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Left behind: intergenerational transmission of human capital in the midst of HIV/AIDS

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Abstract This paper provides evidence on how adverse health conditions affect the transfer of human capital from one generation to the next. We explore the differential exposure to HIV/AIDS epidemic in sub-Saharan Africa as a substantial health shock to both household and community environment. We utilize the recent rounds of the Demographic and Health Surveys for 11 countries in sub-Saharan Africa. First, we find that an additional year of maternal education leads to a 0.37-year increase in children's years of schooling in the developing economies in sub-Saharan Africa. Second, our results show that mother's HIV status has substantial detrimental effects on inheritability of human capital. We find that the association between infected mothers' and their children's human capital is 30 % less than the general population. Finally, focusing only on noninfected mothers and their children, we show that HIV prevalence in the community also impairs the intergenerational human capital transfers even if mother is HIV negative. The findings of this paper are particularly distressing for these already poor, HIV-torn countries as in the future they will have even lower overall level of human capital due to the epidemic.

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1 Introduction

Over the last three decades, HIV/AIDS epidemic continues to be one of the most serious infectious diseases in the world that affects the lives of millions of people internationally. Even though the HIV prevalence has leveled off and the number of new infections has fallen, there are still 33.4 million people living with HIV across the globe, 2.7 million of which became newly infected, and 2 million people have died of AIDS in 2008 alone. These tragic costs of HIV epidemic have been disproportionally borne by the people residing in sub-Saharan Africa. More than two-thirds of all HIV-positive people reside in this region and more than three-quarters of all AIDS deaths occurred there in 2008 (UNAIDS/WHO 2009). It is even more alarming that women account for more than 60 % of estimated HIV infections in the region (UNAIDS 2009). This raises serious concerns about next generations as they are the primary caregivers of children.

An extensive literature documents that there is a strong association between parent's human capital and that of their children in developed countries.[1] This high correlation between parents' and children's human capital is attributed to the genetic transmission of ability (nature) (Becker and Tomes 1986) or to parental wealth and care (nurture) (Sacerdote 2007; Plug and Vijverberg 2003). However, the literature provides limited evidence on the potential underlying mechanisms driving this strong relation (Black and Devereux 2011). Among others, even less is known about how adverse health conditions affect the transfer of human capital from one generation to the next.

In this paper, we first estimate the intergenerational transmission of human capital in the developing economies in sub-Saharan Africa. To the best of our knowledge, the present study is first to estimate the intergenerational transfer of human capital in this region.[2] We next analyze how poor health conditions within the household and in the community environment impact the transfer of

[1] See Black and Devereux (2011) and Corak (2004) for a review of this literature.

[2] A notable exception studying part of African countries is Hertz et al. (2007). They estimate the intergenerational persistence of human capital in four countries in Africa including Egypt, South Africa (KwaZulu-Natal), Ghana, and rural Ethiopia.

human capital from parents to children by exploring the differential exposure to HIV/AIDS epidemic.[3]

This paper makes several contributions. First, as pointed out in Black and Devereux (2011), the direction of current research on intergenerational mobility is to understand the underlying mechanisms driving the inheritability of economic and social status across generations. This paper adds to this growing literature by analyzing the differential exposure to disease as a potential underlying mechanism. We distinguish between two separate channels that are likely to differentially affect the intergenerational transfers, i.e., mother's HIV status and the community HIV prevalence. This enables us to disentangle household and community effects of the epidemic. Mothers who are HIV positive may transfer less of their human capital to their children due to physiological reasons, i.e., they may be too sick to educate their children. Moreover, increased risk of mortality may lead to behavioral changes among both infected and noninfected mothers. In particular, regardless of their HIV status, mothers in sub-Saharan Africa may underinvest in their children's human capital since in the disease environment, their children are likely to have a shorter life span to utilize returns to their human capital investment as our model presented in Section 2 suggests.

This paper also contributes to the broader literature looking at the association between life expectancy and economic development.[4] Other than directly looking at growth, more recent studies look at the determinants of growth, such as education, fertility, and labor force participation to examine the effects of health and life expectancy. For instance, mainly focusing on orphans, several studies have documented that HIV/AIDS epidemic in Africa has significant negative impacts on educational attainment (Case and Ardington 2006; Evans and Miguel 2007). On the other hand, a small number of studies show that HIV/AIDS epidemic has adverse effects beyond orphans through changing incentives for human capital investment even among nonorphan children (Fortson 2011).

[3]It would be ideal to analyze the effects of father's HIV status on intergenerational transmission of human capital too; however, HIV testing for fathers is only available for small fraction of fathers that are married to mothers in our sample and reside in the same household. We present estimation analysis with father's HIV status in Appendix Table 12. In Appendix Table 12, we find that for every additional year of father's education, children with HIV-positive fathers experience 0.13 fewer years of increase in their educational attainment. In percentage terms, the persistence coefficient between HIV-positive fathers and their children is 60 % smaller than the general population. Similarly, we find that children of HIV-positive fathers are half as likely to attend school and, if they attend, they show slower progress at school compared to children with HIV-negative fathers.

[4]There is no consensus on the direction or even the existence of a correlation between life expectancy and economic growth. Weil (2007) and Lorentzen et al. (2008) find positive effects of life expectancy on economic growth, whereas Acemoglu and Johnson (2007) find no effects.

We conduct our empirical analysis using newly available microdata from nationally representative Demographic Health Surveys (DHS) for Burkina Faso, Cameroon, Cote d'Ivorie, Ghana, Kenya, Malawi, Mali, Niger, Senegal, Zambia, and Zimbabwe. These data have several advantages. First, essential to the purpose of this paper, DHS allows us to link mother's demographic data to her own HIV status as well as to her husband's and children's demographic data, which is not possible in most of the available data for developing countries. Second, in contrast to previous HIV data that were based on women attending prenatal clinics, our data are nationally representative and provide very detailed information on individuals' geographic location. Third, since our data provide information on HIV infection at the individual level, we can utilize this source of variation to examine the effects of HIV/AIDS epidemic at the household level and community level separately. Finally, availability of previous surveys allows us to explore both cross-sectional variation and the long-term changes in intergenerational human capital transmission that is induced by HIV/AIDS.

To preview our results, we find that an additional year of maternal education is associated with a 0.37-year increase in children's years of schooling in the developing economies in sub-Saharan Africa. This correlation declines to 0.2 years when we control for household characteristics and community fixed effects. Moreover, our results show that mother's positive HIV status has detrimental effects on her ability to transfer her human capital to her children. We find that for every additional year of maternal education, educational attainment of children with HIV-positive mothers increases 30 % less than the general population. Additionally, controlling for maternal education, we find that children with HIV-infected mothers are half as less likely to attend school and, if they attend, they show slower progress at school. Robustness check shows that these results are not driven by individual unobserved heterogeneity.

Focusing only on noninfected mothers and their children, we find that the disease environment in the community also hinders the transfer of human capital over generations and children's attachment to school even if the mother is HIV negative. For example, in community fixed effect models, we find that children residing in a high HIV-prevalent community experience 0.09 fewer years of increase in their educational attainment for every additional year of maternal education compared to similar children in zero HIV-prevalent communities even if their mothers are healthy. Moreover, our findings suggest that a health shock experienced within the household (i.e., having a HIV-infected mother) is substantially more likely to decrease the transfer of human capital to the next generations compared to a community-wide health shock. Although the HIV prevalence in the community might lead to behavioral changes even among noninfected mothers as suggested by Fortson (2011), the findings in this paper show that the pure physiological impact of the disease is primarily responsible for the detrimental effects of the epidemic on the intergenerational transfer of human capital.

The remainder of the paper is organized as follows: Section 2 lays out the model. Section 3 describes the data used in the analysis. Section 4 discusses the empirical strategy and presents the main results, extensions, and robustness checks. Finally, Section 5 concludes.

2 Theoretical framework

In this section, using a human capital model, we show that changes in probability of survival generated by HIV prevalence lead to a decline in children's human capital investment. We use a standard Mincerian model of returns to education where each year of schooling leads to a certain percentage increase in earnings throughout the lifetime (T).[5] In our model, the only cost of schooling is its opportunity cost which is measured as foregone earnings and that earnings are constant thereafter. We assume that an increase in mortality risk today changes beliefs about both the current risk and future risks. Parents' years of schooling is defined as s_{p}, and children's schooling level is s_{c}. Parents' educational attainment is predetermined before the onset of HIV epidemic. Only children's schooling level (s_{c}) is affected by the changes in current and future mortality risks. Households discount future consumption with δ. The return of schooling is γ, and income is y for someone with no schooling. We assume that utility is linear in consumption. Thus, the discounted utility is the integral of instantaneous income over the time period during which income is earned. Following this, the utility-maximizing household maximizes the present discounted value of income of parents and the children as follows:[6]

$$\max_{s_{\mathrm{c}}} \int_0^T e^{-\delta t} y e^{\gamma s_{\mathrm{p}}} p(t)dt + \int_{s_{\mathrm{c}}}^T e^{-\delta t} y e^{\gamma s_{\mathrm{c}}} q(t)dt \tag{1}$$

where parents and children are subject to the probability of survival at age t, $p(t)$ and $q(t)$, respectively. Let $\mu(z)$ be the probability of death at age z. If the individuals face a risk of mortality m at each age t, then the parents' and the children's probability of survival at age t are[7]

$$p(t) = q(t) = e^{-\int_0^t \mu(z)dz} = e^{-mt}. \tag{2}$$

We assume that m depends on parents' HIV infection, HIV prevalence in the community, and other arguments. Also, we assume that $\frac{dm}{d\mathrm{HIVparents}} > 0$ and $\frac{dm}{d\mathrm{HIVcommunity}} > 0$. For these assumptions, we rely on results from Timaus and Jasseh (2004) and UNAIDS (2009) which provide estimates of changes in mortality induced by HIV/AIDS epidemic in countries in sub-Saharan Africa. Then, from Eq. 2, we obtain $\frac{dq(t)}{d\mathrm{HIVparent}} < 0$ and $\frac{dq(t)}{d\mathrm{HIVcommunity}} < 0$, meaning that

[5] In our model, we endogenize children's human capital formation. See Cigno (1998), Kalemli-Ozcan (2002), and Soares (2005) for models endogenizing both fertility and human capital decisions.

[6] We present the derivation of our model in Appendix.

[7] If we assume that parents and children have different mortality rates, our FOC remains the same.

the children's survival probability decreases both with parents' HIV infection and community HIV rate.

Solving Eq. 1 yields the optimal schooling level for children:

$$s_{\mathrm{c}}^{*} = T \ ln \frac{\gamma - \delta - m}{\gamma} \tag{3}$$

which yields $\frac{ds_{\mathrm{c}}}{dm} < 0$ and $\frac{ds_{\mathrm{c}}}{dq(t)} > 0$ from Eq. 2. This suggests that children get more schooling when the probability of survival increases. Hence, children's survival probability at age t, q(t), decreases both with parents' HIV infection and HIV prevalence in the community; therefore,

$$\frac{ds_{\mathrm{c}}}{d\mathrm{HIVparents}} < 0 \text{ and } \frac{ds_{\mathrm{c}}}{d\mathrm{HIVcommunity}} < 0. \tag{4}$$

The main mechanism behind the predictions of our model is the decreasing return to education in the disease environment (Ehrlich and Lui 1991; Meltzer 1992; Kalemli-Ozcan et al. 2000; Kalemli-Ozcan 2002; Soares 2005). The reduction in life expectancy induced by HIV epidemic decreases the time horizon over which benefits of human capital investment can be realized. HIV/AIDS decreases incentives for more years of schooling as both child and adult mortality increase due to epidemic. Given that life expectancy is 40–45 years of age in many sub-Saharan countries due to the high HIV prevalence (UNPD 2008), parents and children may prefer lower educational investment, and this may affect the intergenerational transfer of human capital.

3 Data

We use nationally representative samples from DHS.[8] DHS provides a wide range of information on demographic characteristics of women and their husband and children. In recent waves of DHS, respondents were asked to provide a few drops of their blood to be tested for HIV. The results from HIV testing provide reliable information on individual HIV status for a representative sample of women who are interviewed.

The strengths of these data are multifold. First of all, we can actually link children to their parents, which is not possible in most of the available data for developing countries. Moreover, women's HIV-testing results can all be linked to their husbands' and children's surveys which enable us to have a cleaner identification. Second, all previously available HIV data were based on samples of pregnant women attending prenatal clinics.[9] Our data, however, are based on a representative sample of the population. Response rate for

[8]DHS datasets are available at www.measuredhs.com, MEASURE DHS, Macro International Inc.

[9]Timberg (2006), among others, argues that this method overestimates HIV prevalence because pregnant women have higher risk of HIV infection since they are engaging in unprotected sex.

HIV testing is high, 86 % on average, for our sample of countries as shown in Appendix Table 10. One may argue that DHS estimates may be biased downwards due to the voluntary nature of the testing; however, in our view, these are the most reliable and representative estimates of HIV prevalence available to date. Third, since we have HIV status of mothers, we can utilize this information to examine the association between intergenerational transmission and mother's HIV status and distinguish it from the effect of community HIV prevalence. Finally, availability of older surveys allows us to account for unobserved heterogeneity at the community level in estimating the effects of community HIV prevalence on the transfer of human capital across generations.

Our data include Burkina Faso (2003, 1992), Cameron (2004, 1991), Cote d'Ivorie (2005, 1994), Ghana (2003, 1993/1994), Kenya (2003, 1993), Mali (2006, 1995/1996), Malawi (2004, 1992), Niger (2006, 1992), Senegal (2005, 1992), Zambia (2007, 1992), and Zimbabwe (2005/2006, 1994). In the latest rounds of DHS, HIV testing was administered in 17 African countries; however, we use 11 countries in our empirical analysis that have both a recent survey with HIV testing and an earlier wave from early 1990s.[10] By using old surveys, first, we are able to document the intergenerational transmission of human capital in early 1990s when the HIV/AIDS was virtually negligible. Second, and most importantly, we could test robustness of our main results for community-level unobserved heterogeneity by controlling for community fixed effects and secular changes over time. Details about the surveys used in the study are given in Appendix Table 10.

Data consist of mothers age between 15 and 49 and children age between 13 and 17. Mothers' human capital accumulation should be unaffected by the epidemic in order to capture the effect of HIV on transmission of human capital across generations. To account for this concern, since before 1980, HIV prevalence in sub-Saharan Africa was negligible (Fortson 2011), only women who were born before 1980 and their children are used in the analysis.[11] Furthermore, we exclude from the analysis children younger than 13 years of age who are likely to be at school continuing their education.

It is still likely that some of the children in our sample are still at school continuing their education. Thus, to quantify the educational progress of the children who are still at school, we construct additional measures of educational attainment including school attendance and progress through school.[12] Although these additional measures only allow us to capture the progress of

[10] Although we have a smaller sample when we restrict ourselves to 11 countries, the results change only slightly compared to the analysis using all 17 countries that HIV data are available. Therefore, since this is a more robust identification, we stick to 11-country sample in the empirical analysis.

[11] Mothers who were born before 1980 account for 99 % of all mothers in our sample.

[12] We define these additional measures of educational attainment as follows: We assign a value of 1 to the variable "school attendance" if the child has completed one or more years of schooling, 0 otherwise. Similarly, we create a variable as "progress through school," which is correct-grade-for-age, computed by dividing the years of schooling by years since age 7.

the children, not the realized educational attainment, there is strong evidence suggesting that these progress outcomes are likely to correlate with other measures of children's success (National Center for Education Statistics 1995).

Table 1 presents the descriptive statistics for mothers at 1990s and 2000s in columns (1) and (2), respectively. As aforementioned, HIV epidemic became prevalent in sub-Saharan Africa in late 1980s; therefore, the analysis of 1990s provides insight on the demographics of the population in the region in the absence of the epidemic. Table 1 shows that mothers' years of schooling increased by over more than a year on average since 1990s. In columns (3) and (4), we compare HIV-positive and HIV-negative mothers using the recent waves of DHS with HIV testing. Table 1 reveals that HIV-positive mothers are more educated, wealthier, less likely to be married, work and reside in rural areas, and have less children compared to HIV-negative mothers. Similarly, Table 2 reports the descriptive statistics for children at 1990s and 2000s. Table 2 points out that there is a positive trend in children's educational attainment in sub-Saharan Africa, in which children's years of schooling increased by a year. Moreover, columns (3) and (4) display children's characteristics by their mothers' HIV status. Children with HIV-positive mothers have higher years of schooling and school attendance and they progress better at school.

Table 1 Descriptive statistics for mothers

	All 1990s (1)	All 2000s (2)	HIV-positive 2000s (3)	HIV-negative 2000s (4)
Years of schooling	2.436	3.574	5.687	3.345
	(3.463)	(3.919)	(3.668)	(3.877)
Poorest		0.216	0.166	0.222
		(0.412)	(0.372)	(0.416)
Working status	0.627	0.664	0.575	0.674
	(0.484)	(0.489)	(0.495)	(0.487)
Married	0.913	0.866	0.567	0.899
	(0.282)	(0.340)	(0.496)	(0.302)
Number of children living	5.911	5.524	4.499	5.635
	(2.065)	(1.990)	(1.872)	(1.971)
Husband's HIV status		0.072	0.687	0.039
		(0.259)	(0.465)	(0.192)
Husband's years of schooling	3.633	5.039	7.768	4.885
	(4.414)	(5.849)	(7.317)	(5.718)
Age	37.964	38.884	37.879	38.993
	(5.501)	(5.455)	(5.154)	(5.475)
Rural	0.666	0.701	0.628	0.709
	(0.472)	(0.458)	(0.484)	(0.454)
Group share			0.098	0.902
N	9,562	8,992	879	8,113

Summary statistics are for mothers who are 15–49 years old in the survey year and were born before 1980. Column (1) reports the descriptive statistics from earlier waves of DHS conducted between 1991 and 1996. Columns (2)–(4) present descriptive statistics from recent surveys with HIV-testing data. In columns (2)–(4), only mothers with nonmissing HIV status are included. Standard deviations are reported in parentheses

Table 2 Descriptive statistics for children

	All 1990s (1)	All 2000s (2)	HIV-positive 2000s (3)	HIV-negative 2000s (4)
Years of schooling	3.439	4.444	5.927	4.283
	(2.698)	(2.857)	(2.382)	(2.859)
Progress through school	0.532	0.621	0.796	0.602
	(0.417)	(0.384)	(0.301)	(0.388)
School attendance	0.701	0.814	0.954	0.799
	(0.458)	(0.389)	(0.209)	(0.401)
Age	13.465	14.076	14.482	14.032
	(0.499)	(1.210)	(1.362)	(1.185)
Female	0.500	0.480	0.512	0.477
	(0.500)	(0.500)	(0.500)	(0.499)
Rural	0.666	0.701	0.628	0.709
	(0.472)	(0.458)	(0.484)	(0.454)
Group share			0.098	0.902
N	9,562	8,992	879	8,113

Summary statistics are for children who are 13–17 years old in the survey year. Column (1) reports the descriptive statistics from earlier waves of DHS conducted between 1991 and 1996. Columns (2)–(4) present descriptive statistics from recent surveys with HIV-testing data. In columns (2)–(4), only children with mothers that have nonmissing HIV status are included. Standard deviations are reported in parentheses

4 Empirical framework and results

We conduct our empirical analysis in three parts. First, we estimate the persistence of educational attainment across generations in sub-Saharan countries. Second, we examine how mother's own HIV status affects children's human capital formation controlling for mother's human capital and other household and community characteristics. In the third part, focusing only on noninfected mothers and their children, we analyze the impact of community HIV prevalence on the transfer of human capital across generations.

4.1 Intergenerational transmission of human capital

Before estimating the effects of HIV/AIDS, we want to analyze the intergenerational transmission of human capital in developing economies in sub-Saharan Africa. We use the standard specification relating the child's human capital to the mother's human capital:

$$\text{Child Outcomes}_{\text{irc}} = \alpha + \beta \text{Mother Outcomes}_{\text{irc}} + X'_{\text{irc}}\gamma + D_{\text{rc}} + D_{\text{rural}} + \epsilon_{\text{irc}} \quad (5)$$

where i denotes the individual and rc denotes the community, which is by country by region. Child $\text{Outcomes}_{\text{irc}}$ stands for child's human capital, while Mother $\text{Outcomes}_{\text{irc}}$ is the mother's human capital. X'_{irc} is a vector of other covariates, and ϵ_{irc} is a random error term. We include a wide range of child and mother characteristics in our analysis such as child's age, sex and number of siblings, mother's age, marital status, current working status, and dummies for wealth quintile as controls. We also add dummies for community and rural residence denoted as D_{rc} and D_{rural}, respectively.

Equation 5 should be regarded as a reduced-form equation, where β measures the degree of persistence or immobility in the society and is the fraction of the mother's human capital that her child inherits.[13] β is determined by multiple factors including genetic and behavior attributes transmitted from mothers to children (nature and nurture). In this formulation, Mother Outcomes_{irc} controls for all of the factors that affected mother's human capital, while X_{irc} includes everything else, such as the additional characteristics of the child and mother that did not affect mother's own human capital formation. Apparently, we do not observe all the characteristics of the mothers that might be correlated with child's human capital. However, ignoring X_{irc} variables that might be correlated with child's education may yield to upper bound estimates of the coefficient. Therefore, to address the potential omitted variables problem, we introduce more controls to Eq. 5 including family's background characteristics. We also incorporate rural and community dummies in our regressions to account for the differences across communities and different types of residence. All other remaining factors affecting children's human capital but not associated with maternal education are assumed to be captured by ϵ_{irc} (Aydemir et al. 2008).

In the intergenerational mobility literature, there is an ongoing debate on whether maternal or paternal education is more important for child's human capital formation. Child development literature suggests that mother's education has a prime influence on child's educational attainment (Haveman and Wolfe 1994). However, Behrman and Rosenzweig (2002), Gang and Zimmermann (2000), and Aydemir et al. (2008) find that child's postsecondary education is positively related to that of both parents. To address these mixed findings in the literature, we investigate whether maternal or paternal education matters more in children's human capital formation in sub-Saharan Africa. However, as mentioned earlier, in DHS, fathers are interviewed only if they reside in the same household as mothers and their response rate is relatively low. Therefore, analysis focusing on fathers warrants caution since fathers' sample is not representative. Results with father's education are reported in Appendix Table 11. Our analysis suggests that maternal education has more influence on child's human capital formation than paternal education in sub-Saharan Africa; hence, the persistence coefficient with maternal education in Table 3 is more than twice in magnitude compared to persistence coefficient with paternal education in Appendix Table 11. This may stem from the fact

[13]Estimates of β close to unity imply high persistence and limited mobility, whereas values of β close to 0 suggest low persistence and almost complete intergenerational mobility in outcomes. Presumably, any real number could be obtained from the estimation of Eq. 5; a positive value indicates immobility where higher parental education is associated with higher child education, whereas a negative value of β indicates a generational reversal where higher parental education is associated with lower child education.

Table 3 Intergenerational transmission of human capital

	(1)	(2)	(3)
Panel A: 2003–2007			
Mother's year of schooling	0.374*	0.362*	0.203*
	(0.006)	(0.006)	(0.007)
R^2	0.403	0.410	0.509
N	8,992	8,984	8,984
Panel B: 1991–1996			
Mother's year of schooling	0.422*	0.420*	0.230*
	(0.006)	(0.006)	(0.007)
R^2	0.299	0.306	0.494
N	9,562	9,561	9,561
Child's age and sex	Yes	Yes	Yes
Household characteristics		Yes	Yes
Region fixed effects			Yes

Mothers with nonmissing HIV status and their children are used in the regressions. Household characteristics include mother's age, wealth quintile, marital status, working status, and number of children. Column (3) also controls for community dummies and a rural dummy. Each column is from a separate regression with a constant. Robust standard errors are in parentheses
*$p < 0.05$ (significance level)

that most of the children have low levels of education in sub-Saharan Africa (i.e., the average years of schooling for children is 4.4 years) and mother's human capital is more important for the basic human capital formation as pointed in Pronzato (2012). Thus, in the remainder of the paper, we use maternal education in estimating intergenerational persistence of human capital.

Table 3 reports the persistence of educational attainment across generations in sub-Saharan countries. Panel A presents results from the recent DHS data collected in 2003–2007, while panel B shows the analysis using 1991–1996 DHS data. HIV prevalence is assumed to be zero or negligible in sub-Saharan Africa in early 1990s; thus, it is of interest to analyze the intergenerational mobility of human capital before and after HIV epidemic becomes prevalent in the region. The baseline specification that only controls for child's characteristics (reported in column (1) of panel A) suggests that persistence coefficient for human capital is 0.37 in developing economies in sub-Saharan Africa in 2000s. In column (2), we control for household characteristics by including dummies for wealth quintile, mother's age, working and marital status, and number of children to account for the fact that children's human capital may be sensitive to family background. Correlation coefficient, β, presented in column (2) is similar to the baseline specification suggesting that even after controlling for household characteristics, we observe a lot of persistence in education across generations in the region. Just as importantly, to account for differences in educational attainment across communities and different types of residence, in column (3), we include community dummies and a rural dummy into our estimation. The persistence coefficient in column (3) drops by almost half to 0.20 once we control for community characteristics and type of residence. This suggests that after controlling for household characteristics and community heterogeneity, for every additional year of maternal education, children's education increases by 0.2 years in the HIV-torn region after the epidemic.

This persistence coefficient is lower than the persistence coefficient in the USA (0.46, Hertz et al. 2007). One of the possible reasons for this difference between our estimates and estimates for the USA may stem from the fact that some of children in our sample may be still at school. This may lead to underestimation of the correlation. To minimize this potential problem, we exclude from our analysis children who are at primary-school age and younger. Given that educational attainment is low in sub-Saharan Africa (the average years of schooling is 3.6 years in mothers' generation and 4.4 years in children's generation in 2000s), we believe that we mostly capture children who completed or are about to complete their human capital formation. Therefore, it is unlikely that this accounts for a lower correlation between children and their mothers' education in sub-Saharan Africa. Second possible reason for lower correlation may be classical errors-in-variables problem in mother's and children's years of schooling. This is a particularly important concern in the estimation of the intergenerational transmission of earnings, where it is essential to have information on individual's permanent income (Solon 1992; Zimmerman 1992). However, as discussed in Aydemir et al. (2008) and Black and Devereux (2011), measurement of an outcome like education is less of a concern compared to earnings since nonemployment causes no difficulties and people tend to know and report their educational attainment more accurately.

In panel B, we analyze the persistence of educational attainment across generations using earlier waves of DHS. Following specifications mentioned earlier, in panel B, we find that the association between mothers' and children's years of schooling is 0.42 in sub-Saharan Africa in 1990s, before the HIV/AIDS epidemic became prevalent in the region. The persistence coefficient in 1990s is higher compared to 2000s (the difference in persistence coefficient between two periods is statistically significant, where in 2000s, children's years of schooling increase by 0.05 fewer years for every additional year of maternal education). A likely mechanism for the change in the intergenerational mobility over the last decade may be the increasing HIV prevalence in the region, which we will rigorously elaborate in the next sections.

4.2 Effect of mother's HIV status on intergenerational transmission of human capital

Results from the previous section show that there is a strong association between mothers' and their children's human capital in sub-Saharan Africa. Given the high rates of HIV prevalence among the prime-age women in the region, our primary interest in this paper is to determine whether mothers' HIV infection alters the human capital transfer across generations. In order to examine whether mother's HIV status impacts her ability to transfer her human capital, we allow persistence coefficient to differ between children with HIV-positive and HIV-negative mothers by interacting mother's human capital with her HIV status. More specifically, we estimate the following specification using 11 recent surveys with mother's HIV testing:

$$
\begin{aligned}
\text{Child Outcomes}_{\text{irc}} = \alpha + \beta \text{Mother Outcomes}_{\text{irc}} + \beta_2 \text{Mother Outcomes}_{\text{irc}} \\
* \, \mathit{Mother's HIV Status}_{\text{irc}} + \theta \, \mathit{Mother's HIV Status}_{\text{irc}} \\
+ X'_{\text{irc}} \gamma + D_{\text{rc}} + D_{\text{rural}} + \epsilon_{\text{irc}} \qquad (6)
\end{aligned}
$$

where Mother's HIV $\text{Status}_{\text{irc}}$ is a dummy variable that takes a value of 1 if mother i in community rc is tested HIV positive, and 0 otherwise. In this specification, β is the intergenerational persistence coefficient for the general population, whereas β_2 measures whether transmission coefficient differs for children with HIV-infected mothers. We estimate Eq. 6 following the specifications discussed in the previous section.

Table 4 shows the estimation results for mother's HIV status. Mother's HIV infection can impact child's human capital formation along extensive margin (whether child attends school or not) and/or intensive margin (years of schooling a child attains and her/his progress at school). To capture the impact of HIV epidemic on both dimensions of child's human capital formation, in panels A and B, we report the estimation results for child's years of schooling and progress at school, respectively, while panel C presents the analysis for child's school attendance. Panel A shows in all specifications that mother's positive HIV status impairs her ability to transfer her human capital. Column (1) suggests that for every additional year of maternal education, children with HIV-positive mothers have 0.1 fewer years of schooling compared to rest of the population. We find quantitatively similar results when we incorporate household characteristics into the baseline specification such as dummies for household wealth quintile, mother's working and marital status, and number of children (column (2)). The last column presents our preferred specification that also controls for community fixed characteristics and a type of residence. In this specification, we explore the variation in educational attainment between children with HIV-positive and HIV-negative mothers that have the same household characteristics and reside in the same community. Column (3) shows that the association between mother's and children's years of schooling decreases by 0.04 years if the mother is HIV positive. This is a sizable effect, given that the persistence coefficient for the entire population is 0.13. Thus, in percentage terms, the persistence coefficient between HIV-positive mothers and their children is approximately 30 % smaller than the persistence coefficient for the entire population.

Additional analysis presented in panel B examines progress through school as an alternative measure for child's educational attainment to account for the concern that some of children in our sample may be still at school continuing their education. Similar to child's years of schooling, in panel B, we find that children with HIV-infected mothers show slower progress at school compared to children of noninfected mothers. Since the analysis for progress through school yields similar results as children's years of schooling, in the reminder of the paper, we will mainly focus on children's years of schooling as an

Table 4 Effect of mother's HIV status on inheritability of human capital

	(1)	(2)	(3)
Panel A: Years of schooling			
Mother's year of schooling	0.378*	0.267*	0.135*
	(0.006)	(0.009)	(0.009)
HIV-positive mother * Mother's year of schooling	−0.109*	−0.130*	−0.038*
	(0.020)	(0.019)	(0.018)
HIV-positive mother	1.092*	1.016*	0.124
	(0.154)	(0.145)	(0.133)
R^2	0.407	0.477	0.567
N	8,992	8,200	8,200
Panel B: Progress through school			
Mother's year of schooling	0.055*	0.040*	0.020*
	(0.001)	(0.001)	(0.001)
HIV-positive mother* Mother's year of schooling	−0.018*	−0.021*	−0.006*
	(0.003)	(0.003)	(0.003)
HIV-positive mother	0.169*	0.163*	0.036
	(0.021)	(0.021)	(0.019)
R^2	0.314	0.367	0.478
N	8,892	8,200	8,200
Panel C: School attendance			
Mother's year of schooling	0.040*	0.029*	0.004*
	(0.001)	(0.001)	(0.001)
HIV-positive mother* Mother's year of schooling	−0.026*	−0.029*	−0.007*
	(0.003)	(0.002)	(0.002)
HIV-positive mother	0.202*	0.200*	0.028
	(0.020)	(0.020)	(0.017)
R^2	0.174	0.194	0.380
N	8,892	8,200	8,200
Child's age and sex	Yes	Yes	Yes
Household characteristics		Yes	Yes
Region fixed effects			Yes

Women with nonmissing HIV status and their children are used in the regressions. Household characteristics include household wealth quintile, mother's age, marital and working status, and number of children. Column (3) also controls for community dummies and a rural dummy. Each column is from a separate regression with a constant. Robust standard errors are reported in parentheses

$^* p < 0.05$ (significance level)

outcome to be able to draw parallel conclusions to the previous literature on intergenerational mobility of human capital.

Panel C presents the estimation results for the extensive margin of child's education (the outcome in panel C is child's school attendance). Panel C reports that children of HIV-positive mothers are about half as likely to attend school for each additional year of maternal education. For instance, in column (3), we find that having a HIV-infected mother takes away the positive effects of maternal education on child's school attendance, where the coefficient for the interaction term in row (2) is negative and larger in magnitude than the coefficient of maternal education alone in row (1). Overall, findings in Table 4 suggest that the HIV/AIDS epidemic has sizable detrimental effects beyond mothers' generation. Since more educated and wealthier mothers are more likely to be HIV positive, as summarized in Tables 1 and 5, HIV epidemic decreases the inequality in sub-Saharan Africa, per se. However, it is not that the disadvantageous population is doing any better, but the advantageous fraction of the population is worse off as a result of HIV epidemic.

The ordinary least squares (OLS) estimation above assumes that controlling for observable characteristics, the error term ϵ_{irc} is uncorrelated with mother's HIV status. However, if HIV-positive and HIV-negative mothers are systematically different in unobservable ways, OLS estimations would be biased. To account for this concern, we employ propensity score matching to ensure that mother's HIV status is random based on the distribution of observable covariates.

In Table 5, we investigate the determinants of mother's HIV status that will be used in the matching process. Table 5 reports the marginal probabilities and the associated standard errors from a reduced-form probit regression. This table shows that mother's education is significantly related to mother's HIV status with an inverted-U shape relationship where mothers with secondary education have the highest infection rates. Currently, married mothers have lower infection rates than mothers who are never married or formerly married. Residence type has no significant effect on mother's HIV status. Additionally, mothers in the first two wealth quintile categories (i.e., poorest and poorer)

Table 5 Determinants of mother's HIV status: probit regression

Dependent variable	Mother's HIV status
Age	0.008
	(0.007)
Age^2	−0.000
	(0.000)
Primary education	0.009
	(0.008)
Secondary education	0.022*
	(0.012)
Tertiary education	−0.013
	(0.018)
Currently married	−0.218*
	(0.155)
Formerly married	−0.004
	(0.023)
Rural	−0.014
	(0.010)
Poorer	−0.001
	(0.009)
Middle	0.026*
	(0.011)
Richer	0.038*
	(0.013)
Richest	0.058*
	(0.018)
R^2	0.208
N	7,720

Community dummies are included in the regression. The omitted categories are "no education," "urban," "never married," and "poorest wealth." Robust standard errors are reported in parentheses
*$p < 0.05$ (significance level)

Table 6 Effect of mother's HIV status on intergenerational transmission of human capital: propensity score matching

	Years of schooling (1)	Progress through school (2)	School attendance (3)
Mother's year of schooling	0.140*	0.021*	0.003
	(0.033)	(0.005)	(0.004)
HIV-positive mother* Mother's year of schooling	−0.062*	−0.011*	−0.010*
	(0.031)	(0.005)	(0.004)
HIV-positive mother	0.351	0.064	0.038
	(0.277)	(0.042)	(0.040)
R^2	0.597	0.523	0.502
N	1,629	1,629	1,629
Child's age and sex	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes

HIV-positive and HIV-negative women are matched (nearest-neighbor matching without replacement) based on mother's age, marital status, years of schooling, and wealth quintile. Only matched sample is used in the regressions. Each column is from a separate regression with a constant. Household characteristics include household wealth quintile, mother's marital and working status, and number of children. Each column also controls for community dummies and a rural dummy. Robust standard errors are reported in parentheses

* $p < 0.05$ (significance level)

are significantly less likely to be infected; 879 pairs of HIV-positive and HIV-negative mothers are matched based on the propensity scores within each region using one-to-one nearest neighbor matching without replacement.[14]

Table 6 mimics the specification in column (3) in Table 4 and reports the analysis using matched sample of 1,629 mothers (the matched sample is 1,758 in specification with no controls). Table 6 shows that children with HIV-positive mothers are 6 % less likely to have the same levels of education as their mothers compared to similar children with HIV-negative mothers residing in the same community. In addition, similar to Table 4, in columns (2) and (3) of Table 6, we find that mother's HIV infection offsets the positive effect of maternal education on child's progress at school and child's school attendance. Taken together, analyses presented in Table 6 yield similar results to OLS results in Table 4; thus, this lends credence that our results are not driven by unobserved heterogeneity.

Another potential concern is mortality. It may be the case that the HIV-positive mothers in Table 4 are not a representative sample of all mothers who ever contracted the virus. It is possible that mothers who contracted the disease earlier had already died. Based on observable characteristics that are associated with mother's HIV status, those who are more likely to contract the

[14] We use the matching procedure developed and described by Leuven and Sianesi (2003). Simple t tests on the equality of means between the HIV-positive and HIV-negative mothers show that our matched sample satisfies the balancing requirement. That is, there are no statistically significant differences between control and treatment groups in terms of observable characteristics.

disease and those who had already died from the disease are better educated. Therefore, if anything, our results present the lower bound for the potential negative effects of the epidemic on the inheritability of human capital across generations.

One of the potential mechanisms behind our findings may be the under-investment on child's human capital in the region. This decline in parental investment can be attributed to the pure physiological impact of the disease (which disables mothers to take proper care of their children), change in family structure and family income (70 % of fathers in the households with HIV-positive mothers are also HIV-positive themselves), or behavioral response of mothers stemming from the increased lifetime uncertainty in the region after the onset of the epidemic. To disentangle the potential channels responsible for the estimated effects of mother's HIV status on intergenerational transmission of human capital, Table 7 reports the analysis that mimics the specification in column (3) in Table 4. In addition, in Table 7, we also control for father's characteristics such as father's education, working, marital and HIV status, and number of children and variables proxying for parental investment on child's human capital. As measures of parental investment, we use mother's frequency of reading newspaper and magazine to child and child's frequency of listening radio and watching television. Table 7 reports that if both of the parents are HIV positive, every additional year of maternal education increases children's years of education by 0.05 years, whereas the corresponding association between noninfected parents and their children is 0.13 (almost three times larger). In addition, the significant negative effect of parents' HIV status on intergenerational transmission of human capital remains even when we control for parental human capital investment measures. Overall, Table 7 provides suggestive evidence that it is not the change in family structure or deterioration in investment in child's human capital that is mainly responsible for estimated effects of mother's HIV infection. Therefore, likely mechanisms behind our findings seem to be the physiological and behavioral impacts of the epidemic.

4.3 Effect of community HIV prevalence on intergenerational transmission of human capital

HIV epidemic may affect the human capital formation more broadly beyond the children of infected mothers. In this section, we quantify how growing up in a community with high mortality risk affects the transfer of human capital across generations. To isolate the pure impact of the community prevalence on child's human capital formation, in this section, we restrict our analysis to children with noninfected mothers.[15] We run the following community and

[15]Results are quantitatively similar when we include children with HIV-positive mothers into estimations. But since we find a significant effect of mother's HIV status in the previous section, in this part of the paper, we prefer to restrict our analysis to children with HIV-negative mothers only. Results including HIV-positive mothers are available upon request.

Table 7 Effect of mother's HIV status on intergenerational transmission: channels

	Years of schooling (1)	Progress through school (2)	School attendance (3)
Mother's year of schooling	0.130*	0.019*	0.005*
	(0.013)	(0.002)	(0.002)
HIV-positive parents* Mother's year of schooling	−0.079*	−0.011*	−0.017*
	(0.038)	(0.006)	(0.004)
HIV-positive parents	0.140	0.008	0.067
	(0.360)	(0.054)	(0.038)
Mother read newspaper or Magazine	0.180*	0.018	−0.020*
	(0.087)	(0.013)	(0.010)
Listen radio	0.195*	0.030*	0.043*
	(0.077)	(0.012)	(0.014)
Watch TV	0.238*	0.034*	0.002
	(0.092)	(0.014)	(0.016)
R^2	0.572	0.494	0.388
N	3,773	3,773	3,773

Regressions control for father's and mother's characteristics, i.e., age, years of schooling, HIV status, wealth quintile, working status, marital status, and number of living children. Other controls are proxies for investment for child's human capital, i.e., mother's propensity to read newspaper or magazines and child's propensity to listen radio and watch TV. Community dummies, rural dummy, child's age, and sex are also included in the regressions. Robust standard errors are reported in parentheses

$^{*}p < 0.05$ (significance level)

time period fixed effects regression exclusively on children with noninfected mothers:

$$\text{Child Outcomes}_{\text{irct}} = \alpha + \beta \text{Mother Outcomes}_{\text{irct}} + \beta_2 \text{Mother Outcomes}_{\text{irct}} * Community\,HIV_{\text{rct}} + X'_{\text{irct}}\gamma + D_{\text{rc}} + \zeta_t + D_{\text{rural}} + \epsilon_{\text{irct}}. \tag{7}$$

Community is defined country by region cells. Community HIV is defined as the fraction of adults 15–49 (both men and women) with positive HIV status in the community. t refers to time period, 1991–1996 and 2003–2007. D_{rc} is community fixed effects, controlling for the fact that communities may be systematically different from each other. ζ_t is the time-specific fixed effects, controlling for likely secular changes over time. The standard errors are clustered by community to account for the correlations in outcomes between children residing in the same community over time. Some descriptive statistics of communities are reported in Table 8. As Table 8 shows, community level HIV prevalence ranges from 0 to 21 % with the average being 7 %.

As mentioned earlier, Tables 1 and 5 show that better educated and wealthier mothers are more likely to be HIV positive. Thus, communities with higher HIV prevalence might also have higher human capital endowments and economic activity which may raise potential concerns on the interpretation of our analysis. To address this concern, we estimate the community and time

Table 8 Descriptive statistics for communities

	Mean	Standard deviation	Min	Max
Panel A: 2003–2007				
Child years of schooling	4.29	1.69	1.16	7.72
Child school attendance	0.79	0.23	0.25	1.00
Progress through school	0.62	0.22	0.17	1.00
Mother years of schooling	3.53	2.58	0.27	9.24
Father years of schooling	5.32	3.22	0.08	12.88
HIV prevalence	0.07	0.07	0.00	0.21
Panel B: 1991–1996				
Child years of schooling	3.65	1.69	0.86	6.95
Child school attendance	0.72	0.28	0.20	1.00
Progress through school	0.57	0.26	0.14	1.08
Mother years of schooling	2.63	1.98	0.00	7.55
Father years of schooling	3.88	2.88	0.00	12.29

"Community" refers to country by region cell. HIV prevalence is based on both men and women, while mother's and child's education variables refer to mothers with nonmissing HIV status and their children only

period fixed effects model using earlier waves of DHS. More specifically, in Eq. 7, we estimate to what extent the association between mothers' and children's human capital has changed over time with regard to the HIV prevalence in the community, which is measured by the coefficient β_2.[16]

Table 9 reports that high HIV prevalence in the community hinders children's human capital development both along intensive and extensive margins. For instance, column (1) shows that an additional year of maternal education leads to a 0.16-year increase in children's years of schooling if children live in a community that experienced 21 % increase in HIV prevalence between two time periods (which is the highest HIV prevalence increase in Table 8). On the other hand, the similar children residing in a community with zero HIV prevalence experience 0.25 years of increase in their educational attainment for every additional year of maternal education. In columns (2) and (3), we find similar results suggesting that children residing in high HIV-prevalent communities are less likely to attend school and, if they attend, they progress slower compared to children in communities with zero HIV prevalence.

Evidence presented in Table 9 suggests that community-wide health shocks lead to behavioral responses even among noninfected mothers as our model suggests. First, in communities with high HIV prevalence, parents may be less willing to send their children to school due to the decrease in incentives for human capital investment as discussed in the theoretical framework section. Second, HIV/AIDS may also affect human capital investment through changes in the school and community environment. For instance, deterioration along peers, teachers, and other school inputs can reinforce the negative impacts of HIV on children's educational attainment. Moreover, parents may be reluctant to send their children to school in high HIV-prevalent communities due to the stigma and misconceptions associated with the epidemic. In fact, in our

[16]Community-level OLS analyses using the recent waves of DHS are available upon request.

Table 9 Effect of community HIV prevalence on intergenerational transmission: fixed effect

	Years of schooling (1)	Progress through school (2)	School attendance (3)
Mother's year of schooling	0.250*	0.039*	0.027*
	(0.014)	(0.002)	(0.003)
Community HIV*	−0.004*	−0.001*	−0.002*
Mother's year of schooling	(0.001)	(0.000)	(0.000)
2003–2007	0.285*	0.043*	0.085*
	(0.064)	(0.010)	(0.012)
R^2	0.495	0.454	0.402
N	17,311	17,311	17,311
Child's age and sex	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes

Surveys used in the regressions are from Burkina Faso (2003, 1992), Cameron (2004, 1991), Cote d'Ivorie (2005, 1994), Ghana (2003, 1993/1994), Kenya (2003, 1993), Mali (2006, 1995/1996), Malawi (2004, 1992), Niger (2006, 1992), Senegal (2005, 1992), Zambia (2007, 1992), and Zimbabwe (2005/2006, 1994). HIV-negative mothers and their children are included in the regressions. All regressions include community and time period fixed effects. Other controls are child's and mother's age, child's sex, household wealth quintile, mother's marital and working status, and number of living children. Each column is from a separate regression with a constant. Robust standard errors clustered by the community and time period are reported in parentheses
* $p < 0.05$ (significance level)

dataset, 55 % of the parents do not approve HIV-positive teachers to continue teaching.

5 Conclusion

The literature on education and intergenerational mobility has established that there is a strong association between parent's human capital and that of their children. Recently, however, the literature seeks to understand the causal mechanisms that underlie this relationship. This paper adds to this growing literature by analyzing the differential exposure to disease as a potential underlying mechanism. More specifically, using DHS for 11 countries in sub-Saharan Africa, we study the effect of HIV/AIDS on intergenerational transmission of human capital by distinguishing between the effect of mother's HIV status and the community HIV prevalence rate.

First, we find that the association between mothers' and their children's human capital is 0.37 in the developing economies in sub-Saharan Africa. This correlation declines to 0.2 when we control for household characteristics and community dummies. Second, our findings suggest that the persistence coefficient between HIV-positive mothers and their children is approximately 30 % smaller than the mobility coefficient for the entire population. Moreover, controlling for maternal education, we find that children with HIV-infected mothers are less likely to attend school and show slower progress at school. Third, community and time period fixed effects analysis shows that the disease environment in the community also hinders the transfer of human capital over generations and children's attachment to school even if the mother is HIV negative.

The findings of this paper are in accord with the existing literature stating the detrimental impact of HIV/AIDS on accumulation of human capital and underlining the importance of combat against HIV/AIDS, which must be a first-order policy concern as epidemic has impacts beyond the current generation. Given that almost half of the African population is children and that the high incidence of HIV/AIDS is substantially decreasing the middle-age population in the region, all accounts suggest that dramatic steps are required to aggressively curb further loss of human capital accumulation and step up efforts to ensure that all African children can grow up to lead productive and healthy lives.

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Appendix: Derivation of the model

All assumptions and parameters are explained in the theoretical framework section. The utility-maximizing household maximizes the present discounted value of income of parents and the children as follows:

$$\max_{s_c} \int_0^T e^{-\delta t} y e^{\gamma s_p} p(t) dt + \int_{s_c}^T e^{-\delta t} y e^{\gamma s_c} q(t) dt$$

where the present discounted value of parents' income is

$$Yp(p(t)) = \int_0^T e^{-\delta t} y e^{\gamma s_p} p(t) dt$$

and the present discounted value of children's income is

$$Yc(q(t)) = \int_{s_c}^T e^{-\delta t} y e^{\gamma s_c} q(t) dt.$$

Hence,

$$q(t) = e^{-\int_0^t \mu(z) dz} = e^{-mt}.$$

Table 10 DHS data

	Survey year (1)	Main survey response rate (2)	HIV testing response rate (3)	HIV prevalence (%) (4)
Burkina Faso	2003	96.3	92.3	1.82
Cameroon	2004	94.3	92.1	6.63
Cote d'Ivorie	2005	89.8	79.1	4.72
Ghana	2003	95.7	89.3	2.71
Kenya	2003	94.0	76.3	8.69
Malawi	2004	95.7	70.4	13.32
Mali	2006	95.7	92.0	1.39
Niger	2005	95.6	90.7	0.71
Senegal	2005	93.7	84.5	0.88
Zambia	2007	96.5	74.7	14.2
Zimbabwe	2005/2006	90.2	75.9	21.12

Column (1) is the survey year. Column (2) gives the response rate of women to the main survey. Column (3) reports the fraction of sample who were sampled to be HIV-tested and give their consent for testing. Based on the reason for nonresponse, individuals who were not tested are divided into four categories: those who refused testing, those who were interviewed in the survey but who were absent when the health worker arrived for testing, those who were never interviewed, and those who had missing test results due to technical problems. Column (4) reports the national HIV prevalence

Table 11 Importance of paternal education

	(1)	(2)	(3)
Panel A: 2003–2007			
Father's year of schooling	0.178*	0.165*	0.079*
	(0.026)	(0.025)	(0.017)
R^2	0.263	0.282	0.426
N	4,623	4,619	4,619
Panel B: 1991–1996			
Father's year of schooling	0.366*	0.372*	0.219*
	(0.012)	(0.014)	(0.016)
R^2	0.361	0.371	0.539
N	1,711	1,393	1,393
Child's age and sex	Yes	Yes	Yes
Household characteristics		Yes	Yes
Country fixed effects			Yes

Fathers with nonmissing HIV status and their children are used in the regressions. Household characteristics include household wealth quintile, father's marital and working status, and number of children. Column (3) also controls for community dummies and rural dummy. Each column is from a separate regression with a constant. Robust standard errors are reported in parentheses
$*p < 0.05$ (significance level)

Table 12 Effect of father's HIV status on inheritability of human capital

	(1)	(2)	(3)
Panel A: Years of schooling			
Father's year of schooling	0.205*	0.151*	0.068*
	(0.034)	(0.028)	(0.018)
HIV-positive father* Father's year of schooling	−0.127*	−0.124*	−0.062*
	(0.050)	(0.031)	(0.019)
HIV-positive father	1.876*	1.601*	0.572*
	(0.335)	(0.222)	(0.175)
R^2	0.278	0.341	0.448
N	3,964	3,960	3,960
Panel B: Progress through school			
Father's year of schooling	0.031*	0.023*	0.010*
	(0.005)	(0.004)	(0.003)
HIV-positive father* Father's year of schooling	−0.019*	−0.019*	−0.009*
	(0.007)	(0.004)	(0.003)
HIV-positive father	0.271*	0.230*	0.073*
	(0.047)	(0.032)	(0.025)
R^2	0.195	0.268	0.401
N	3,964	3,960	3,960
Panel C: School attendance			
Father's year of schooling	0.025*	0.021*	0.006*
	(0.004)	(0.004)	(0.002)
HIV-positive father* Father's year of schooling	−0.023*	−0.022*	−0.010*
	(0.004)	(0.004)	(0.002)
HIV-positive father	0.266*	0.245*	0.071*
	(0.025)	(0.026)	(0.021)
R^2	0.179	0.199	0.383
N	3,964	3,960	3,960
Child's age and sex	Yes	Yes	Yes
Household characteristics		Yes	Yes
Region fixed effects			Yes

Fathers with nonmissing HIV status and their children are used in the regressions. Household characteristics include household wealth quintile, father's age, marital and working status, and number of children. Column (3) also controls for community dummies and a rural dummy. Each column is from a separate regression with a constant. Robust standard errors are reported in parentheses

$^*p < 0.05$ (significance level)

Then, the schooling decision for children is as follows:

$$\max_{s_c} \int_{s_c}^{T} e^{-\delta t}\, y\, e^{\gamma s_c}\, e^{-mt} dt$$

$$\Longrightarrow y e^{\gamma s_c} \left[-\frac{1}{(\delta+m)} e^{-(\delta+m)t} \Big|_{s_c}^{T} \right] = y e^{\gamma s_c} \left[-\frac{1}{(\delta+m)} \left(e^{-(\delta+m)T} - e^{-(\delta+m)s_c} \right) \right]$$

$$F = \left[\frac{y e^{\gamma s_c}}{(\delta+m)} \left(e^{-(\delta+m)s_c} - e^{-(\delta+m)T} \right) \right].$$

For the optimal level of children's schooling,

$$\frac{\partial F}{\partial s_c} = 0$$

$$\frac{\partial F}{\partial s_c} = \gamma \left(e^{-(\delta+m)s_c} - e^{-(\delta+m)T}\right) - (\delta+m)e^{-(\delta+m)s_c} = 0$$

$$(\gamma - \delta - m)e^{-(\delta+m)s_c} = \delta e^{-(\delta+m)T}$$

$$e^{(\delta+m)s_c} = \left(\frac{\gamma - \delta - m}{\gamma}\right) e^{(\delta+m)T},$$

when we take the log of both sides, we get the optimal level of schooling for the children's generation:

$$s_c^* = Tln\left(\frac{\gamma - \delta - m}{\gamma}\right)$$

which yields $\frac{ds_c}{dm} < 0$ and $\frac{ds_c}{dq(t)} > 0$. This suggests that children get more schooling when the probability of survival increases. Hence, children's survival probability at age t, $q(t)$, decreases both with parents' HIV infection and HIV prevalence in the community; therefore

$$\frac{ds_c}{d\text{HIVparents}} < 0 \ and \ \frac{ds_c}{d\text{HIVcommunity}} < 0$$

References

Acemoglu D, Johnson S (2007) Disease and development: the effect of life expectancy on economic growth. J Polit Econ 115(6):925–985

Aydemir A, Chen W, Corak M (2008) Intergenerational education mobility among the children of Canadian immigrants. IZA DP 3759

Becker G S, Tomes N (1986) Human capital and the rise and fall of families. J Labor Econ 4(3):1–39

Behrman JR, Rosenzweig MR (2002) Does increasing women's schooling raise the schooling of the next generation? Am Econ Rev 92(1):323–334

Black S, Devereux PJ (2011) Recent developments in intergenerational mobility. In: Orley A, Card D (eds) Handbook of labor economics, vol 4B. Elsevier, Amsterdam, pp 1487–1541

Case A, Ardington C (2006) The impact of parental death on school outcomes: longitudinal evidence from South Africa. Demography 43(3):401–420

Cigno A (1998) Fertility decisions when infant survival is endogenous. J Popul Econ 11(1):21–28

Corak M (2004) Generational income mobility in North America and Europe. Cambridge University Press, Cambridge

Ehrlich I, Lui FT (1991) Intergenerational trade, longevity, and economic growth. J Polit Econ 99(5):1029–1059

Evans DK, Miguel E (2007) Orphans and schooling in Africa: a longitudinal analysis. Demography 44(1):35–57

Fortson J (2011) Mortality risk and human capital investment: the impact of HIV/AIDS in Sub-Saharan Africa. Rev Econ Stat 93(1):1-15

Gang IN, Zimmermann KF (2000) Is child like parent? Educational attainment and ethnic origin. J Hum Resour 35(3):550–569

Haveman R, Wolfe B (1994) Succeeding generations: on the effects of investments in children. Russell Sage Foundation, New York
Hertz T, Jayasundera T et al (2007) The inheritance of educational inequality: international comparisons and fifty-year trends. B E J Econ Anal Pol 7(2), Article 10
Kalemli-Ozcan S, Ryder H, et al (2000) Mortality decline, human capital investment and economic growth. J Dev Econ 62(1):1–23
Kalemli-Ozcan S (2002) Does mortality decline promote economic growth? J Econ Growth 7(4):411–439
Leuven E, Sianesi B (2003) PSMATCH2: stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing
Lorentzen P, McMillan J et al (2008) Death and development. J Econ Growth 13(1):81–124
Meltzer D (1992) Mortality decline, the demographic transition and economic growth. PhD Dissertation, University of Chicago
National Center for Education Statistics (1995) Dropout rates in the United States. NCES Research Paper, no: 97-473
Plug E, Vijverberg W (2003) Schooling, family background, and adoption: is it nature or is it nurture? J Polit Econ 111(3):611–641
Pronzato C (2012) An examination of paternal and maternal intergenerational transmission of schooling. J Popul Econ 25(2):591–608
Sacerdote B (2007) How large are the effects from changes in family environment? A study of Korean American adoptees. Q J Econ 122(1):119–157
Soares RR (2005) Mortality reductions, educational attainment, and fertility choice. Am Econ Rev 95(3):580–601
Solon GR (1992) Intergenerational income mobility in the United States. Am Econ Rev 82(3):393–408
Timaus IM, Jasseh M (2004) Adult mortality in sub-Saharan Africa: evidence from demographic and health surveys. Demography 41(4):757–772
Timberg C (2006) How AIDS in Africa was overstated. Washington Post
UNAIDS/WHO AIDS (2009) AIDS epidemic updates
United Nations Population Division (2008) World population prospects
Weil DN (2007) Accounting for the effect of health on economic growth. Q J Econ 122(3):1265–1306
Zimmerman DJ (1992) Regression toward mediocrity in economic stature. Am Econ Rev 82(3):409–429