'high impact cohort' from a linear model. While there does not appear to be a differential pre-trend in the number of years that children were behind, the result in column 1 of panel B suggests that children from regions where ART eventually scaled up were more likely to be behind grade-for-age.

6.1.2 Country outliers

Since my analysis includes seven African countries, one might ask whether the results are primarily driven by a single country. I look for "country outliers" by dropping one country at a time and repeating the analysis. If the estimates are unstable with the exclusion of any one country, then the results may be an artifact of the composition of countries included in the sample. Appendix Tables 3a through 3c show that our conclusions on ART scale-up and school attendance (Appendix Table 3a), probability of being behind grade-for-age (Appendix Table 3b), and years behind grade-for-age (Appendix Table 3c) are not sensitive to dropping any one country from the sample.

6.1.3 Relative and absolute changes in HIV prevalence rates

Another concern is that regional HIV prevalence rates should enter in relative terms rather than in levels; in other words, what matters is the fraction of HIV-positive individuals who survive rather than the fraction of HIV-positive individuals who now live in the population. Arguably, the scale of the AIDS epidemic is important, and thus, changes in the level of HIV prevalence are preferable. Still, the results are robust to taking a log-transformation of regional HIV prevalence of the 'high impact cohort.' Since there are no regions in the seven countries in which HIV prevalence of the 'high impact cohort' is zero, I do not lose observations. However, there are several regions where HIV prevalence of young adults (i.e. adults 15-19 years old) is zero, and therefore, I leave it [HIV prevalence of young adults] in levels.

6.2 Potential channels

Thus far, we have seen that children 7 to 14 years old from regions where ART more successfully scaled up, as measured by changes in regional HIV prevalence rates of the 'high impact cohort,' were more likely to attend school and, if behind grade-for-age, were less far behind. These results hold for children from households with and without HIV-positive adult members and for children with and without parents. How can we explain these patterns, or in other words, through what channels does ART scale-up influence child schooling decisions? I propose three mechanisms: (1) by helping HIV-positive adults to regain their health, ART freed up time for children to attend school; (2) ART changed people's attitudes about whether HIV-positive teachers should be permitted to continue

their jobs; and (3) the influx of development aid for ART allowed the government to maintain or increase public spending on education, or alternatively, to spend on other public goods that would help save time and energy for households. Among these hypotheses, I find some support for the third explanation on national public spending. Country-specific trends can account for much of the increase in school attendance, particularly for children from households without HIV-positive members, but children still appear to be less far behind grade-for-age. Attitudes towards HIV-positive teachers is strongly predictive of attending school and falling behind grade-for-age, but controlling for attitudes does not alter the main results.

The first proposed mechanism is that ART may have changed household production in that children who no longer need to care for sick adults or take up household chores were free to go to school. Examples of household chores include carrying water and fetching firewood. I find little evidence supporting this hypothesis because the results are not stronger in households with HIV-positive members, where children would need to step up for care-taking or housework. Also, one might think that the effect should be stronger in households that rely on firewood as a cooking fuel or households who must travel farther for drinking water. I control for these characteristics and their interaction with regional HIV prevalence of the 'high impact cohort,' and I failed to reject that the effect is the same regardless of cooking fuel or distance to water source.

The second potential channel is that ART transformed people's attitudes about AIDS, especially regarding teachers who may be HIV-positive. On the DHS questionnaire, adult men and women were asked, "In your opinion, if a female teacher has the AIDS virus but is not sick, should she be allowed to continue teaching in the school?[22]" Between the pre-ART and post-ART periods, the share of adults who responded that 'HIV-positive teachers should be allowed to continue' rose by nearly 20 percentage points (61.9% to 80.2%).[23] Can a change in attitude account for the increase in schooling where ART scaled up? As seen in Table 5, controlling for attitude towards HIV-positive teachers has virtually no effect on the magnitude and standard error of the coefficient estimate on

[22]The question quoted in the text comes from the post-ART questionnaires, and possible responses include: "(1) should be allowed; (2) should not be allowed; and (3) don't know/not sure/depends." In the pre-ART questionnaires, the wording is, "If a female teacher has the AIDS virus, should she be allowed to continue teaching in the school?" The three possible answers are: "(1) can continue; (2) should not continue; and (3) don't know/not sure/depends." The question was omitted in Lesotho 2004 and Tanzania 2003/04, and Lesotho and Tanzania are excluded from the analysis. The fraction of respondents answering "don't know/not sure/depends" is less than 5% (weighted and unweighted) in the pre-ART period and less than 3% in the post-ART period.

[23]Numbers are based on men 15-59 years old and women 15-49 years old from Cameroon, Kenya, Malawi, Rwanda, and Zimbabwe.

regional HIV prevalence. The outcomes on child schooling are listed across the top of the columns, and columns 1, 3, and 5 replicate the main results among children from five of the seven countries that have information from both periods on attitudes. Columns 2, 4, and 6 show the results when attitude enters as an explanatory variable; if any adult household member responded that an HIV-positive teacher should be permitted to continue, then the variable was coded as 1. While a shift in attitude may not be a mechanism through which ART scale-up affects child schooling, it is strongly predictive of school attendance and timely progress through school. Children from households in which at least one adult felt that an HIV-positive teacher should continue in his or her occupation were 2.2 p.p. more likely to attend school and 5.5 p.p. less likely to be behind grade-for-age.

A third plausible story is that ART scale-up is a marker for inflows of health aid, and with the influx of development assistance, the national or local government has been able to maintain its budget on education or public goods. Drawing on data from UNESCO, Appendix Figures 2 and 3 show trends in national spending on education as a percent of total government spending and GDP, respectively. The time trends reflect that relative spending on education has not increased after 2005: as a percent of total government expenditures (see Appendix Figure 2), spending on education appears to have fallen in some countries since the early 2000s, although a number of data points after 2006 are missing for Kenya, Lesotho, Malawi, and Rwanda. As a percent of GDP (see Appendix Figure 3), the trends in spending on education appear flat, but again, most countries are missing data after 2006.

Another way to examine this issue is to include country-specific time trends in the regression analysis because spending on education varies at the national level. That said, one could argue that country-specific time trends absorb too much of the spatial variation in ART roll-out as well, particularly when external funding for HIV programs also changes over time at the national level. Thus, with country-specific time trends in the regression model, identification of the coefficient on regional HIV prevalence is based on within-region changes that deviates from a country-wide trend. A statistically insignificant result does not necessarily mean that ART scale-up has no bearing on schooling outcomes but much of the "action" may be on the national level, which would be consistent with a government budget-allocation story.

In Tables 6a and 6b, I compare the results for school attendance and years behind grade-for-

age using regression models without (panel A) and with (panel B) country-specific time trends.[24] Across the columns, I focus on different sub-populations, namely households with and without HIV-positive adult members. Panel A of Table 6a replicates the results from panel B of Table 2a on school attendance rates, and panel A of Table 6b replicates the results from panel B of Table 2b for years behind grade-for-age. It is evident from Table 6a that country-specific time trends capture much of the positive result between regional HIV prevalence of the 'high impact cohort' and school attendance for households without HIV-positive members. As one would expect, the standard errors are bigger with country-specific time trends. More telling, the point estimate is considerably smaller in magnitude for non-HIV households (column 4) whereas it becomes bigger, albeit imprecisely measured, for HIV households (column 3).

While the results for school attendance largely disappear with country-specific time trends, the results for years behind grade-for-age (see Table 6b) remain somewhat robust, although the size of the point estimate decreases by roughly two-fifths to nearly two-thirds for HIV households. Is the estimate uniform across young and older children? In Table 7, I allow the coefficient on HIV prevalence to vary by age. Columns 1-4 includes all children 8 to 14 years old who are behind grade-for-age. Since we would also like to know whether the results in columns 1-4 are driven by dropouts, columns 5-8 includes all children 8 to 14 years old who are behind grade-for-age and currently attending school. Focusing on the first four columns, there are two observations worth highlighting: first, country-specific time trends have little impact on the point estimates whether or not we allow the effect to vary by age, and second, the point estimates get more negative as age increases. The second observation indicates that the gap between children from regions with more and less successful ART scale-up efforts widens with age, but we cannot reject that the coefficients are the same based on a joint F-test. How much of the growing disparity is attributable to dropouts? For children who are 13 and 14 years old, much of the gap associated with ART scale-up can be explained by children who no longer attend school.

Besides spending on education, the government may also pay for public goods that would decrease time and energy spent on housework or improve child health. In Table 8, I test whether regional HIV prevalence of the 'high impact cohort' may stand for electricity coverage, sanitation coverage, or piped water instead of ART. The dependent variable is listed at the top of the columns,

[24] Results for the probability of being behind grade-for-age can be found in Appendix Table 4.

and each column corresponds to a separate regression. The top row reports the estimate on regional HIV prevalence of the 'high impact cohort.' For school attendance (columns 1-4) and years behind grade-for-age (columns 9-12), the estimate remains stable, and this finding suggests that public goods provision was not a key link between ART scale-up and schooling.

Although the evidence does not support the hypothesis that ART scale-up works through public goods provision in the region, access to these services are strongly predictive of child schooling outcomes at the household level and may capture aspects of household wealth. Children living in regions with higher electricity coverage and lower rates of open defection, i.e. no toilets, were more likely to currently attend school attendance. For years behind grade-for-age, regional electricity coverage predicts that children were behind by fewer years, and for all outcomes, regional piped water coverage appears to have had no systematic effect.

At first glance, it is disconcerting to see that children from regions with higher rates of open defecation were less likely to fall behind grade-for-age (columns 6 and 8), although children from households with no toilet were more likely to be behind. This seemingly perverse result is likely driven by the fact that 'behind grade-for-age' is a cumulative measure of school attendance in the past for each child, and when open defecation and school attendance are inversely related, the correlation between a change in open defection and change in the share of children behind grade-for-age can be negative. A simple exercise can help to illustrate why this is the case.

Let γ be the covariance between the change in grades behind school-for-age ($behind_t - behind_{t-1}$) and change in local open defecation ($opendef_t - opendef_{t-1}$). I suppress the individual and regional subscripts. Years behind grade-for-age is the sum of absences since school starting age (normalized to 1) through the preceding period, i.e. $behind_t = \sum_{j=1}^{t-1} absent_j$. Then we can rewrite the covariance as follows:

$$\begin{aligned}
\gamma &= cov\left(behind_t - behind_{t-1}, opendef_t - opendef_{t-1}\right) \\
&= cov\left(\sum_{j=1}^{t-1} absent_j - \sum_{j=1}^{t-2} absent_j, opendef_t - opendef_{t-1}\right) \\
&= cov\left(absent_{t-1}, opendef_t - opendef_{t-1}\right) \\
&= cov\left(absent_{t-1}, opendef_t\right) - cov\left(absent_{t-1}, opendef_{t-1}\right).
\end{aligned}$$

Assuming that school absences do not affect the local rate of open defecation, the first term on the right-hand side would be 0. If children are less likely to attend school in areas where open defecation is more pervasive – possibly because of clinical (or even sub-clinical) disease that impair cognitive and physical development – then $cov\left(absent_{t-1}, opendef_{t-1}\right) > 0$. Indeed, this negative relationship is confirmed in Appendix Figure 4, and Appendix Figure 5 confirms that children from regions with lower school attendance rates in the pre-ART were more likely to be behind grade-for-age in the post-ART period. Thus, we could find that regions with more open defecation experience larger declines in the fraction of children behind grade-for-age, i.e. $\gamma < 0$, as observed in columns 6 and 8 of Table 8.

7 Conclusion

ART is one of the most significant medical breakthroughs in history, and its implications for people living in Africa - particularly Eastern and Southern Africa - are enormous. Child education is one mechanism through which ART may dynamically affect national economies and wellbeing of the population. In this paper, I empirically answer the question, "Has ART scale-up helped to improve child schooling in countries where AIDS is a generalized epidemic, and if so, what do we know about potential channels that link ART with educational outcomes?"

I use trends in regional HIV prevalence of "high [ART] impact cohorts" to infer where ART more successfully rolled out, and although this measure can only serve as a proxy for ART coverage, it is easily and transparently constructed at the sub-national level for a broad set of African countries. Using this method, I present suggestive evidence that ART scale-up had a positive effect on school attendance and advancement through school. I find that children 7 to 14 years old from regions with smaller declines in HIV prevalence of the high impact cohorts were more likely to have attended school in the current school year and, conditional on being behind grade-for-age, lagged behind by fewer years. The data does not indicate that intrahousehold allocation of labor, public goods provision, or HIV/AIDS attitudes drive the results. However, allocation of resources at the country-level may be an important channel for further investigation.

Three avenues for future research on this topic remain wide open. First, what are the medium- or long-run effects of ART scale-up on schooling? Do the short-run improvements persist 10, 15, or

20 years later? Second, can we find direct evidence for channels through which ART affects child schooling? Third, what are (if any) the benefits of more schooling for children? Do these children become more productive workers and earn higher wages? Do they pursue different occupations or industries from their parents and neighbors? Do more educated girls become more effective caretakers of their families?

The initial findings in the literature on ART and child education are encouraging, and more broadly, ART has been shown to have positive effects on worker productivity (Habyarimana et al., 2010; Thirumurthy et al., 2008) and utilization of maternal health services (Grépin, 2012; Duh, 2013). Although these gains are large and far-reaching across the population, the costs of providing universal access to ART is rapidly growing with longer life expectancies for HIV-positive individuals. As the global response to HIV/AIDS evolves from an emergency intervention to chronic-disease management, improvements in schooling among the next generation of Africans bring hope of future leaders and communities who will rise up and take ownership in the fight to end AIDS.

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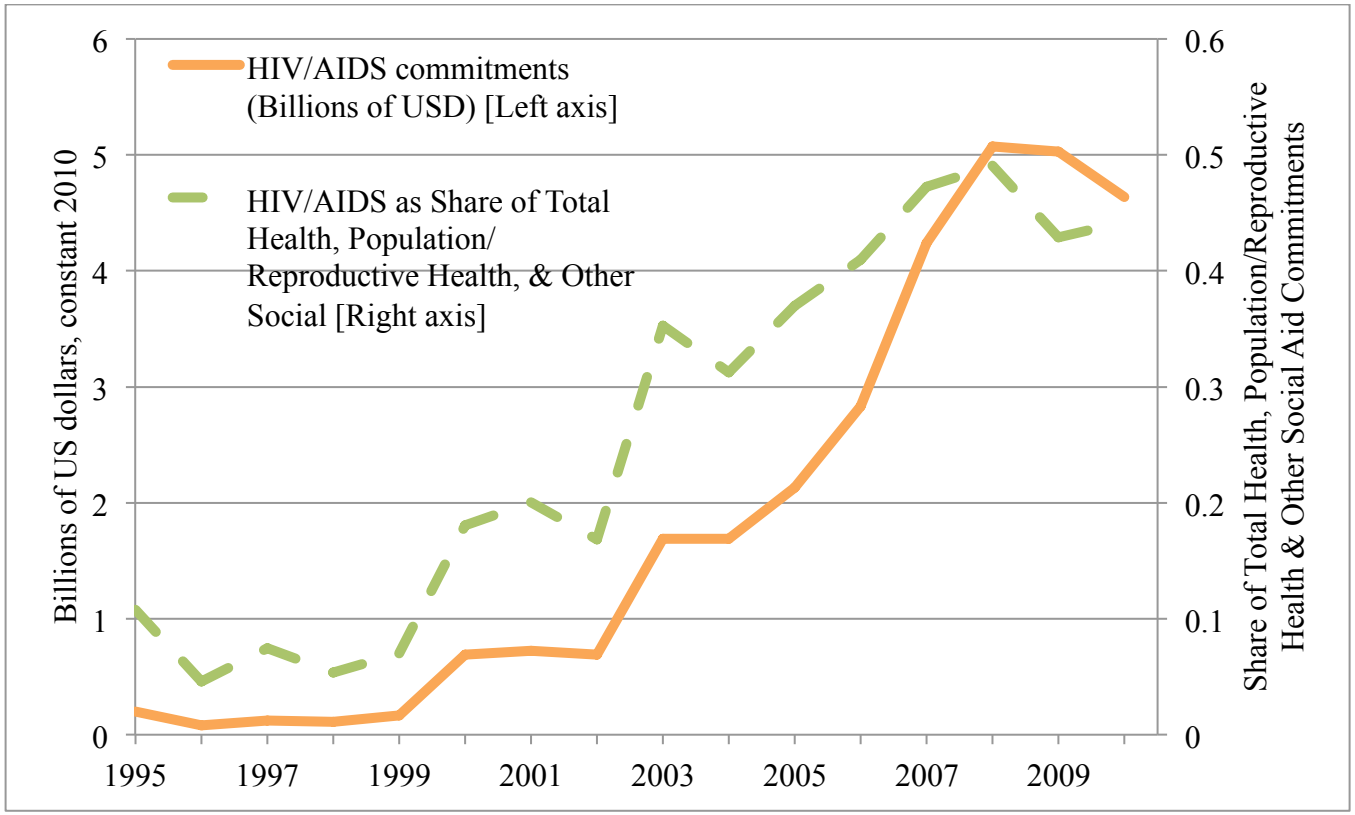


FIGURE 1

Trends in absolute and relative levels of donor aid commitments for HIV/AIDS from OECD countries to sub-Saharan Africa, 1995-2010

Source: OECD Credit Reporting Services, downloaded on 9 October 2012

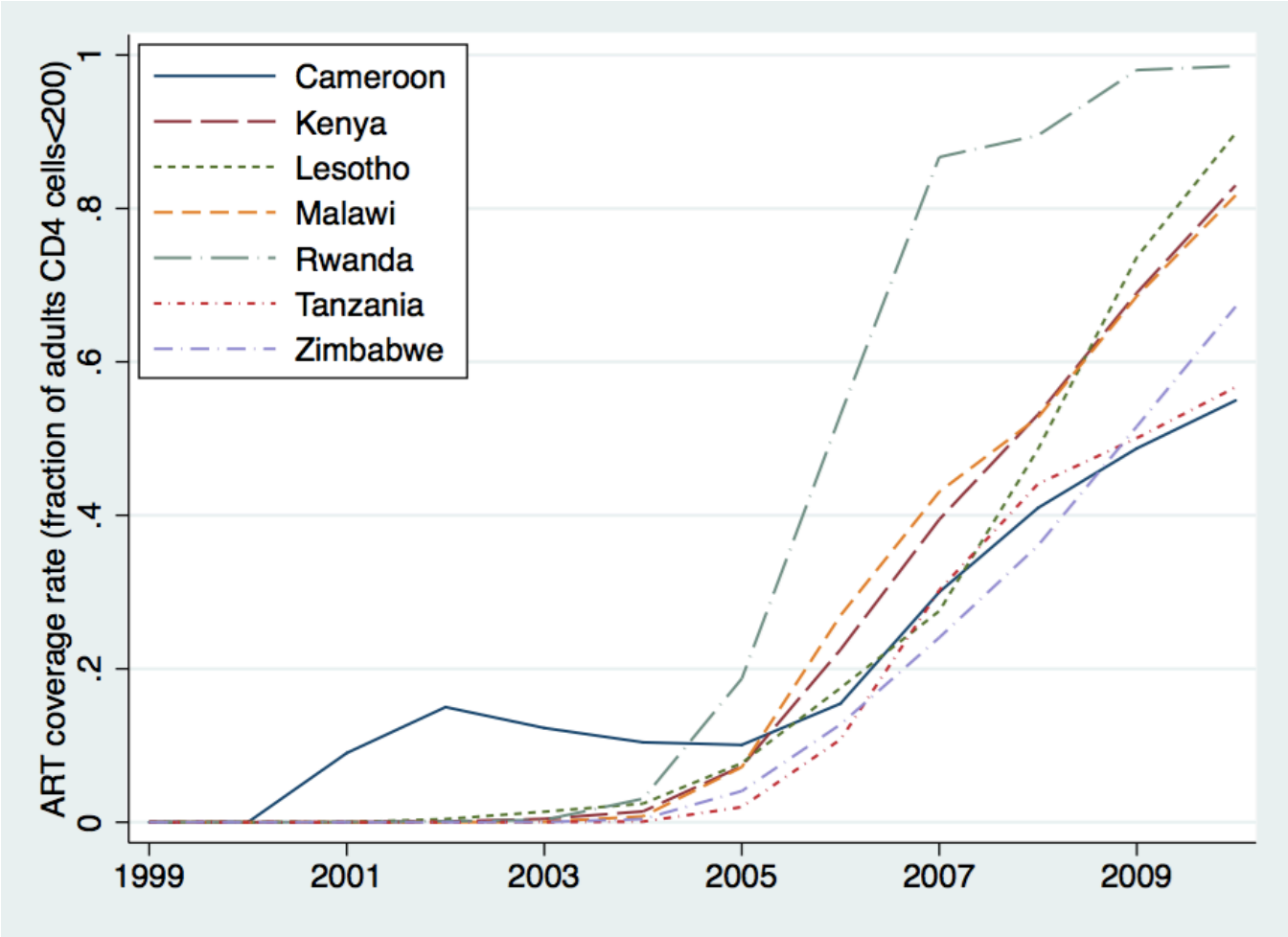


FIGURE 2

Dramatic increase in national ART coverage rates after 2004

Source: Spectrum/EPP 2011 v. 4.50, downloaded on 20 October 2012

Notes: ART coverage rate is defined as the number of adults 15-49 years old receiving ART divided by the number of adults 15-49 years old eligible for ART, i.e. CD4 cell counts below 200 cells per cubic millimeter.

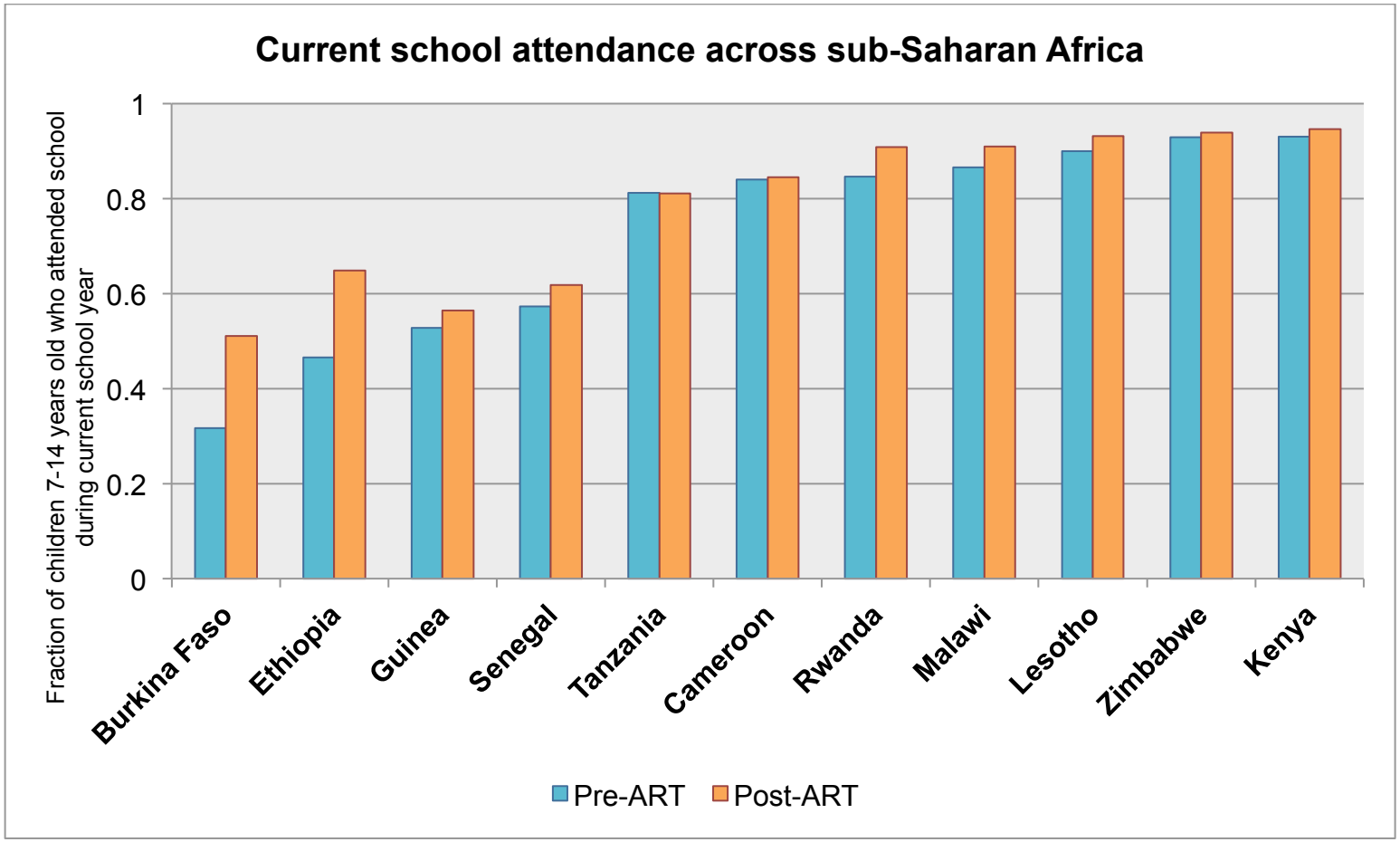


FIGURE 3.

Increasing trends in current school attendance among children 7-14 years old from 2003/05 (pre-ART period) to 2009/12 (post-ART period), by country

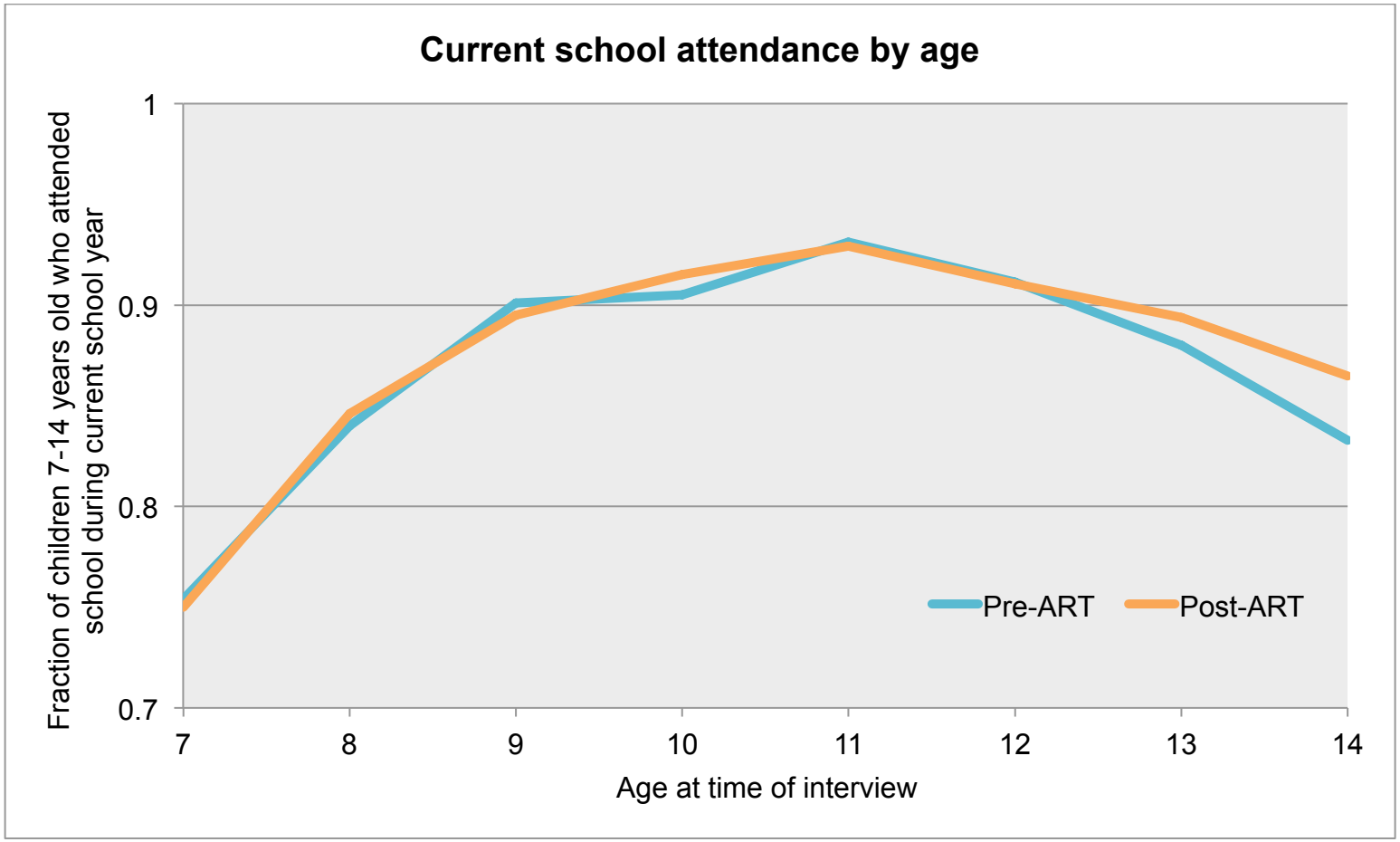


FIGURE 4.
Age profile of current school attendance among children 7-14 years old in 2003/05 (pre-ART period) and 2009/12 (post-ART period)

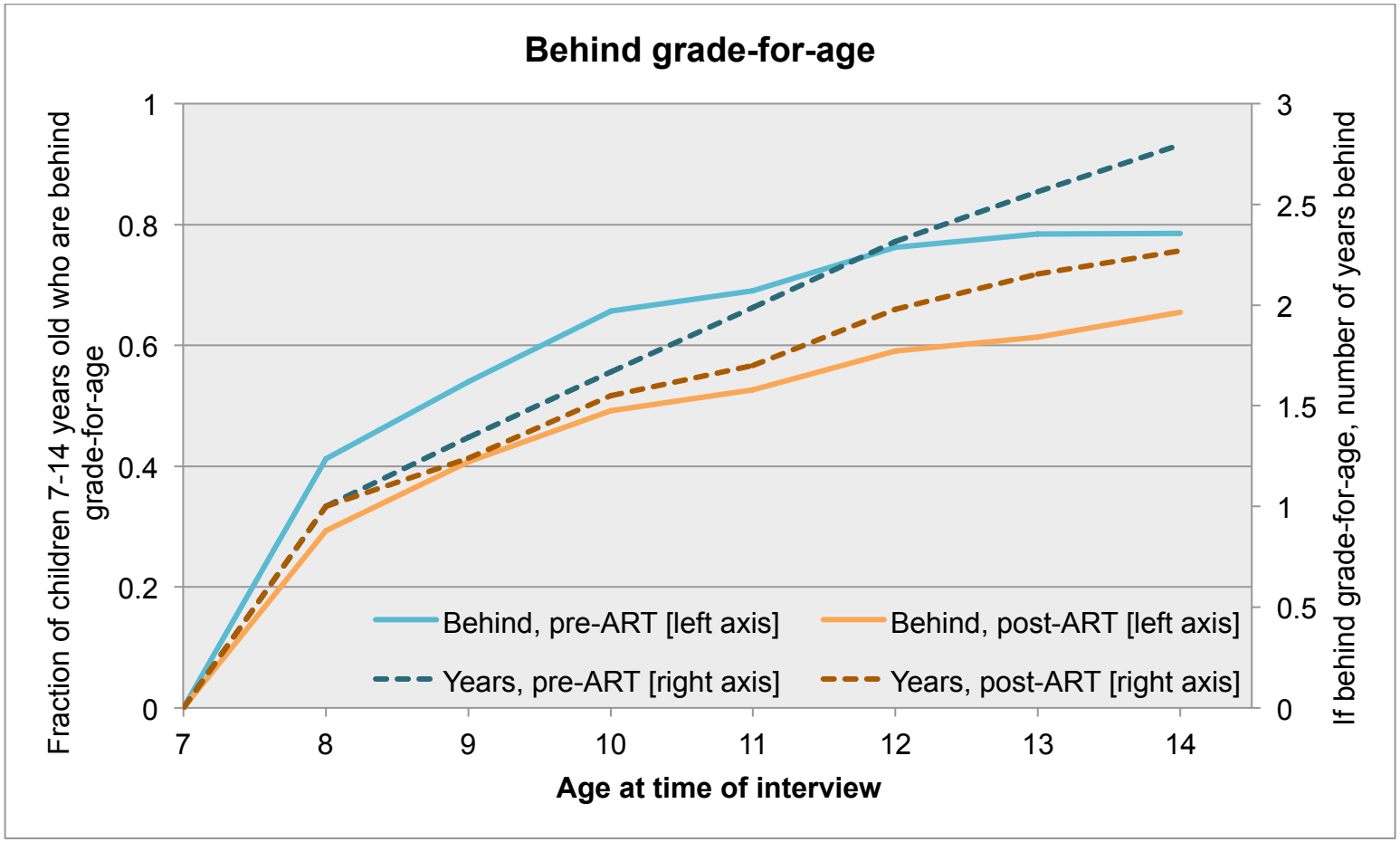


FIGURE 5.
Age profile of children 7-14 years old who are behind grade-for-age in 2003/05 (pre-ART period) and 2009/12 (post-ART period)

TABLE 1. Sample means

	Before ART 2003/05	After ART 2009/12	Change (03/05-09/12)
	(1)	(2)	(3)
CHILD SCHOOLING			
Current school attendance:			
Ages 7-10	0.847	0.849	0.002
Ages 11-14	0.892	0.904	0.012**
Behind grade-for-age:			
Age 8	0.412	0.292	-0.120**
Age 9	0.540	0.408	-0.132**
Age 10	0.657	0.492	-0.165**
Age 11	0.690	0.526	-0.164**
Age 12	0.762	0.591	-0.171**
Age 13	0.784	0.614	-0.170**
Age 14	0.785	0.655	-0.130**
CHILD CHARACTERISTICS			
Age	10.4	10.3	-0.090**
Female	0.493	0.502	0.009**
HOUSEHOLD CHARACTERISTICS			
Urban	0.221	0.202	-0.019**
Has electricity	0.148	0.173	0.025**
No toilet facility	0.148	0.135	-0.013
Piped water	0.282	0.286	0.004
Type of flooring:			
Natural	0.688	0.657	-0.031**
Rudimentary	0.002	0.001	-0.001**
Finished	0.308	0.339	0.031**
Highest educational attainment of adult 20+ years in household:			
No education	0.154	0.123	-0.031**
Incomplete primary	0.243	0.227	-0.016**
Complete primary	0.324	0.345	0.021**
Incomplete secondary	0.156	0.202	0.046**
Complete secondary	0.080	0.059	-0.021**
Higher	0.043	0.043	-0.0003
ORPHANS (Kenya excluded)			
Maternal/paternal/double orphans	0.190	0.167	-0.023**
Maternal orphans	0.034	0.032	-0.002
Paternal orphans	0.120	0.106	-0.014**
Double orphans	0.036	0.029	-0.007**
HIV/AIDS ATTITUDES			
Female teacher with HIV should be allowed to teach	0.700	0.892	0.192**
REGIONAL HIV PREVALENCE RATES			
All adults 15-49 years old	0.079	0.068	-0.011**
High ART impact cohort	0.123	0.118	-0.005
Adults 15-19 years old	0.020	0.015	-0.005**
N (children 7-14 years)	67,396	90,554	

Notes: Sample consists of children 7-14 years old at the time of survey from Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. "Natural" flooring is earth/sand or dung; "rudimentary" consists of wood planks, palm/bamboo, or broken bricks; and "finished" is parquet/polished wood, vinyl/asphalt strips, ceramic tiles, cement, or carpet. Grade-for-age is set to equal 0 when a 7 years-old child is enrolled in grade 1. **p<0.05

TABLE 2a. ART scale-up increases current school attendance among children 7-14 years old from households with and without HIV+ adult members

Sample:	All households	HIV & Non-HIV households	HIV households	Non-HIV households
	(1)	(2)	(3)	(4)
PANEL A. **Specification: Linear probability model**				
Regional HIV prevalence rate of `high impact cohort'	0.329	0.364	0.355	0.353
	(0.104)***	(0.128)***	(0.211)*	(0.137)**
Adjusted R-squared	0.138	0.140	0.123	0.144
PANEL B. **Specification: Probit model**				
Regional HIV prevalence rate of `high impact cohort'	0.400	0.463	0.488	0.443
	(0.109)***	(0.138)***	(0.232)**	(0.150)***
Pseudo R-squared	0.176	0.176	0.172	0.179
PANEL C. **Specification: Logit model**				
Regional HIV prevalence rate of `high impact cohort'	0.419	0.477	0.488	0.457
	(0.121)***	(0.156)***	(0.249)**	(0.167)***
Pseudo R-squared	0.177	0.178	0.173	0.181
Mean of outcome variable in pre-ART period	0.867	0.863	0.891	0.859
N (children 7-14 years old)	157746	77537	12625	64821
N (regions)	70	70	68	70

Notes: Standard errors in parentheses are clustered by region. Sample consists of children alive at time of interview from the following 7 countries: Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. The outcome variable is binary and equals 1 if child had attended school during the current academic year. For probit and logit models, the average arginal effect is reported. Additional controls include regional HIV prevalence of adults 15-19 years old, indicators for chidl's age, indicator for child's sex, age indicators interacted with sex, urban resident, indicator for births in post-ART period, urban-specific time trend, indicators for highest educational attainment of household member 20+ years old, type of flooring, and region fixed effects. All regressions include household sample weights adjusted by population size in year of survey. ***p<0.01,**p<0.05,*p<0.10

TABLE 2b. Children ages 8-14 from regions with more successful ART scale-up are not less likely to be behind grade-for-age but, if behind, they lag by fewer years

Sample:	All households	HIV & Non-HIV households	HIV households	Non-HIV households
	(1)	(2)	(3)	(4)
PANEL A. **Outcome: Child is behind in grade-for-age**				
Regional HIV prevalence rate of `high impact cohort'	-0.005	-0.248	-0.126	-0.250
	(0.374)	(0.473)	(0.509)	(0.493)
[Mean of outcome variable in pre-ART period:]	*[0.660]*	*[0.655]*	*[0.566]*	*[0.670]*
N (children 8-14 years old)	133743	65852	10781	55071
N (regions)	70	70	70	70
PANEL B. **Outcome: If behind grade-for-age, number of years**				
Regional HIV prevalence rate of `high impact cohort'	-2.256	-2.872	-2.097	-2.908
	(0.619)***	(0.696)***	(1.796)	(0.848)***
[Mean of outcome variable in pre-ART period:]	*[2.295]*	*[2.274]*	*[2.101]*	*[2.297]*
N (children 8-14 years old)	78829	36958	5227	31731
N (regions)	70	70	70	70

Notes: Standard errors in parentheses are clustered by region (70 regions). Sample consists of children alive at time of interview from 7 countries: Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. Grade-for-age is set to equal 0 if an eight year-old child has completed one year of school. If the child is ahead by more than two years, grade-for-age is coded as missing. In panel A, the outcome variable equals 1 if the child was behind grade-for-age. In panel B, the outcome variable ranges from 1 to 7. Each cell reports the coefficient on "regional HIV prevalence rate of adults born between 1965 and 1975" from a linear regression model. Additional covariates include indicators for child's age, female, age-female interaction terms, highest educational attainment of household member 20+ years old, type of flooring, urban residence, time trend (indicator if interview was conducted after 2005), urban-specific time trend, and region fixed effects. Regressions are weighted using household sample weights adjusted by population size. ***p<0.01,**p<0.05,*p<0.10

TABLE 3a. ART scale-up increases current school attendance among orphans

Sample:	All households	Maternal orphans	Paternal orphans	Double orphans	Non-orphans
	(1)	(2)	(3)	(4)	(5)
PANEL A. **Specification: Linear probability model**					
HIV prevalence of high impact cohort	0.363	0.416	0.385	0.443	0.356
	(0.108)***	(0.403)	(0.177)**	(0.234)*	(0.129)***
Adjusted R-squared	0.136	0.125	0.114	0.139	0.147
PANEL B. **Specification: Probit model**					
HIV prevalence of high impact cohort	0.453	0.455	0.497	0.750	0.444
	(0.122)***	(0.491)	(0.212)**	(0.301)**	(0.144)***
Pseudo R-squared	0.162	0.165	0.143	0.157	0.177
PANEL C. **Specification: Logit model**					
HIV prevalence of high impact cohort	0.484	0.503	0.513	0.739	0.479
	(0.136)***	(0.518)	(0.241)**	(0.339)**	(0.160)***
Pseudo R-squared	0.164	0.167	0.143	0.158	0.179
Mean of outcome variable in pre-ART period	0.844	0.837	0.855	0.815	0.844
N (children 7-14 years old)	145994	5581	19513	6187	114343
N (regions)	63	63	63	59	63

Notes: Standard errors in parentheses are clustered by region. Sample consists of children alive at time of interview from the following 6 countries: Cameroon, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. The outcome variable is binary and equals 1 if child had attended school during the current academic year. Each cell shows the average marginal effect using a linear, probit, or logit model. Additional controls include regional HIV prevalence of adults 15-19 years old, indicators for chidl's age, indicator for child's sex, age indicators interacted with sex, urban resident, indicator for births in post-ART period, urban-specific time trend, indicators for highest educational attainment of household member 20+ years old, type of flooring, and region fixed effects. All regressions include household sample weights adjusted by population size in year of survey. A child is classified as an orphan if his or her parent is dead, known, or missing response. Double orphan refers to children for whom neither parent is reported to be living. Maternal, paternal, and double orphans are mutually exclusive categories.
***p<0.01,**p<0.05,*p<0.10

TABLE 3b. Orphans and non-orphans lag in grade-for-age by fewer years in regions with more successful ART scale-up

Sample:	All households	Maternal orphans	Paternal orphans	Double orphans	Non-orphans
	(1)	(2)	(3)	(4)	(5)
PANEL A. **Outcome: Child is behind grade-for-age**					
HIV prevalence of high impact cohort	0.153	1.327	-0.204	0.084	0.160
	(0.421)	(0.491)***	(0.424)	(0.428)	(0.449)
[Mean of outcome variable in pre-ART period:]	*[0.670]*	*[0.713]*	*[0.680]*	*[0.660]*	*[0.667]*
N (children 8-14 years old)	123616	4985	17326	5690	95353
N (regions)	63	63	63	63	63
PANEL B. **Outcome: If behind grade-for-age: number of years**					
HIV prevalence of high impact cohort	-2.385	-2.277	-3.516	-3.596	-2.144
	(0.704)***	(1.935)	(1.444)**	(1.170)***	(0.650)***
[Mean of outcome variable in pre-ART period:]	*[2.338]*	*[2.431]*	*[2.464]*	*[2.569]*	*[2.300]*
N (children 8-14 years old)	73006	3229	10566	3521	55516
N (regions)	63	63	63	63	63

Notes: Standard errors in parentheses are clustered by region (63 regions). Sample consists of children alive at time of interview from the following 6 countries: Cameroon, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. Grade-for-age is set to equal 0 if an eight year-old child has completed one year of school. If the child is ahead by more than two years, grade-for-age is coded as missing. In panel A, the outcome variable equals 1 if the child was behind grade-for-age. In panel B, the outcome variable ranges from 1 to 8. Each cell reports the coefficient on "regional HIV prevalence rate of adults born between 1965 and 1975" from a linear regression model. Additional controls include regional HIV prevalence of adults 15-19 years old, indicators for chidl's age, indicator for child's sex, age indicators interacted with sex, urban resident, indicator for births in post-ART period, urban-specific time trend, indicators for highest educational attainment of household member 20+ years old, type of flooring, and region fixed effects. All regressions include household sample weights adjusted by population size in year of survey. A child is classified as an orphan if his or her parent is dead, known, or missing response. Double orphan refers to children for whom neither parent is reported to be living. Maternal, paternal, and double orphans are mutually exclusive categories.
***p<0.01,**p<0.05,*p<0.10

TABLE 4a. Placebo test for pre-existing trends in school attendance before ART scale-up

	Linear	Probit	Logit
	(1)	(2)	(3)
PANEL A. **Actual time period: 2003/05 & 2009/12**	0.342	0.413	0.432
	(0.110)***	(0.115)***	(0.127)***
[Mean of outcome, 2003-2005]	*[0.867]*	*[0.867]*	*[0.867]*
N (children 7-14 years old)	140515	140515	140515
N (regions)	60	60	60
Pseudo R-squared	0.138	0.177	0.178
PANEL B. **Placebo test period: 1998/00 & 2003/06**	0.015	-0.004	-0.063
	(0.335)	(0.300)	(0.313)
[Mean of outcome, 1998-2000]	*[0.781]*	*[0.781]*	*[0.781]*
N (children 7-14 years old)	110358	110358	110358
N (regions)	60	60	60
Pseudo R-squared	0.176	0.197	0.202

Notes: Standard errors in parentehses are clustered by region (60 regions). Sample consists of children alive at time of interview from the following six countries: Cameroon, Kenya, Malawi, Rwanda, Tanzania, and Zimbabwe. Each cell shows the average marginal effect of "regional HIV prevalence rate of adults born between 1965 & 1975 [high impact cohort]" on the outcome, which is a binary indicator for whether the child attended school during the current school year. In the placebo period, the pre-period (1998-2000) is assigned regional HIV prevalence rates from the pre-ART period and the post-period (2003-2006) is assigned regional HIV prevalence rates from the post-ART period. The regression model specification is listed at the top of each column. Additional covariates include indicators for the child's age, child's sex, age-sex interaction terms, highest educational attainment of household member over 20 years old, type of flooring, urban residence, time trend (indicator for post-period), urban-specific time trend, and region fixed effects.
***p<0.01,**p<0.05,*p<0.10

TABLE 4b. Placebo test for pre-existing trends in probability of being behind grade-for-age and number of years behind grade-for-age before ART scale-up

	Behind grade-for-age	If behind grade-for-age: number of years
	(1)	(2)
PANEL A. **Actual time period: 2003/05 & 2009/12**	-0.011	-2.475
	(0.397)	(0.678)***
[Mean of outcome, 2003-2005]	*[0.660]*	*[2.297]*
N (children 6-14 years old)	118703	69919
N (regions)	60	60
PANEL B. **Placebo test period: 1998/00 & 2003/06**	0.688	1.193
	(0.339)**	(0.931)
[Mean of outcome, 1998-2000]	*[0.707]*	*[2.413]*
N (children 6-14 years old)	95598	62692
N (regions)	60	60

Notes: Standard errors in parentehses are clustered by region (60 regions). Sample consists of children alive at time of interview from the following six countries: Cameroon, Kenya, Malawi, Rwanda, Tanzania, and Zimbabwe. Each cell shows the coefficient of "regional HIV prevalence rate of adults born between 1965 & 1975 [high impact cohort]" from a linear regression model. Grade-for-age is set to equal 0 if an eight years-old child has completed one year of school. If the child is ahead by more than two years, grade-for-age is coded as missing. Under the column titled "Behind grade-for-age," the outcome variable equals 1 if the child was behind grade-for-age. Under the column titled "If behind grade-for-age: number of years," the outcome variable is the number of years behind grade-for-age and ranges from 1 to 7. In the placebo period, the pre-period (1998-2000) is assigned regional HIV prevalence rates from the pre-ART period and the post-period (2003-2006) is assigned regional HIV prevalence rates from the post-ART period. The regression model specification is listed at the top of each column. Additional covariates include indicators for the child's age, child's sex, age-sex interaction terms, highest educational attainment of household member over 20 years old, type of flooring, urban residence, time trend (indicator for post-period), urban-specific time trend, and region fixed effects.
***p<0.01 **p<0.05 *p<0.10

TABLE 5. Attitude towards HIV+ teachers does not explain effect of ART scale-up on child schooling

	Attended school during current school year		Behind grade-for-age		If behind grade-for-age, number of years	
	(1)	(2)	(3)	(4)	(5)	(6)
Regional HIV prevalence rate of `high impact cohort'	0.297	0.282	-0.586	-0.569	-3.008	-2.965
	(0.111)***	(0.111)**	(0.264)**	(0.263)**	(0.765)***	(0.777)***
Female teacher with HIV should be allowed to continue teaching		0.022		-0.055		-0.171
		(0.007)***		(0.010)***		(0.032)***
Mean of outcome variable in pre-ART period	0.898	0.898	0.618	0.618	2.283	2.283
N (children)	99817	99817	84050	84050	49208	49208
N (regions)	40	40	40	40	40	40

Notes: Standard errors in parentheses are clustered by region. The sample consists of children alive at time of interview from five countries: Cameroon, Kenya, Malawi, Rwanda, and Zimbabwe. For current school attendance (columns 1 & 2), sample includes children 7-14 years old, and for behind grade-for-age and years behind (columns 3-6), sample includes children 8-14 years old. For columns 1 & 2, the outcome variable equals 1 if the child was in school at some point during the current academic year and 0 otherwise. For columns 3 & 4, the outcome equals 1 if the child was behind grade-for-age and 0 otherwise. Grade-for-age is set to equal 0 if the child had completed at least 1-3 year(s) of schooling at age 8. For columns 5 & 6, the outcome can take on integer values between 1 and 8; this is the number of years behind grade-for-age conditional on being behind. Each column reports average marginal effects from a logit model (columns 1 & 2) or linear model (columns 3-6; note that average marginal effect would be the coefficient estimate). Additional covariates include indicators for child's age, female, age-female interaction terms, highest educational attainment of household member 20+ years old, type of flooring, urban residence, time trend (i.e. indicator if survey was conducted after 2005), urban-specific time trend, and region fixed effects. ***p<0.01,**p<0.05,*p<0.10

TABLE 6a. Country-specific time trends accounts for much of the effect of ART scale-up on non-HIV households

Sample:	All households	HIV & Non-HIV households	HIV households	Non-HIV households
	(1)	(2)	(3)	(4)
PANEL A. **Without country-specific time trends**				
Regional HIV prevalence rate of `high impact cohort'	0.419	0.477	0.488	0.457
	(0.121)***	(0.156)***	(0.249)**	(0.167)***
Country-specific time trends	No	No	No	No
Pseudo R-squared	0.177	0.178	0.173	0.181
PANEL B. **With country-specific time trends**				
Regional HIV prevalence rate of `high impact cohort'	0.177	0.330	0.579	0.264
	(0.178)	(0.219)	(0.353)	(0.221)
Country-specific time trends	Yes	Yes	Yes	Yes
Pseudo R-squared	0.178	0.180	0.174	0.183
Mean of outcome variable in pre-ART period	0.867	0.863	0.891	0.859
N (children 7-14 years old)	157746	77537	12625	64821
N (regions)	70	70	68	70

Notes: Standard errors in parentheses are clustered by region. Sample consists of children alive at time of interview from the following 7 countries: Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. The outcome variable is binary and equals 1 if child had attended school during the current academic year. Each cell shows the average marginal effect from a logit model. Additional controls include regional HIV prevalence of adults 15-19 years old, indicators for chidl's age, indicator for child's sex, age indicators interacted with sex, urban resident, indicator for births in post-ART period, urban-specific time trend, indicators for highest educational attainment of household member 20+ years old, type of flooring, and region fixed effects. All regressions include household sample weights adjusted by population size in year of survey. ***p<0.01,**p<0.05,*p<0.10

TABLE 6b. Country-specific time trends cannot account for effect of ART scale-up on number of years behind grade-for-age

Sample:	All households	HIV & Non-HIV households	HIV households	Non-HIV households
	(1)	(2)	(3)	(4)
PANEL A. **Without country-specific time trends**				
Regional HIV prevalence rate of `high impact cohort'	-2.256	-2.872	-2.097	-2.908
	(0.619)***	(0.696)***	(1.796)	(0.848)***
Country-specific time trends	No	No	No	No
Adjusted R-squared	0.306	0.291	0.258	0.295
PANEL B. **With country-specific time trends**				
Regional HIV prevalence rate of `high impact cohort'	-1.738	-2.009	-1.278	-2.016
	(0.699)**	(0.885)**	(2.265)	(1.089)*
Country-specific time trends	Yes	Yes	Yes	Yes
Adjusted R-squared	0.307	0.292	0.259	0.297
Mean of outcome variable in pre-ART period	2.295	2.274	2.101	2.297
N (children 8-14 years old)	78829	36958	5227	31731
N (regions)	70	70	70	70

Notes: Standard errors in parentheses are clustered by region (70 regions). Sample consists of children, who are behind grade-for-age, alive at time of interview from 7 countries: Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. Grade-for-age is set to equal 0 if an eight year-old child has completed one year of school. If the child is ahead by more than two years, grade-for-age is coded as missing. The outcome variable is the number of years that the child is behind grade-for-age, and it ranges from 1 to 8. Each cell reports the coefficient on "regional HIV prevalence rate of adults born between 1965 and 1975" from a linear regression model. Additional covariates include indicators for child's age, female, age-female interaction terms, highest educational attainment of household member 20+ years old, type of flooring, urban residence, time trend (indicator if interview was conducted after 2005), urban-specific time trend, and region fixed effects. Regressions are weighted using household sample weights adjusted by population size. ***p<0.01,**p<0.05,*p<0.10

TABLE 7. Gap in years behind grade-for-age increases with age but, for 13-14 year-olds, can partially be explained by dropouts

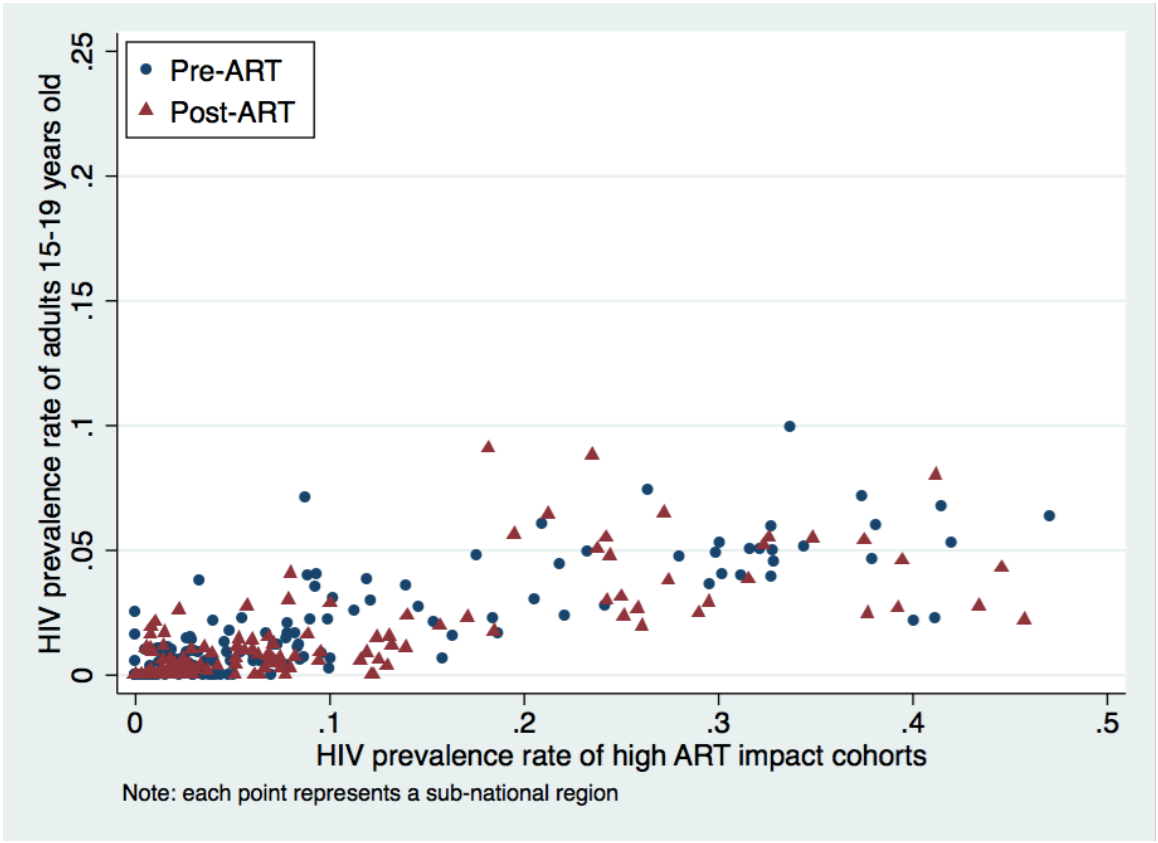
	Children who are behind grade-for-age:				Children who are behind grade-for-age and are currently attending school:			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HIV prevalence of `high impact cohort' [HIV]	-2.256	0.581	-1.738	1.122	-1.041	0.471	-0.922	0.602
	(0.619)***	(0.944)	(0.699)**	(1.226)	(0.655)	(0.723)	(0.428)**	(0.810)
HIV X Age 9		-1.900		-1.941		-1.130		-1.157
		(0.496)***		(0.477)***		(0.382)***		(0.379)***
HIV X Age 10		-1.856		-1.944		-1.021		-1.084
		(0.616)***		(0.610)***		(0.468)**		(0.476)**
HIV X Age 11		-2.679		-2.724		-1.723		-1.715
		(0.916)***		(0.898)***		(0.558)***		(0.542)***
HIV X Age 12		-3.182		-3.252		-1.904		-1.938
		(1.151)***		(1.141)***		(0.772)**		(0.768)**
HIV X Age 13		-3.912		-3.981		-1.828		-1.879
		(1.490)**		(1.478)***		(1.013)*		(1.005)*
HIV X Age 14		-3.880		-3.894		-1.564		-1.508
		(1.691)**		(1.678)**		(1.233)		(1.221)
F-statistic: HIVxAge9=HIVxAge10=HIVxAge11= HIVxAge12=HIVxAge13=HIVxAge14		1.34		1.34		1.30		1.15
Prob > F		0.257		0.259		0.276		0.344
Country-specific time trends?	No	No	Yes	Yes	No	No	Yes	Yes
N (children 8-14 years old)	78829	78829	78829	78829	66888	66888	66888	66888
N (regions)	70	70	70	70	70	70	70	70

Notes: Standard errors in parentheses are clustered by region. Sample consists of children 8-14 years old from the following 7 countries: Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. The outcome variable is number of years behind grade-for-age conditional on being behind; grade-for-age is set to equal 0 if the child has completed 1 year of schooling at age 8. The outcome variable can take on integer values between 1 and 8. "HIV prevalence of the `high impact cohort' [HIV]" is the regional HIV prevalence rate of adults born between 1965 & 1975. Additional covariates include regional HIV prevalence rate of adults 15-19 years old, age indicators, female indicator, age-female interaction terms, indicators for the highest level of education attained by a household member over 20 years old, type of flooring, urban residence, indicator for interviews conducted after 2005 (i.e. time trend), urban-specific time trend, and region fixed effects. Columns 3 & 4 include country-specific time trends. In columns 2 & 4, age-specific coefficients for HIV prevalence of adults 15-19 years old are also included. ***p<0.01,**p<0.05,*p<0.10

TABLE 8. Improvements in child education with ART scale-up are not explained by public goods provision at the region level

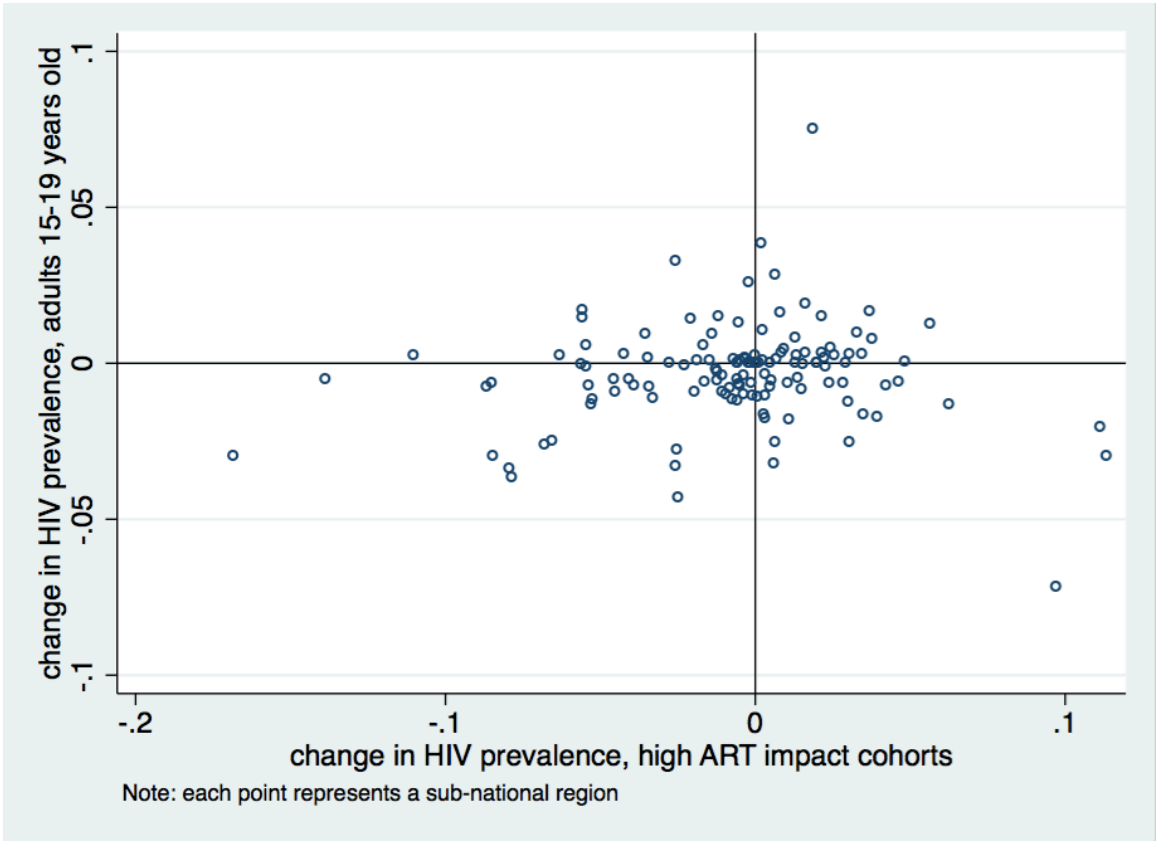
Outcome variable:	Child is currently attending school				Child is behind grade-for-age				If behind, number of years that child is behind grade-for-age			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Regional HIV prevalence rate of `high impact cohort'	0.356	0.221	0.351	0.229	0.035	-0.090	0.153	0.041	-2.248	-2.067	-2.074	-2.097
	(0.114)***	(0.101)**	(0.118)***	(0.094)**	(0.366)	(0.345)	(0.350)	(0.314)	(0.519)***	(0.606)***	(0.633)***	(0.560)***
Regional electricity coverage	0.265	.	.	0.219	-0.161	.	.	-0.203	-1.098	.	.	-1.000
	(0.077)***	.	.	(0.078)***	(0.241)	.	.	(0.237)	(0.457)**	.	.	(0.496)**
Household has electricity	0.012	.	.	0.012	-0.071	.	.	-0.071	-0.105	.	.	-0.105
	(0.006)**	.	.	(0.006)**	(0.010)***	.	.	(0.010)***	(0.034)***	.	.	(0.034)***
Regional rate of open defecation	.	-0.282	.	-0.252	.	-0.560	.	-0.653	.	0.453	.	0.201
	.	(0.091)***	.	(0.099)**	.	(0.178)***	.	(0.209)***	.	(0.386)	.	(0.388)
Household does not have toilet	.	-0.070	.	-0.069	.	0.094	.	0.094	.	0.342	.	0.343
	.	(0.017)***	.	(0.017)***	.	(0.019)***	.	(0.019)***	.	(0.078)***	.	(0.079)***
Regional rate of piped water coverage	.	.	0.041	-0.013	.	.	-0.197	-0.227	.	.	-0.314	-0.167
	.	.	(0.055)	(0.051)	.	.	(0.195)	(0.178)	.	.	(0.264)	(0.300)
Household drinks from piped water source	.	.	0.017	0.017	.	.	-0.034	-0.034	.	.	-0.054	-0.054
	.	.	(0.005)***	(0.005)***	.	.	(0.008)***	(0.008)***	.	.	(0.027)**	(0.027)**
Pseudo R-squared	0.188	0.188	0.187	0.188	0.285	0.286	0.286	0.287	0.314	0.314	0.314	0.314
N (children)	157735	157735	157735	157735	133735	133735	133735	133735	78822	78822	78822	78822
N (regions)	70	70	70	70	70	70	70	70	70	70	70	70

Notes: Standard errors in parentheses are clustered by region (70 regions). Sample consists of children 7-14 (columns 1-4) or children 8-14 years old (columns 5-12) from Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. Grade-for-age is defined as the completion one or more years of schooling at age 8. The `high impact cohorts' are adults born between 1965 and 1975. Each column corresponds to a separate regression, and all regressions include the following controls: indicators for child's age, child's sex, sex interacted with age indicators, urban residence, post-ART period dummy variable, urban interacted with post-ART period dummy, highest educational attainment of household member 20+ years old, type of flooring, source of drinking water (piped water, borehole/tubewell, well water), no toilet, access to electricity, and region fixed effects. ***p<0.01,**p<0.05,*p<0.10



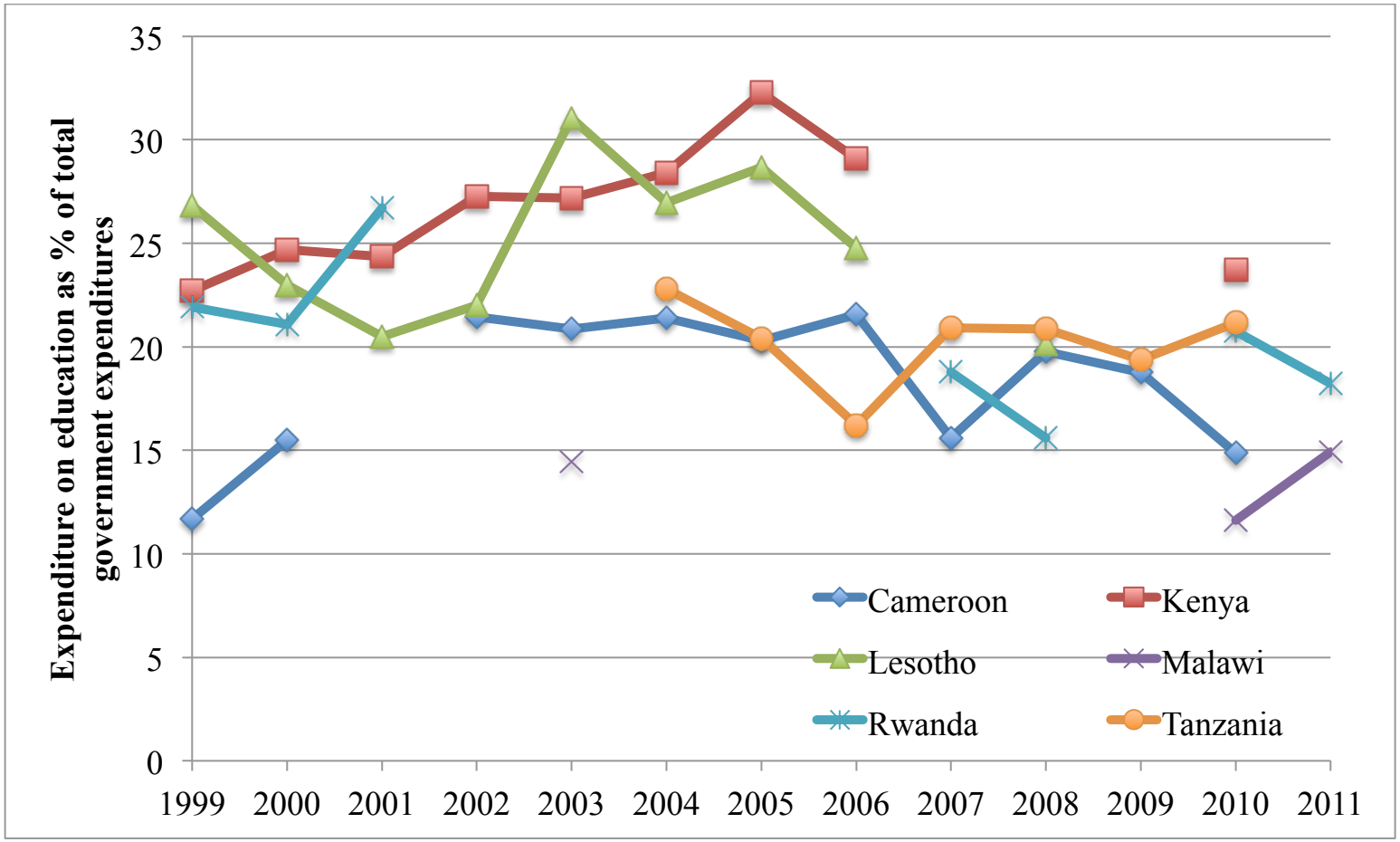
APPENDIX FIGURE 1a.

Regional HIV prevalence rates of high impact cohorts and young adults, in levels

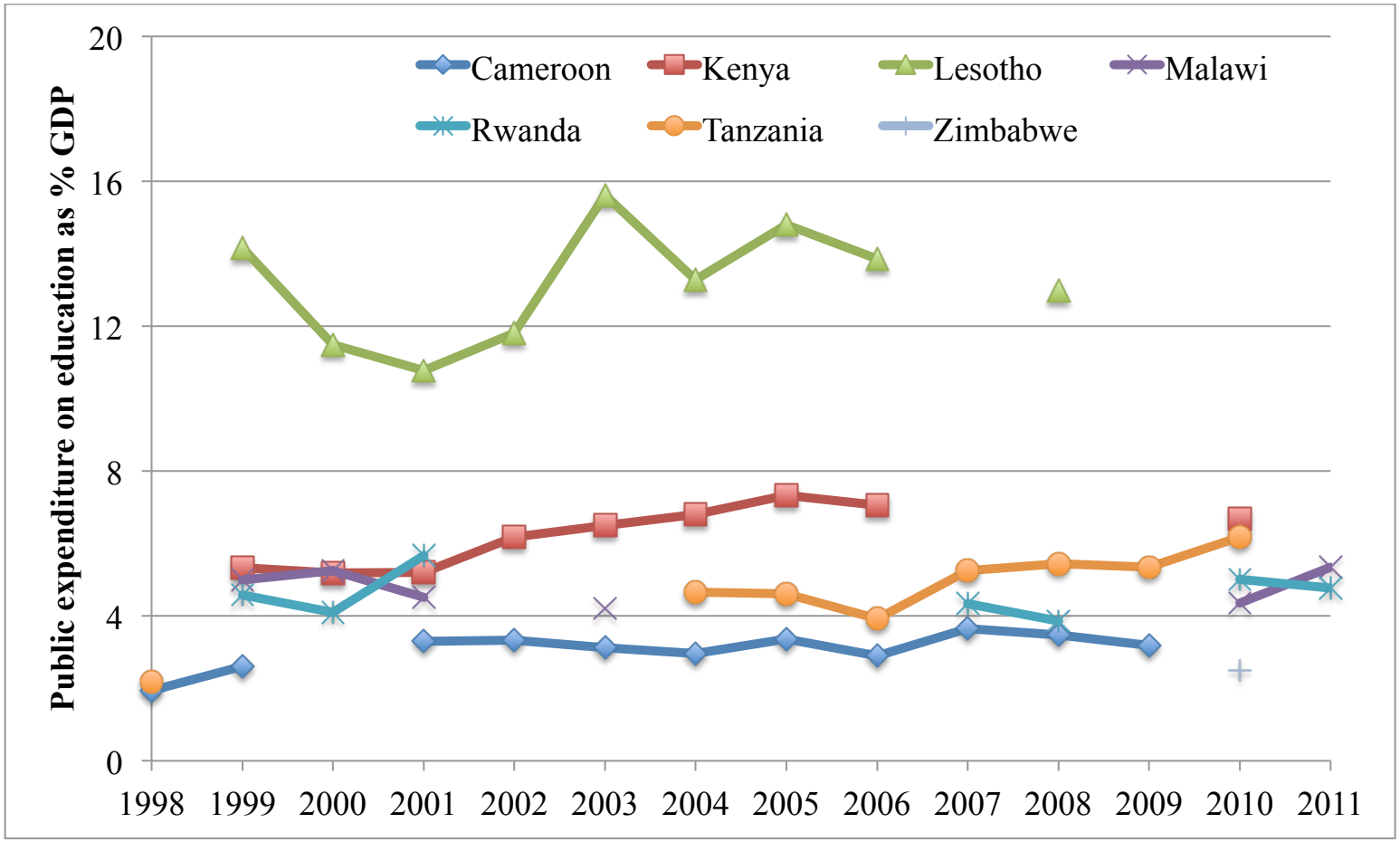


APPENDIX FIGURE 1b.

Changes in regional HIV prevalence rates of high impact cohorts and young adults



APPENDIX FIGURE 2.
Trends in expenditure on education as a percentage of total government expenditures
Source: UNESCO, downloaded on 4 March 2014



APPENDIX FIGURE 3.
Trends in public expenditure on education as percent of GDP
Source: UNESCO, downloaded on 4 March 2014

APPENDIX TABLE 1. Differential trends in observable characteristics among older children, children from households selected to test for HIV, children from households in which adults refused to test, and children from households in which at least one adult tested HIV-positive

	No education	Natural flooring	Has electricity	Urban residence	Female-headed household
	(1)	(2)	(3)	(4)	(5)
PANEL A. Children 7-9 years old vs. children 11-13 years old					
Children 11 to 13 years old [Constant]	0.162	0.683	-0.147	0.221	0.287
	(0.003)***	(0.004)***	(0.004)***	(0.003)***	(0.005)***
Children 7 to 9 years old	-0.007	0.021	-0.002	-0.004	-0.024
	(0.004)	(0.004)***	(0.003)	(0.004)	(0.004)***
Post-ART period	-0.041	-0.035	0.033	-0.017	0.017
	(0.006)***	(0.008)***	(0.008)***	(0.006)***	(0.011)
Children 7 to 9 years old x Post-ART period	0.004	-0.008	-0.009	0.002	-0.010
	(0.006)	(0.006)	(0.005)*	(0.005)	(0.008)
N (children ages 7 to 9 years, 11 to 13 years)	118932	118932	118932	118932	118932
PANEL B. Children from household selected to test for HIV					
No adult in household was asked to test for HIV [Constant]	0.213	0.701	0.138	0.211	0.305
	(0.009)***	(0.005)***	(0.005)***	(0.005)***	(0.009)***
At least one adult was asked to test for HIV	-0.086	-0.016	0.013	0.012	-0.041
	(0.015)***	(0.007)**	(0.006)**	(0.006)**	(0.012)***
Post-ART period	-0.044	-0.028	0.026	-0.016	0.018
	(0.008)***	(0.010)***	(0.010)**	(0.008)*	(0.011)*
Asked to test for HIV x Post-ART period	0.008	-0.015	0.004	-0.0004	-0.007
	(0.008)	(0.012)	(0.010)	(0.0087)	(0.013)
N (children ages 7 to 14 years)	157950	157950	157950	157950	157950
PANEL C. If household was selected to test for HIV: children from households in which at least one adult member refused/was absent for HIV test					
No adult in household refused or was absent for HIV test [Constant]	-0.032	0.706	0.127	0.198	0.277
	(0.008)***	(0.006)***	(0.004)***	(0.005)***	(0.007)***
At least one adult refused or was absent for HIV test	-0.040	-0.082	0.056	0.088	-0.052
	(0.005)***	(0.012)***	(0.009)***	(0.012)***	(0.017)***
Post-ART period	0.018	-0.059	0.042	-0.004	0.012
	(0.010)*	(0.009)***	(0.007)***	(0.007)	(0.011)
Refused/was absent for HIV test x Post-ART period	0.134	0.042	-0.032	-0.026	-0.005
	(0.003)***	(0.017)**	(0.013)**	(0.017)	(0.021)
N (children ages 7 to 14 years)	83345	83345	83345	83345	83345
PANEL D. If household was selected and agreed to test for HIV: children from households in which at least one adult member tested HIV+					
No adult in household tested HIV-positive [Constant]	0.147	0.730	0.116	0.178	0.268
	(0.004)***	(0.005)***	(0.004)***	(0.004)***	(0.007)***
At least one adult tested HIV-positive	-0.070	-0.122	0.044	0.091	0.048
	(0.009)***	(0.017)***	(0.011)***	(0.014)***	(0.017)***
Post-ART period	-0.045	-0.065	0.042	-0.002	0.009
	(0.006)***	(0.010)***	(0.007)***	(0.007)	(0.012)
At least one adult tested HIV-positive x Post-ART period	0.043	0.047	0.0001	-0.015	0.042
	(0.011)***	(0.024)*	(0.0172)	(0.021)	(0.025)*
N (children ages 7 to 14 years)	62717	62717	62717	62717	62717

Notes: Standard errors in parentheses are clustered by region (70 clusters). Sample consisted of children 7-14 years old from the following countries: Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe." Post-ART period" refers to years 2009-2012, and omitted category is the pre-ART period, i.e. 2003-2005. Women 15-49 years old and men 15-59 years old living in households that also were chosen to answer the men's questionnaire were eligible for HIV testing by DHS. Regressions included region fixed effects. ***p<0.01,**p<0.05,*p<0.10

APPENDIX TABLE 2. Comparison of main results using HIV prevalence of the `high impact cohort' versus HIV prevalence of all adults 15-49 years old

	Mean of outcome, pre-ART period	Regional HIV prevalence rate of… `high impact cohort' (birth years 1965/75)	Regional HIV prevalence rate of… adults 15-49 years old
Outcome: **Current school attendance**	0.867	0.419 (0.121)***	0.572 (0.341)*
Outcome: **Behind grade-for-age**	0.660	-0.005 (0.374)	0.384 (0.899)
Outcome: **If behind grade-for-age, number of years**	2.295	-2.256 (0.619)***	-3.103 (1.118)***
Outcome: **If behind grade-for-age, number of years (model includes country-specific time trends)**	2.295	-1.738 (0.699)**	-1.561 (1.183)

Notes: Standard errors in parentheses are clustered by region (70 clusters). Sample consists of children 7-14 years old (or children 8-14 years old when examining behind grade-for-age) from the following countries: Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. Grade-for-age is defined as 1-3 years of school completed at age 8 and is based on years of completed education. "Current school attendance" and "Behind grade-for-age" are binary variables that equal 1 if the statements are satisfied; "If behind grade-for-age, numbers of years" takes on positive integer values between 1 and 7. For current school attendance, I use a logit model and report average marginal effect on regional HIV prevalence; for all other outcomes, I use linear models and report the coefficient estimate on regional HIV prevalence. Additional covariates include indicators for child's age, child's sex, age-sex interaction terms, highest educational attainment of household member 20+ years old, urban residence, post-ART dummy, urban-specific time trend, type of flooring, and region fixed effects.
***p<0.01,**p<0.05,*p<0.10

APPENDIX TABLE 3a. Results for current school enrollment are not driven by a single country (i.e. robustness check for country outliers)

Exclude:	None	Cameroon	Kenya	Lesotho
HIV prevalence of high impact cohort	0.419	0.452	0.484	0.429
	(0.121)***	(0.137)***	(0.136)***	(0.128)***
[Mean of dependent variable in pre-ART period]	*[0.867]*	*[0.872]*	*[0.844]*	*[0.867]*
N (children 7-14 years)	157746	130689	145994	140519
N (regions)	70	60	63	60
Exclude:	Malawi	Rwanda	Tanzania	Zimbabwe
HIV prevalence of high impact cohort	0.369	0.401	0.254	0.465
	(0.148)**	(0.127)***	(0.090)***	(0.133)***
[Mean of dependent variable in pre-ART period]	*[0.867]*	*[0.869]*	*[0.892]*	*[0.862]*
N (children 7-14 years)	114347	134676	139258	140993
N (regions)	67	60	50	60

Notes: Standard errors in parentheses are clustered by region. Each cell shows the average marginal effect from a logit model. Additional covariates include indicators for age, female, age-female interaction terms, urban residence, indicator if survey was conducted after 2005 (time trend), urban-specific time trend, highest educational attainment of household member 20+ years, type of flooring, and region fixed effects. Dependent variable is a dummy variable that equals one if the child was currently attending school. Regressions are weighted by household sample weights adjusted for population size. `Number of observations' displayed in the table are unweighted. ***p<0.01,**p<0.05,*p<0.10

APPENDIX TABLE 3b. Results for behind grade-for-age are not driven by a single country (i.e. robustness check for country outliers)

Exclude:	None	Cameroon	Kenya	Lesotho
HIV prevalence of high impact cohort	-0.005	-0.029	0.153	-0.013
	(0.374)	(0.441)	(0.421)	(0.397)
[Mean of dependent variable in pre-ART period]	*[0.660]*	*[0.673]*	*[0.670]*	*[0.660]*
N (children 7-14 years)	133743	111547	123616	118695
N (regions)	70	60	63	60
Exclude:	Malawi	Rwanda	Tanzania	Zimbabwe
HIV prevalence of high impact cohort	-0.275	-0.010	-0.364	0.430
	(0.410)	(0.389)	(0.242)	(0.397)
[Mean of dependent variable in pre-ART period]	*[0.655]*	*[0.640]*	*[0.625]*	*[0.690]*
N (children 7-14 years)	97196	114114	117902	119388
N (regions)	67	60	50	60

Notes: Standard errors in parentheses are clustered by region. Each cell shows the coefficient on "regional HIV prevalence rate of adults born between 1965 & 1975 [high impact cohort]' from a linear regression model. Grade-for-age is set to 0 if an eight year-old child has completed one year of school. If the child is ahead by more than two years, grade-for-age is coded as missing. The outcome variable equals 1 if the child was behind grade-for-age. Additional covariates include indicators for age, female, age-female interaction terms, urban residence, indicator if survey was conducted after 2005 (time trend), urban-specific time trend, highest educational attainment of household member 20+ years, type of flooring, and region fixed effects. Dependent variable is a dummy variable that equals one if the child was currently attending school. Regressions are weighted by household sample weights adjusted for population size. `Number of observations' displayed in the table are unweighted. ***p<0.01,**p<0.05,*p<0.10

APPENDIX TABLE 3c. Results for years behind grade-for-age are not driven by a single country (i.e. robustness check for country outliers)

Exclude:	None	Cameroon	Kenya	Lesotho
HIV prevalence of high impact cohort	-2.256	-2.224	-2.385	-2.420
	(0.619)***	(0.696)***	(0.704)***	(0.669)***
[Mean of dependent variable in pre-ART period]	*[2.295]*	*[2.288]*	*[2.338]*	*[2.297]*
N (children 7-14 years)	78829	67502	73006	69915
N (regions)	70	60	63	60
Exclude:	Malawi	Rwanda	Tanzania	Zimbabwe
HIV prevalence of high impact cohort	-3.084	-1.912	-2.239	-1.776
	(0.598)***	(0.570)***	(0.637)***	(0.678)**
[Mean of dependent variable in pre-ART period]	*[2.283]*	*[2.251]*	*[2.295]*	*[2.317]*
N (children 7-14 years)	55448	62954	69128	75021
N (regions)	67	60	50	60

Notes: Standard errors in parentheses are clustered by region. Each cell shows the coefficient on "regional HIV prevalence rate of adults born between 1965 & 1975 [high impact cohort]' from a linear regression model. Grade-for-age is set to 0 if an eight year-old child has completed one year of school. If the child is ahead by more than two years, grade-for-age is coded as missing. The outcome variable is the number of year that the child is behind and ranges from 1 to 8. Additional covariates include indicators for age, female, age-female interaction terms, urban residence, indicator if survey was conducted after 2005 (time trend), urban-specific time trend, highest educational attainment of household member 20+ years, type of flooring, and region fixed effects. Dependent variable is a dummy variable that equals one if the child was currently attending school. Regressions are weighted by household sample weights adjusted for population size. `Number of observations' displayed in the table are unweighted. ***p<0.01,**p<0.05,*p<0.10

APPENDIX TABLE 4. ART scale-up and probability of being behind grade-for-age -- with country-specific time trends

	(1) All households	(2) HIV & Non-HIV households	(3) HIV households	(4) Non-HIV households
PANEL A. **Without country-specific time trends**				
Regional HIV prevalence rate of `high impact cohort'	-0.005	-0.248	-0.126	-0.250
	(0.374)	(0.473)	(0.509)	(0.493)
Country-specific time trends	No	No	No	No
PANEL B. **With country-specific time trends**				
Regional HIV prevalence rate of `high impact cohort'	-0.014	-0.037	0.350	-0.099
	(0.325)	(0.408)	(0.434)	(0.441)
Country-specific time trends	Yes	Yes	Yes	Yes
Mean of outcome variable in pre-ART period	0.660	0.655	0.566	0.670
N (children 8-14 years old)	133743	65852	10781	55071
N (regions)	70	70	70	70

Notes: Standard errors in parentheses are clustered by region (70 regions). Sample consists of children, who are behind grade-for-age, alive at time of interview from 7 countries: Cameroon, Kenya, Lesotho, Malawi, Rwanda, Tanzania, and Zimbabwe. Grade-for-age is set to equal 0 if an eight year-old child has completed one year of school. If the child is ahead by more than two years, grade-for-age is coded as missing. The outcome variable is binary and equals 1 if the child is behind grade-for-age. Each cell reports the coefficient on "regional HIV prevalence rate of adults born between 1965 and 1975" from a linear regression model. Additional covariates include indicators for child's age, female, age-female interaction terms, highest educational attainment of household member 20+ years old, electricity, type of flooring, urban residence, time trend (indicator if interview was conducted after 2005), urban-specific time trend, and region fixed effects. Regressions are weighted using household sample weights adjusted by population size.
***p<0.01,**p<0.05,*p<0.10

APPENDIX 5. SAMPLE COMPOSITION

	Table 2	Table 3	Table 4	Table 5	Table 6
	Baseline	Orphans	Placebo test	Country-specific time trends	Attitude towards HIV+ teachers
Cameroon	X	X	X	X	X
Kenya	X		X	X	X
Lesotho	X	X		X	
Malawi	X	X	X	X	X
Rwanda	X	X	X	X	X
Tanzania	X	X	X	X	
Zimbabwe	X	X	X	X	X