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HIV/AIDS & the Accumulation & Utilization of Human Capital in Africa

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Abstract

Education is among the most prominent of the great challenges of development. This paper outlines the likely effects of the AIDS pandemic in Africa on the continent's ability to produce education and use it effectively for growth and poverty reduction. Four channels are explored. First, a supply effect: The deaths of millions of adults, and among them hundreds of thousands of teachers, will bring an increase in Africa's already relatively high fiscal burden of teacher salaries or the need to reduce the educational requirements of teachers. If not for the epidemic, this effect would be akin to an effort to reduce class sizes by about 50 percent. Second, a demand effect: The foreshortening of time horizons will reduce the lifetime private returns to education, making investments of time and money in schooling appear less attractive. Using data from Demographic and Health Surveys conducted in Africa, we find that for every 10 years that life expectancy has increased in Africa, schooling attainment increased by some 0.3-0.6 years, other things equal. In countries at the vanguard of the epidemic, life expectancy has already declined by over 20 years. If the effect is symmetric, this erosion in life expectancy may be expected to reduce average schooling in young adults in a country like Botswana, Zimbabwe, or Uganda to 1-3 years from the current 2-4 years. Third, a factor productivity effect: In many countries the loss of a large share of the skilled work force may reduce the social returns to skill among educated people who survive, reducing the contribution of education to overall growth. To the extent that a "critical mass" of skilled workers is necessary in order for positive externalities associated with high levels of education to be realized, the epidemic will reverse the gradual accumulation of this critical mass in the hardest hit countries. And finally, a complementarity effect: The loss of physical capital assets may reduce the ability of skilled workers to contribute to overall economic production, to the extent that physical and human capital are complementary inputs. As the epidemic reduces domestic savings, as well as foreign investment, it will erode the physical capital stocks in the hardest hit countries. Insofar as this in turn reduces the skill premium, it will have a negative impact on both the rate of growth and social productivity of the human capital stock.

AIDS and the Accumulation and Utilization of Human Capital in Africa

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Abstract

Education is among the most prominent of the great challenges of development. This paper outlines the likely effects of the AIDS pandemic in Africa on the continent's ability to produce education and use it effectively for growth and poverty reduction. Four channels are explored. First, a supply effect: The deaths of millions of adults, and among them hundreds of thousands of teachers, will bring an increase in Africa's already relatively high fiscal burden of teacher salaries or the need to reduce the educational requirements of teachers. If not for the epidemic, this effect would be akin to an effort to reduce class sizes by about 50 percent. Second, a demand effect: The foreshortening of time horizons will reduce the lifetime private returns to education, making investments of time and money in schooling appear less attractive. Using data from Demographic and Health Surveys conducted in Africa, we find that for every 10 years that life expectancy has increased in Africa, schooling attainment increased by some 0.3-0.6 years, other things equal. In countries at the vanguard of the epidemic, life expectancy has already declined by over 20 years. If the effect is symmetric, this erosion in life expectancy may be expected to reduce average schooling in young adults in a country like Botswana, Zimbabwe, or Uganda to 1-3 years from the current 2-4 years. Third, a factor productivity effect: In many countries the loss of a large share of the skilled work force may reduce the social returns to skill among educated people who survive, reducing the contribution of education to overall growth. To the extent that a "critical mass" of skilled workers is necessary in order for positive externalities associated with high levels of education to be realized, the epidemic will reverse the gradual accumulation of this critical mass in the hardest hit countries. And finally, a complementarity effect: The loss of physical capital assets may reduce the ability of skilled workers to contribute to overall economic production, to the extent that physical and human capital are complementary inputs. As the epidemic reduces domestic savings, as well as foreign investment, it will erode the physical capital stocks in the hardest hit countries. Insofar as this in turn reduces the skill premium, it will have a negative impact on both the rate of growth and social productivity of the human capital stock.

Introduction

Among the great challenges of development, education continues to take pride of place. In this paper we assess the likely effects of the AIDS pandemic in Africa on the continent's ability to produce education and to use it effectively for growth and poverty reduction. Our assessment is highly preliminary and meant to outline a larger research agenda rather than to dispose of it.

The effect of the pandemic on the supply of and demand for adequate public education matters because education is both *constitutive of* and *instrumental in* the process of development (Sen 1999). Education is an end in itself, a vital part of individuals' capacity to lead lives that they value. Furthermore, it is an important *instrument* with which people can improve their lives in other ways. For example, more education, particularly of women, is associated with better family health and improved capacity to plan and time births. Furthermore, education enhances the capacity of poor people to participate in the political process, and thus to organize for other social and political rights and to demand governments that are more representative and accountable.

The effect of the pandemic on African economies' ability to utilize education to enhance growth matters because faster growth is important to sustain poverty reduction and human development. Education contributes to higher individual productivity and income, and thus to sustainable economic growth, although education alone is not sufficient for faster growth. High measured levels of education and human capital did not generate healthy growth in the former Soviet Union, nor have rapid increases in average education in Egypt, Latin America and much of Africa in the last three decades. But microeconomic analyses demonstrate repeatedly the contribution of education to productivity at the individual, household and farm and firm level (Schultz, 1963, first made the point; Schultz, 1993 reviews the now large microeconomic literature). Where the relationship between "more" education and faster growth has failed to materialize—both within countries and between countries (e.g. Pritchett, 1999)—one or more of several difficulties may be responsible. First, "more" education is often assessed in terms of increasing public spending on education; but if education systems are weak, then more public spending may not translate into true increases in the human capital stock. Second, even where the human capital stock is increasing, problems in other policy spheres (including for example macroeconomic instability, civil unrest, or market distortions) may prevent these gains from being translated into economic growth.[1] Third, it may be that as long as the existing stock of human capital remains below some threshold, marginal increases are relatively ineffective in producing growth; what's more, the deficit between the existing stock and this threshold, combined with adverse economic structure and low organizational and institutional capacity, could perpetuate a poverty trap. (This is an issue to which we will return.) The contribution of education to high and relatively equitable growth in much of East Asia over the last five decades, where the educational systems were relatively high in quality, and where market and other distortions were limited, provides the best counterexample on all these scores (Birdsall, Ross and Sabot, 1995).

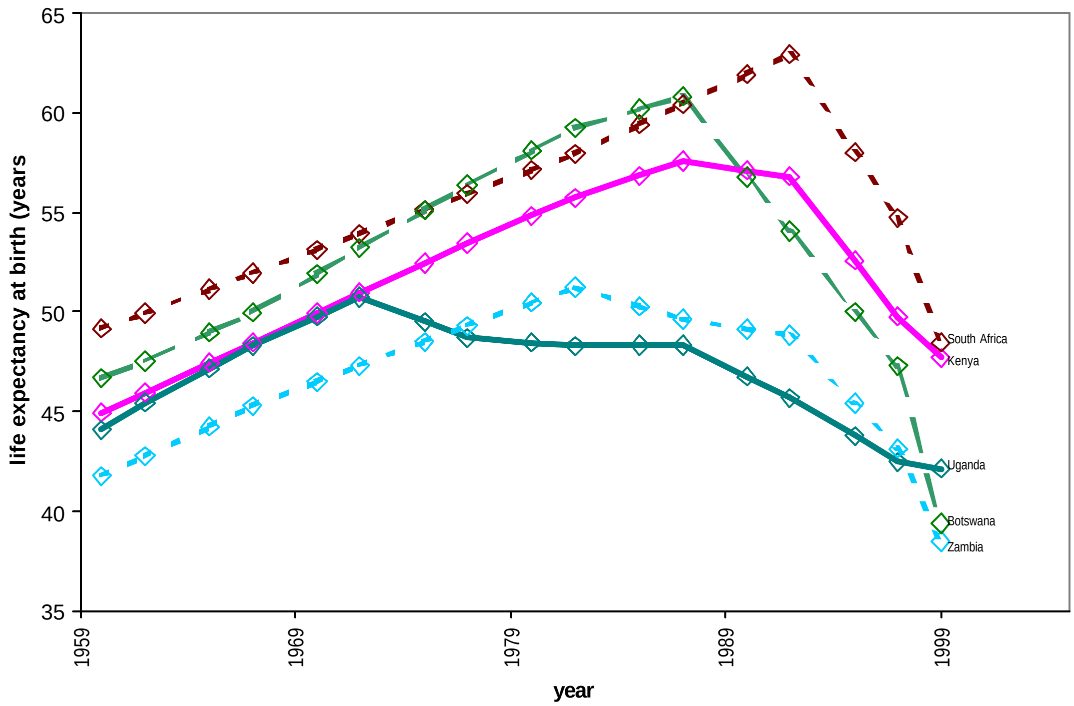
In addition to faster growth, education is also key to an equitable *pattern* of growth most likely to reduce poverty. For the poor, the human capital acquired via formal education is a critical economic asset that, once acquired, cannot be appropriated. At the societal level, education that is broadly shared contributes to a more equitable distribution of total wealth (including human capital wealth) (Birdsall, 1999; Birdsall and Londoño, 1997), and thus ultimately to a more equitable distribution of opportunities and of income.

Prospects for accumulation and effective economic deployment of education in Africa have to be assessed against the backdrop of the ongoing epidemic of HIV/AIDS. According to UN estimates, AIDS claimed the lives of about two million adults and 500,000 children in Africa this year. Over the same period, about three and a half million Africans acquired new HIV infections; without proper medical treatment, almost all of them will die over the next decade (UNAIDS, 2001). As the death toll from the epidemic

[1] In fact, typically, various market distortions in developing countries keep the marginal private return high, if not the average private return compared to that in developed countries. An example is the case of Egypt, where a policy of guaranteeing a public sector job to all secondary and university graduates assured high marginal private returns especially to higher education, but these returns were independent of the quality of education, the actual productivity of people attributable to some combination of their human capital, their motivation, and complementary inputs on the job, and of course whether there was or not a real demand for their skills in the public sector. The policy probably also reduced the demand for and the pressure on the educational system for real gains in learning and skills as opposed to simply certifying graduates. On Egypt see Birdsall and O'Connell, 1999.

has mounted, life expectancies across the continent have declined precipitously. In Zambia, for example, life expectancy at birth increased from 43 to 51 years between 1962 and 1982, only to decline again from 50 years to 38 years between 1985 and 1999—a loss of over twenty years' progress in less than a decade (World Bank, 2001). Figure 1 shows some of the more dramatic declines in life expectancy over the past four decades. Economists and others have begun to focus attention on the likely effects of the epidemic on overall social welfare and material well-being. However, its more specific effects on the supply of, demand for, and productive use of education have not been explicitly explored.

Figure 1

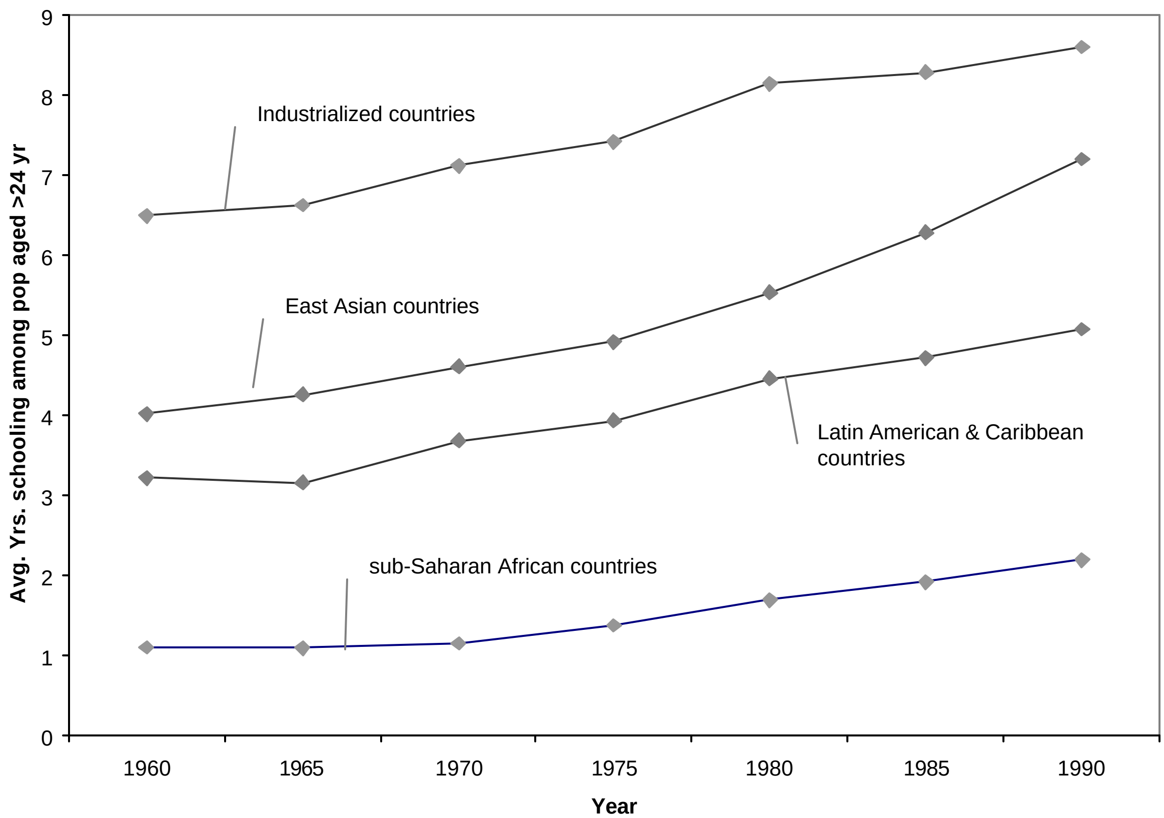


Notes

National life expectancy at birth, by year. The diamonds indicate years for which data are available—1960, 1962, 1965, 1967, 1970, 1972, 1975, 1977, 1980, 1982, 1985, 1987, 1990, 1992, 1995, 1997, and 1999. The lines connecting the diamonds are simple linear interpolations. The data are taken from World Bank (2001).

The problem of Africa's small human capital stock, to be sure, predates the arrival of the epidemic. Figure 2 shows the evolution of one measure of the region's human capital stock (albeit a very crude one)—the average years of schooling attained among the general population aged 25 years or older. Although the rate of growth in human capital (by this measure) in sub-Saharan Africa picked up briefly in the late 1970s, the continent continues to lag behind other developing regions.

Figure 2



Notes

Source: Barro and Lee

Data series represent unweighted regional averages of country mean years of schooling as reported by Barro and Lee. Countries include: sub-Saharan Africa—Benin, Botswana, Cameroon, Central African Republic, Republic of the Congo, Democratic Republic of the Congo, Gambia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mali, Mauritius, Mozambique, Namibia, Niger, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Togo, Uganda, Zambia, Zimbabwe; Latin America and the Caribbean—Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, Venezuela; East Asia—China, Fiji, Hong Kong, Korea, Singapore, Taiwan; Industrialized—Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

This paper explores some of the ways in which the epidemic is likely to affect the rate of new human capital formation on both the supply and demand sides, and the productivity of the existing human capital stock in Africa. We focus on four specific channels:

- The loss of millions of adults, among them tens of thousands of teachers—affects the rate at which education systems in Africa are able to train the next generation for any given cost and quality.
- The foreshortening of time horizons attendant on these premature deaths reduces the expected lifetime private return to schooling, and is therefore likely to reduce demand for education.
- The loss of so many already educated people could reduce the social returns to skill among educated people who survive, to the extent that there are positive externalities associated with a larger total stock of human capital. This could result in a smaller contribution of education to aggregate growth.
- The loss of physical capital assets is also likely to reduce the ability of educated people to contribute to overall economic production, to the extent that physical capital and human capital are complementary inputs.

The latter two of these channels also could affect the long-run private demand for education, insofar as average if not marginal private returns to education remain low in low-productivity settings. This is the case even though marginal private returns to education, especially above the primary level, could well remain high due to the relative scarcity of well-educated workers (including managers, administrators and so on).[2]

Of course, there are other ways in which AIDS is likely to affect education and human capital in Africa. AIDS has already orphaned millions of children across the continent, and will orphan millions more in the years to come. This will undermine family structures and increase the opportunity costs of children's time (as children—especially girls—take on the household responsibilities once handled by their parents). Furthermore, increasing fears, especially for girls, about exposure to HIV in schools may

[2] Psacharoupoulos, 1994, reports that on average, marginal private returns, especially to higher education, are higher in developing countries. This does not mean, of course, that the average returns reflected in wage or salary levels, are higher – only that the additional return over and above less educated workers is greater.

reduce demands for secondary schooling. Here we abstract from these social and psychological effects to focus on the primarily economic channels, direct and indirect.

Section 1. HIV/AIDS and the supply of schooling in sub-Saharan Africa

Of the 25 million Africans estimated by UNAIDS (2000) to be living with HIV infection, over 95 percent are adults and youth over the age of 15 years. Partially as a result of the epidemic, adult mortality rates in Africa are over three times higher than the world average. During the year 1999, an African between the ages of 15 and 60 stood, on average, a 1.4% chance of dying; the world average that same year was 0.4% (World Bank, 2001). According to UNAIDS (2000), by the end of 1999 over 12 million African children had lost their mothers or both their parents to AIDS. Furthermore, empirical evidence suggests that among those adults who were infected early in the epidemic, and who are falling ill and dying now, a disproportionate number are relatively well educated, urban, white-collar workers (Ainsworth and Semali, 1998; Filmer, 1998; Deheneffe, Caraël, and Noumbissi, 1998). It is not surprising, therefore, that educators are one of the hardest hit professions in many AIDS-ravaged African countries. In Zambia, for example, the World Bank estimates that mortality rates among teachers are 70% higher than among the general adult population (World Bank, 2001). UNICEF (2000) estimated that in 1999, 860,000 African schoolchildren lost their teachers to AIDS (out of a total population of some 70 million pupils), on a continent which as early as 1997 had only one teacher for every 59 students (World Bank, 2001).

Demographic projections, using specialized software packages, have been employed to speculate on some of the likely effects of the loss of teachers to AIDS in specific African contexts (Malaney, 2000). One general way to assess these effects is to consider a simple two-equation model. Divide the population in the education system into two mutually exclusive groups: teachers, and students. A lifetime is divided into two periods—childhood and adulthood. Students are children, added to the system at some constant net rate, determined by the difference between enrollment and attrition. Teachers are adults, added to the system by training some proportion of the previous period's students, and lost to the system by death, retirement, and other sources of teacher attrition.

The number of teachers and students in any given time period, therefore, can be expressed as:

$$S_t = [1+n]S_{t-1}$$
$$T_t = [1-d_t]T_{t-1} + rS_{t-1}$$

In these equations, n is the net rate at which students are added to the education system, r is the proportion of last period's students who are retained within the system as teachers, and d is the rate of teacher attrition. Using these two equations, it is possible to determine the teacher/student ratio in each time period as a function of n, r, d, and the teacher student ratio in the previous period:

$$\frac{T_t}{S_t} = \frac{r}{1+n} + (1-d_t)\left(\frac{T_{t-1}}{S_{t-1}}\right)$$

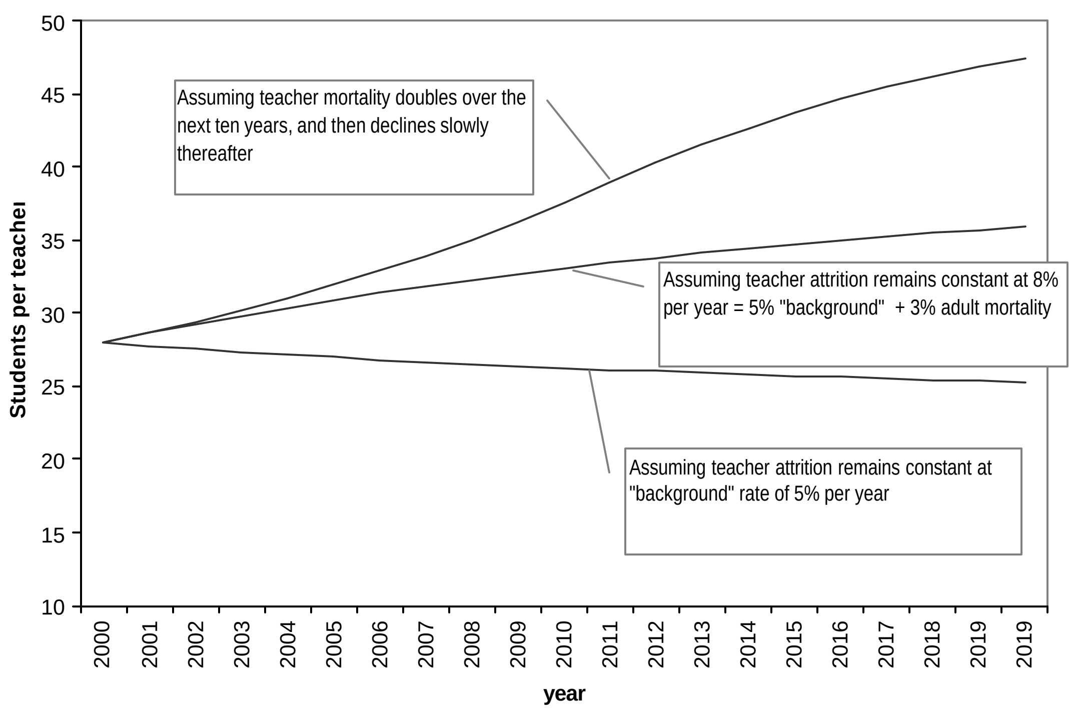
Using plausible parameter estimates, we can apply this model to a real world case in order to speculate on the scale of the effects of future increases in teacher mortality.

According to the World Bank, the current teacher/student ratio in one of the hardest hit countries in Africa—Botswana—is about 1/28. (Note that this is much higher than the continent-wide average of 1/59). According to the World Bank, the population aged under 14 years in Botswana is projected to grow over the next 15 years at an average annual rate of –0.4%.[3] Abstracting away from any changes in the proportion of this population that is of primary school enrollment age, and from any changes in enrollment rates, the net rate of increase in the student population (n), therefore, would be –0.004. Data indicating the rate at which students are trained to become teachers in Botswana are not readily available. However, neighboring Namibia trains about 1000 teachers each year, or some 0.2% of the overall student body (Malaney, 2000). Assuming that

[3] This projected decline reflects the expected decline in fertility and the effects of forecasts in adult mortality as much or more than any increase in mortality at young ages. Declines in fertility are occurring elsewhere in Africa (as education of mothers and access to health care including modern family planning services has been increasing, the latter especially in urban areas). As noted below, our simulation results are highly robust to variations within plausible ranges of this parameter, but obviously a faster growth rate of the school-aged population would exacerbate the problem we illustrate.

Botswana's education system retains this same proportion of its student body to become teachers, then we can set r=0.002. Finally, we will assume that the "background" rate of teacher attrition—that is, the rate of teacher attrition due to retirement and other traditional sources—is about 5% per year, and that the teacher mortality rate in Botswana is about 3% per year (which is the current adult mortality rate in Botswana). Figure 2 shows the evolution of the student/teacher ratio over the next 20 years under three scenarios. The first scenario holds teacher attrition constant at the "background rate" of five percent per year. The second holds teacher attrition at eight percent—five percent of which is accounted for by "background," and three percent by the current adult mortality rate in Botswana. The last assumes—in keeping with UNDP projections (2000)—that adult mortality (and hence, by assumption, teacher mortality) will double over the next ten years, and then decline very gradually thereafter.

Figure 3



Notes

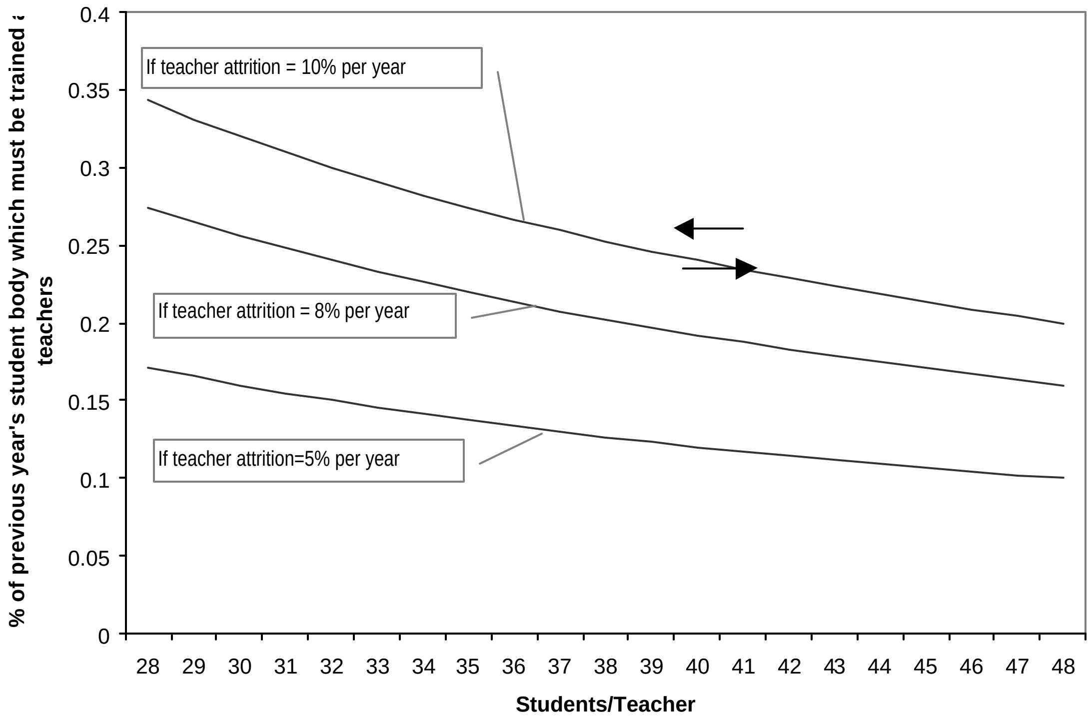
Evolution of student/teacher ratios over time using the simple two equation model described in the text. Assumptions: Twenty eight students per teacher in year 2000; net rate of growth in student population, -0.04% per year; proportion of each year's student body trained to become teachers the following year, 0.2%. Teacher attrition is assumed to be 5% per year plus the rate of teacher mortality. The rate of teacher mortality is assumed to equal the rate of adult mortality. To minimize clutter, the y-axis begins at 10 students per teacher. For more details, see text.

These projections are highly robust to changes in the assumptions about the rate of growth in the student population—which, after all, is likely to be affected by the epidemic as well (although almost certainly not as dramatically as the rate of growth in the teacher population). The World Bank (2001) has projected, for example, that the primary school-aged population in Zimbabwe is likely to contract by about 0.8% per year over the course of the next decade; this . Adjusting our assumptions to examine the effects if the school-aged population in Botswana suffered the same decline, however, does not significantly change the projections shown in figure 2 over the time horizon of the simulation.

By contrast, however, the projections are more sensitive to assumptions about the rate of retention of students who become teachers. [4] For example, the increase in student/teacher ratios shown in the most pessimistic scenario in figure 1 can be entirely averted if the rate at which students are trained to become teachers is increased from 0.2% per year to about 0.35% per year. Figure 3 plots the retention ratio necessary to maintain a constant student/teacher ratio for various rates of teacher attrition. As the arrows indicate, above each line, student/teacher ratios are improving (i.e., declining); below, they are deteriorating (i.e., rising).

[4] This, of course, is not surprising, given the structure of the model, in which an increase in the size of today's student body has two effects, opposite in direction. First, it increases the student/teacher ratio in the present, but second, it provides a larger pool of new potential teachers in the future. The effects of a decrease in the rate of teacher training, however, are not mitigated in any analogous way. This is reflected in the fact that the ratio in each period changes linearly with changes in r, and quadratically with the inverse of $1+n$. Over the range of plausible parameter values in the real world, the result is that changes in r have a more dramatic effect than changes in n. This is shown graphically in appendix figures A and B.

Figure 4



Notes

The proportion of the previous year's student body which must be trained as teachers each year in order to maintain a constant student/teacher ratio, assuming the student population shrinks at a constant net rate of 0.04% per year. The units on the y-axis are percentages—that is, the scale runs from 0% to 0.4%, or from 0 to 0.004. Above each line, the ratio is "improving" (declining), while below it is "deteriorating" (increasing). For more details, see text.

The focus here on teacher/student ratios is not meant to imply that these ratios are the sole measure—or even a good measure—of school quality or efficiency. However, these ratios do reflect clearly one of the most direct effects of the HIV epidemic on the supply of schooling in sub-Saharan Africa—the loss of enormous numbers of teachers over the medium term. For example, from figure 4 it is straightforward to discern that in order to maintain its current teacher/student ratio in the face of excess annual adult mortality, a country like Botswana must plow nearly 150% more of its students back into the education system to become teachers. Therefore, in order to continue to supply schooling services at current enrollment rates, African education systems will either have to tolerate a dramatic increase in class sizes, or find ways to retain significantly more of the country's precious human capital within the education system, or both. This must happen at a time when other sectors of the economy are also desperate to replace their own educated workers who are being lost to the epidemic (African Development Forum, 2000). The implication is that even with increases in class size, public education systems will need to increase salary levels of teachers to attract an additional proportion of graduates into the field. Salary levels of teachers in sub-Saharan Africa are already higher relative to average wages than other regions of the world, probably reflecting the relative scarcity of post-secondary graduates.[5] These results imply an increase in an already relatively high fiscal burden of teacher salaries relative to other regions, or the need to reduce the educational requirements for teachers. The latter adjustment is likely to be necessary, especially in rural areas, and is likely to be even more costly in terms of quality than any increase in class size.[6]

Furthermore, focusing as these results do on nationwide averages implicitly assumes that the government is able to deploy teachers relatively easily throughout the country, in order to ensure that the effects of teacher shortages are evenly felt. Realities, of course, are decidedly more complicated. Student/teacher ratios are generally much higher in rural areas, for example, than urban areas, and the increase in teacher morbidity and mortality may be exacerbating this disparity by increasing demand for posts in urban areas closer to health facilities (UNICEF, 2000). The effects of the epidemic in some rural schools, especially those small ones with only one or two teachers who teach multiple grades, may be far more dramatic than these model results suggest. In Congo, for example, some schools have reportedly been forced to close entirely for lack of teachers (African Development Forum, 2000).

Section 2. HIV/AIDS and demand for schooling in sub-Saharan Africa

Recent theoretical and empirical work has explored relationships between life expectancy and investments in human capital. The reasoning goes that when individuals and households anticipate a longer time horizon over which to reap returns, they are likely to

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[5] On this point, World Bank, 2000 cites Alain Mingat.

[6] Behrman and Birdsall, 1993, use differences in teacher education as a proxy for differences in the quality of schools across states. The resulting differences in the quality of schooling across individuals have a strong and highly robust effect on the private returns to schooling (and presumably the social returns).

be more willing to incur the upfront costs of investments in schooling. Kalmeli-Ozcan, Ryder, and Weil (2000) develop a model in which individuals facing a constant probability of death weigh the foregone earnings during the time spent in school against anticipated returns to schooling, and decide when to leave school and enter the labor force. Calibrating their model using reasonable parameters based on real-world data, they show that changes in life expectancy over the past 150 years can "explain" a significant fraction of the observed increases in schooling rates in the most developed countries.[7]

An empirical treatment of this question by Behrman, Duryea and Székely (1999) relates the educational attainment of birth cohorts—obtained from household surveys conducted in Latin America—to fixed country effects, secular trend effects, and to several year- and country-specific variables reflecting the broader economic and institutional setting. They include life expectancy as one of these latter variables.[8] Their results suggest that changes in life expectancy were associated with quantitatively and statistically significant changes in educational attainment. On average, they found a 10-year increase in life expectancy to be associated with a 0.3 to 0.4 year increase in schooling attainment.

Here, we use a similar "quasipanel" technique to explore this relationship within African contexts. We use data from the Demographic and Health Surveys, in which nationally representative samples of 15-49 year old women are interviewed on topics including reproduction, household assets, children's health, employment status, and educational attainment.

The DHS data demonstrate steady improvements in the educational attainment of birth cohorts across the continent over time. Figure 5 shows attainment profiles for 5 year birth cohorts which reached ages 12-17 in 1967, 1977, 1987, and 1992 in three countries—Uganda, Zambia, and Zimbabwe. The older cohorts reported lower

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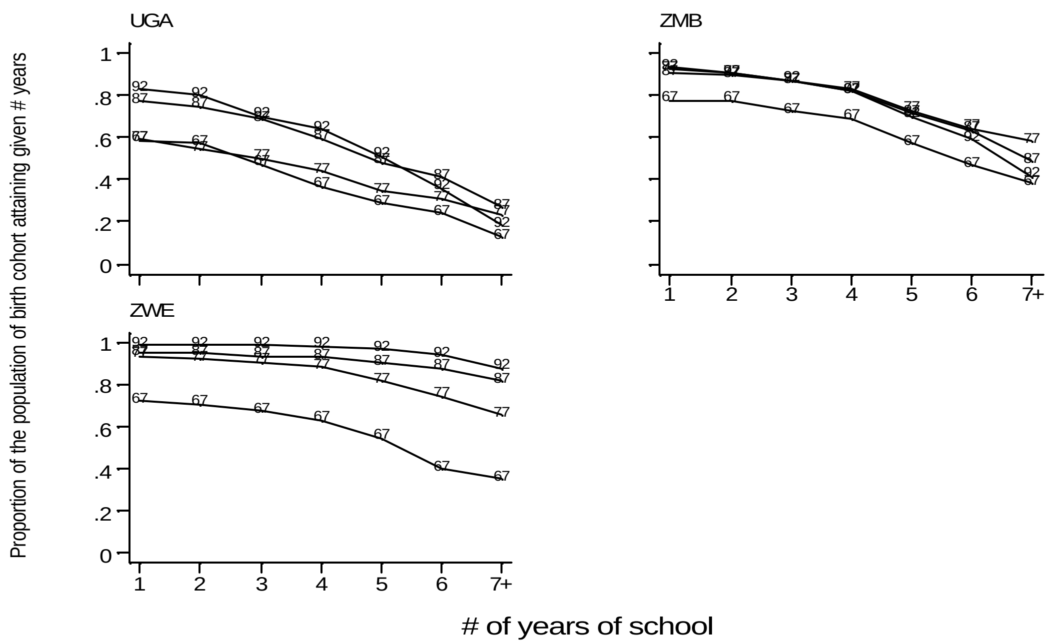
[7] Of course it is not clear that increasing life expectancy *per se* has had a direct causal effect on increases in schooling in advanced economies; life expectancy is usually closely associated with other changes, including increasing average income, technological shifts, and improving institutions, all of which would raise the returns to and the demand for education.

[8] As with life expectancy, these other variables mostly have statistically significant effects in the expected direction on differences and changes in average education.

attainment at almost all countries. In each of the 23 countries for which surveys were available, the same general trend may be observed.[9] It is important to be careful in interpreting these observations, however. These observations are not truly longitudinal, since they are derived from cross-sectional surveys. The time component comes from subdividing the cross-sectional responses to the survey questions based on the year of birth of each respondent. We discuss this at greater length later in this section.

Figure 5

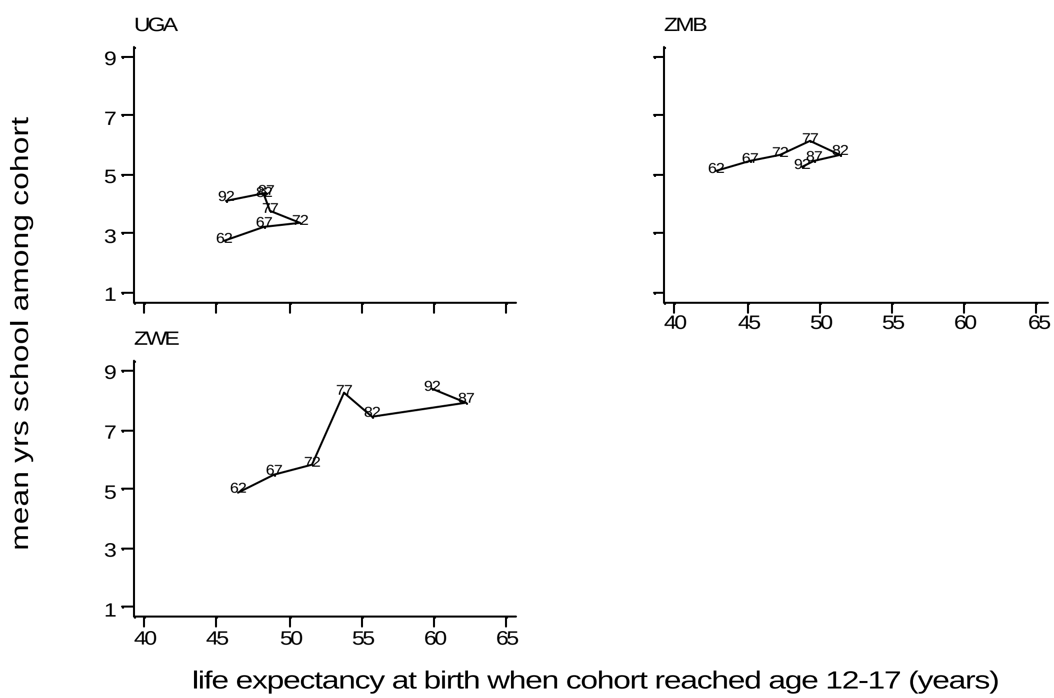


Notes

Proportion of the population in each birth cohort which has achieved each level of schooling. The profiles are created by stratifying Demographic and Health Survey responses according to the year of birth of the respondent and tracking the proportion of respondents who report having completed each year of school, weighting responses by sampling weights. The data points on each line indicate the year in which each cohort of respondents reached age 12. DHS surveys interview nationally representative samples of 15-49 year old women. The surveys from which these profiles were constructed were conducted in 1995 (Uganda), 1996 (Zambia), and 1999 (Zimbabwe). Therefore, for example, in Zimbabwe we can infer that just under 80% of women who reached age 12 in 1967 and were still alive in 1999 had attained at least one year of school, whereas nearly all women who reached age 12 in the years 1977, 1987, and 1992 and were still alive in 1999 had attained at least one year of school. For more details, see text.

[9] The attainment profiles are not shown here, in order to minimize clutter, but are available on request from the authors.

However, it is worth observing a few country experiences over time. Figure 6 shows differences in life average years of schooling between birth cohorts and changes in life expectancy at birth over time in the same three countries shown in figure 5. In Uganda and Zambia, for example, each 5-year birth cohort appears to have been more educated than the one before until 1977. Those reaching ages 12-17 in 1982 and after, however, began to see shorter and shorter life expectancies, and reported as many or fewer years of schooling as the cohorts before them. The experiences of each of the 23 countries for which survey data were available are quite different. They are all shown in appendix figures C and D.



Notes

Evolution of national life expectancy at birth and average cohort years of schooling among five year birth cohorts which reached ages 12-17 in 1962, 1967, 1972, 1977, 1982, 1987, and 1992. The lines move from the oldest to the youngest cohorts, with the year in which each cohort reached ages 12-17 indicated by the data points along the line. Average years of schooling were calculated by collapsing Demographic and Health Survey respondents into cohorts based on their years of birth, and averaging the number of years of education reported by respondents in each group, weighted according to survey sampling weights. Aggregate national life expectancy at birth in the year when each cohort reached ages 12-17 was taken from World Bank (2001). Lines moving up and to the left, therefore, imply that birth cohorts faced lower mortality risks and attained greater schooling. The DHS surveys were conducted in the years 1995 (Uganda), 1996 (Zambia), and 1999 (Zimbabwe). Analogous figures for each of the 23 countries for which DHS survey data were available are shown in appendix tables C and D. For more details, see notes to figure 5, and text.

With this approach, we seek to explore the extent to which changes in educational attainment among individuals and cohorts can be correlated with differences in life expectancy in the years when the individuals and cohorts are making marginal schooling decisions. To this end, we compiled comparable data from 37 Demographic and Health Surveys conducted in 23 sub-Saharan African countries over 12 years, to obtain individual data on some 192,000 respondents. We collapsed these respondents into 214 five-year birth cohorts, and related average years of schooling within these cohorts to household and national characteristics. The oldest among these cohorts was born during the period 1935-39, the youngest during 1980-84. The choice of functional form is similar to that employed by Behrman et. al., with household and country characteristics affecting schooling attainment in a linear fashion.[10] Table 1 shows the results of OLS regressions of average years of schooling in each five year birth cohort against national average life expectancy at birth when the cohort was aged 12-17 years. (Sample sizes are reduced due to lack of data on many of the DHS wealth variables in column 1 or on PPP-adjusted GDP per capita in columns 3 and 4.[11]) "Control" variables for each cohort in each country include indicators of household asset wealth or average income per person, the proportion of each cohort living in urban areas, a separate time trend for each country, and country dummies to capture fixed effects on demand for schooling within countries.

It is important to note that this "quasipanel" technique is not truly longitudinal, since the time varying component in the data comes from dividing individual respondents into groups based on the five year period in which they were born. One difficulty which

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[10] This linear functional form would follow from the standard Mincerian (Mincer, 1974) model in which individuals seek to maximize their expected income, weighing the lost time in the labor force against the wage premium attributable to schooling. In such a model, individuals would be expected to remain in school until (the present value of) their expected lifetime returns to an additional year of school are equal to potential earnings of a year in the labor force. These expected returns are of course linearly related to life expectancy, with each additional year of life in the labor force bringing one additional year of returns.

[11] Due to incompleteness in the data, our regressions do not include all 214 birth cohorts. No aggregate data were available for those birth cohorts which reached ages 12-17 before 1962, leaving 161 cohorts. Among these, household wealth and GDP per capita data were not available for all of them. However, we used a probit regression to test for systematic differences between those observations for which GDP and household wealth data were available and those for which they weren't; the two groups were not statistically different in terms of the other regressors or the dependent variable. Therefore, we are reasonably confident that the loss of these observations did not induce bias in our estimates.

arises from this relates to the question of selection bias due to mortality rates which are correlated with education level. Say, for example, that more educated individuals in each birth cohort are likely to live longer than their less educated peers. Then, even in the absence of any true secular trend, older birth cohorts would appear relatively more educated than younger ones at any moment in time, since the less educated among the older cohorts will be more likely to have been removed (by death) from the sample of potential respondents.[12] In order to correct for this effect, we include a linear time trend in the regressions relating schooling attainment to life expectancy, which implicitly assumes that the effect of education on an individual's mortality risk is constant across birth cohorts.[13] This assumption may fail, however, because of the AIDS epidemic, which in recent years—as we noted above—appears to have greatly increased the risk of mortality among younger, more educated people *relative to* younger, less educated people (at least, in the first wave of the epidemic). As a result, the younger birth cohorts may have been purged by the time of the surveys of the *more* educated among them, while the older birth cohorts would have been purged of the *less* educated. Even in the absence of any true time trend, this would create an apparent concave relationship between time and average schooling. We know (see figure 1) that the same sort of relationship holds between life expectancy and time, because of the epidemic. Therefore, some of the apparent effect of life expectancy may simply be the effect of this "differential mortality" problem. One way to try to separate out this effect from the "true" effect of changes in life expectancy could be to include year squared in the regressions, as we do in columns 2 and 4. The difficulty with this approach, however, relates to multicollinearity in the data—life expectancy among the 138 "quasicohorts" in columns 1 and 3 are almost perfectly quadratic in time, after "controlling" for the other

[12] Of course, this "selection bias" problem may result from other dynamics, and not just mortality risk. For example, if educated people are more likely at any time to emigrate, then the same problem would result. The reasoning is essentially the same, regardless of the selection factor.

[13] Of course, this is not the *only* reason we include a time trend. Including a year trend also captures institutional and technological changes and other developments, so long as these things occur monotonically (and in fact linearly) over time.

factors.[14] It is difficult, therefore, to determine given the existing data how much of the effect of time is attributable to changes in life expectancy over time, and how much is attributable to the selection bias problem.

Another way to deal with this is to restrict the period of analysis to the time before the epidemic, as we do in columns 5 and 6. After all, it is likely that any effect of education on the relative risk of mortality would be constant across time during this period, and therefore that including time linearly in the regression would "control" for the possibly differential effect of education on mortality.[15] But again, before 1987 improvements in life expectancy were almost perfectly linear with time across Africa, after "controlling" for household wealth and country-specific factors.[16] It is difficult therefore even using the restricted sample to untangle the extent to which the "effect" of time on educational attainment is due to life expectancy improvements, how much is due to other time-varying factors, and how much is spurious, resulting from selection bias due to differential mortality.

Nonetheless, it is worth underlining that we account for time invariant country-specific differences (e.g., differences in economic and social policy and institutions) by including country dummies, and any country-specific effects which go linearly with time by including country-year interaction terms.[17] These results suggest that an increase in life expectancy of 10 years is associated with improvements in average schooling attainment of some 0.6-0.9 years. This effect is even more dramatic than that observed by Behrman, Duryea, and Székely in Latin America, and enormous relative to Africa's (relatively low) average education levels.

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[14] A regression of life expectancy at birth against the other regressors in table 1, column 2 produces an R-squared of 0.99.

[15] Note that the coefficient on year squared in column 6 not statistically significantly different from zero at the 5% confidence level.

[16] A regression of life expectancy at birth against the other regressors in table 1, column 5 produces an R-squared of 0.96, with each additional calendar year bringing 0.39 added years of life expectancy (s.e.=0.02).

[17] Analyzing the country dummies and country-specific year trends (not shown) indicates that among the large positive outliers are Ghana and Uganda, and among the large negative outliers are war-torn Ethiopia well as Nigeria and Niger; these are consistent with our intuition about at least institutional variation across countries in the region.

Table 1

mean education in single years among cohort (cohort defined by quinquennium of birth)	(1)	(2)	(3)	(4)	(5)	(6)
					only those cohorts which reached ages 12-17 before 1987	
Life expectancy at birth	***0.175 (0.053)***	***0.064 (0.045)***	***0.170 (0.085)***	***0.086 (0.075)***	***0.070 (0.051)***	***0.062 (0.050)***
Real GDP per capita, in US dollars			0.002 (0.001)	0.001 (0.001)		
Year	.0069 (0.027)	0.494 (0.069)	-0.068 (0.052)	0.513 (0.159)	0.055 (0.023)	0.404 (0.180)
Year squared		-0.003 (0.000)		-0.004 (0.001)		-0.002 (0.001)
Country-specific intercepts	Included					
Country-specific time trends	Included				Not included	
Indicators of household asset wealth	% cohort in households with: electricity, radio, bicycle, motorcycle, car		Not included		% cohort in households with: electricity, radio, bicycle, motorcycle, car	
Observations	144	144	107	107	105	105
R-squared	0.97	0.98	0.96	0.97	0.95	0.96

Notes

Standard error of coefficient estimates in parentheses. Standard error estimates are robust to heteroskedasticity; they are calculated using the Huber-White estimator. The regressions relate average years of schooling for cohorts reaching age 12-17 in the years 1962, 1967, 1972, 1977, 1982, 1987, and 1992 in 23 sub-Saharan African countries to life expectancy at birth, indicators of average wealth in the cohort, and time trends. This implies 161 quinquennial birth cohorts; however, some had to be dropped from the regressions for lack of data (see footnote 11); countries and cohorts included in the regressions are listed in appendix table A. Columns 5 and 6 include only cohorts which reached age 12-17 before the year 1987. Educational attainment and indicators of household asset wealth are calculated using Demographic and Health Surveys. DHS data interview nationally representative samples of women aged 15-49. Cohort averages are taken by collapsing individual respondents into quinquennial cohorts defined by the year of their birth, and taking an average of their responses (weighted by survey sampling weights). Life expectancy at birth and real GDP per capita in year 1987 US dollars are taken from World Bank (2001). For more details, see text.

Table 2 shows the equivalent relationship, with each individual entered into the regression in a single observation, rather than with individuals aggregated into birth cohorts. Schooling attainment for individuals is truncated at zero years; it is impossible to spend a negative number of years in school. We therefore use a tobit specification. [18]

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[18] The tobit functional specification assumes that the schooling attainment data are truncated, not censored by some independent set of dynamics which guides individuals' decisions about whether to go to school separately from their decisions about how long they remain in school, once enrolled. In order to test whether this assumption is appropriate, we estimate the probability that a respondent will have obtained any schooling at all—regardless of how much—and compare the coefficient estimates from this regression with those of the tobit regression in table 2. If the assumption underlying the tobit specification holds, then we should expect the coefficient estimates (scaled by the standard error of the estimate) to be equal. The estimates were indeed quite close, supporting the tobit specification as appropriate.

Table 2

Education in single years of respondent (Tobit regressions)	(1)	(2)	(3)	(4)
			Only those individuals who reached age 12 before 1987	
Life expectancy at birth	***0.058 (0.019)***	***0.029 (0.019)***	***0.107 (0.020)***	***0.060 (0.022)***
Year	0.097 (0.017)	0.947 (0.058)	0.156 (0.007)	0.677 (0.118)
Year squared		-0.005 (0.000)		-0.003 (0.001)
Dummy variable indicating whether respondent resides in an urban area	3.135 (0.058)	3.126 (0.058)	3.475 (0.078)	3.475 (0.078)
Country-specific intercepts	Included			
Country-specific time trends	Included		Not Included	
Indicators of household asset wealth:	Dummy variables indicating whether respondent's household has: Electricity, radio, bicycle, motorcycle, car (5 dummy variables, total)			
Total number of observations	54830	54830	37650	37650
Left-censored obs. (zero yrs school)	24985	24985	18577	18577

Notes

Standard error of coefficient estimates in parentheses. The regressions are as in table 1, except that each individual respondent is entered as a separate observation, rather than collapsed into a quinquennial birth cohort. Data sources are as in table 1. Due to lack of data for intervening years, only individuals who turned 12 in the years 1962, 1967, 1970, 1972, 1977, 1980, 1982, 1985, 1987, 1990, and 1992 were included in the regressions. The number of individuals from each country and year who are included in the regressions are shown in appendix table B. For more details, see notes to table 1, and text.

These results suggest that an increase in life expectancy of 10 years may be associated with an increase in schooling attainment among individuals of about 0.3-0.6 years, somewhat smaller than the 0.6-0.9 years indicated using the "quasicohort" data.

Another way to attack the problem empirically—less subject to the selection bias problem we describe above—is to examine the relationship between gross primary enrollment ratios at the national level and life expectancy at birth. In generating internationally comparable estimates of schooling attainment, Barro and Lee (1996) employ a "perpetual inventory" method to translate gross enrollment ratios[19] and demographic structure into stocks and flows of population at various levels of educational attainment (e.g., no schooling, incomplete primary, complete primary, and so on). They estimate, for example, that the population over age 15 which has attained at least some primary education in any five-year period is equal to the primary educated population from the previous period which has survived, plus the population which turned 15-19 over the previous quinquennium and attended any primary school. This latter population

[19] In a recent update, they use "adjusted gross enrollment ratios" in order to avoid double counting individuals who repeat grades.

is estimated by taking the total population of each five year birth cohort, and multiplying it by the gross primary enrollment ratio in the period when the cohort was aged 10-14.

The assumption, therefore, is that the gross primary enrollment ratio[20] when a five year birth cohort is aged 10-14 indicates the proportion of 15-19 year olds who have at least some primary education. Employing this assumption, we regress gross national primary enrollment ratios across countries and over time against period and country specific life expectancy at birth, income per person, and time trends. This approach eliminates the selection bias problem inherent to the "quasicohort" technique applied above, and so is useful for comparison to our previous results. As table 3 shows, the results suggest that in increase in life expectancy of 10 years may reasonably be associated with an increase in primary enrollment ratios of about 0.2-0.3 (or about 20 to 30 percentage points).[21]

Of course, we still cannot be sure that the apparent effect of life expectancy is not in fact the result of some other unobserved factor which is correlated both with life expectancy and with improvements in school enrollment. It is important to note that as in the previous regressions we include country- (columns 1 and 4) and region-specific (columns 2 and 3) dummies and time trends, which might be expected to capture factors that are time invariant within countries, or that are changing constantly with time within countries. These might include, for example, differences between countries in the quality of social services or the rate of improvement of these services. Furthermore, table 4 shows the results of first difference regressions, in which the change in gross primary enrollment ratios in each country from one quinquennium to the next is related to the proportional change in GDP and life expectancy over the same time period.

[20] Or, in the updated data, the "adjusted" gross primary enrollment ratio.

[21] Since gross primary enrollment ratios are not bounded from above at one as net enrollment ratios are, and since there are no country-periods when gross enrollment ratios were at the lower bound of zero, a functional form which is linear, rather than tobit or cumulative normal or logistic, is not inappropriate.

Table 3

Dependent Variable: Gross primary enrollment ratio	(1) Africa only	(2) Whole world	(3) Whole world	(4) Whole world, fixed effects (by country)
Life expectancy at birth (years)	***0.023 (0.013)***	***0.021 (0.002)***	***0.016 (0.002)***	***0.016 (0.002)***
Interaction: life expectancy*Africa			***0.012 (0.006)***	***0.014 (0.002)***
Real GDP per capita, in US dollars	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Year				0.020 (0.008)
Year squared				0.000 (0.000)
Constant				-0.921 (0.296)
Region specific intercepts and time trends	37 country-specific intcpts & time trends	8 region-specific intcpts & time trends	8 region-specific intcpts & time trends	
Observations	224	743	743	743 (122 countries)
R-squared	0.93	0.45	0.46	0.32

Notes

Standard error of coefficient estimates in parentheses. Standard error estimates are robust to heteroskedasticity; they are calculated using the Huber-White estimator, and for clustering by country. Gross primary enrollment ratios in each of 122 countries (of which 37 are African) in 1965, 1970, 1975, 1980, 1985, 1990, and 1995 are related to life expectancy at birth in the latest available year of the previous quinquennium and real GDP per capita. This implies 259 observations in column 1 and 854 observations in columns 2, 3, and 4; however, some had to be dropped for lack of data. PPP exchange rates were not available for years before 1980; therefore, GDP per capita is not corrected for purchasing power parity. The 37 African countries included are: Algeria, Angola, Benin, Botswana, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Côte d'Ivoire, Comoros, Congo (Rep.), Congo (DR), Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Togo, Uganda, Zambia, and Zimbabwe. The eight world regions in columns 3 and 4 are: South Asia, Africa, Mediterranean/Middle East/North Africa, Latin America/Caribbean, Industrialized Countries (North America, Europe, and Japan), South Pacific/Southeast Asia, East Asia, and Eastern Europe. Gross primary enrollment, life expectancy at birth, and Real GDP per capita data are taken from World Bank (2001). For more details, see text.

Consistent with the results in table 3, these results suggest that countries which improved their life expectancy by 10 years between one quinquennium and the next also saw improvements in school enrollment rates of about 0.2 (or 20 percentage points) over the same time periods. This is also compatible with our findings using the DHS data, above.[22]

[22] In translating enrollment rates to average schooling attainment, Barro and Lee multiply the proportion of the population enrolled at each educational level by the number of years in that level, and then by the probability of completion. The Barro-Lee data suggest that about 25% of those in Africa who enroll in primary school complete it. Therefore, assuming 6 years in primary school, an increase in enrollment of 0.2 would translate to an increase of (0.2)*(0.25)*6=0.3 years in attainment.

Table 4

Dependent Variable: Change in gross primary enrollment ratio over previous quinquennium	(1) Whole World	(2) Africa only	(3) Africa only
Change in life expectancy at birth over previous quinquennim	***0.015*** ***(0.005)***	***0.025*** ***(0.015)***	***0.020*** ***(0.010)***
Change in real GDP per capita over previous quinquennium	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Constant			0.003 (0.021)
Region/country specific intercepts	8 region specific intcpts	39 country specific intcpts	
Observations	613	181	181
R-squared	0.05	0.25	0.04

Notes

Standard error of coefficient estimates in parentheses. Standard error estimates are robust to heteroskedasticity; they are calculated using the Huber-White estimator, and are corrected for clustering by country. First differences of equations in table 3, relating quinquennium-on-quinquennium changes in school enrollment to changes in life expectancy and income. Data sources, regional classifications, and African countries included are as in table 3. Quinquennia-on-quinquennia changes are between the years 1965-1970, 1970-1975, 1975-1980, 1980-1985, 1985-1990, 1990-1995. For more details, see notes to table 3, and text.

Of course, there are the traditional caveats about drawing simple conclusions from these cross-country regressions. Among other things, it may be that decisions about whether and how much to invest in education are too complex to be captured in linear cross-country or cross-household regressions.[23] Some of these problems could be solved using truly longitudinal data, or using more detailed and qualitative "case study" type approaches which examine changes in educational attainment, attitudes toward investments in human capital, and health status in specific communities or countries over time. As these data become available in sufficient detail in African contexts, this line of inquiry deserves a high priority.

Furthermore, even if life expectancy has had an effect on demand for schooling which is similar to the effects we estimate here, it is important to note that these effects may be dramatically different depending on the *direction* in which life expectancy is changing. That is to say, even if ten *additional* years of life expectancy really do *increase* demand for schooling by 0.6 years, as tables 1 and 2 suggest, this by no means would mean that a *loss* of ten years of life expectancy must necessarily *reduce* demand for schooling by 0.6 years. In an epidemic, after all, past trends are not always replicated in the future. These

[23] This is essentially similar to the criticism leveled by many against cross-country economic growth regressions.

results, however, give us a point from which to *begin* to consider the effects of the epidemic on education from the demand side.

Implications

From these results, we can suppose that a loss of ten years' worth of life expectancy at the time that a birth cohort reaches the 12-17 year age range can reasonably be associated with a loss of about 0.6 years in the average schooling attainment of that cohort. Table 3 indicates the potential loss in schooling attainment for cohorts reaching age 25 over the next five to ten years, compared with those who reached age 25 over the first five years of the 1990s. In the case of Zimbabwe, the hardest hit country in the region by HIV/AIDS for which DHS data are available, the implied lost years of schooling attainment for 25 year olds in the period 2006-2011 is on the order of one and a half years, compared to a current average for DHS respondents aged 25 and older of less than five years—implying a devastating potential impact were the past trends replicated in the future. The implications for some of the other hard hit countries in sub-Saharan Africa, where life expectancy has already begun to decline precipitously, and where average schooling attainment was already low by world standards, are profound. In virtually all cases shown in Table 3, the implied reduction in average years of schooling is at least 20 percent of already low averages.

Table 5

Country	Change in years of life expectancy: 1982 to 1999	potential lost years of schooling attainment: cohort reaching age 25 1990-1994 vs 2006-2011	Average years of schooling among female population aged 25-49 years (DHS data closest to 1990)	Average years of schooling among *total* pop. aged >24 years in 1990 (Barro-Lee estimates)
Botswana	-20	-1.2	*No DHS data available*	2.61
Zimbabwe	-15	-0.9	4.79 (yr. 1988)	2.31
Zambia	-13	-0.78	5.51 (yr. 1996)	4.05
South Africa	-10	-0.6	*No DHS data available*	4.84
Lesotho	-9	-0.54	*No DHS data available*	3.28
Kenya	-8	-0.48	6.39 (yr. 1998)	2.82
Uganda	-6	-0.36	3.33 (yr. 1995)	1.42

Notes

Observed change in years of life expectancy (column 1) taken from World Bank (2001); observed average years of schooling among DHS eligible population (column 3) taken from Demographic and Health Surveys in each country, conducted as close as possible to the year 1999. The DHS surveys interview nationally representative samples of women aged 15-49. Column 2 assumes, based on the results in table 1, columns 2, 4, and 6, and table 2, column 4, that the marginal effect on schooling demand of a lost year of life expectancy when a quinquennial birth cohort reaches ages 12-17 is a loss of roughly 0.6 years in average schooling attainment. The cohort reaching age 12-17 in 1982 reached age 25 in the years 1990-94, while the one which reached ages 12-17 in 1999 will reach age 25 in 2006-2011. Applying the estimated marginal effect to the observed change in life expectancy yields the potential lost years of schooling reported in column 2. For further comparison, column 4 shows the estimates reported by Barro and Lee (1996) of average years of schooling among the total population, which are not based on survey data. For more details, see notes to tables 1 and 2, and text.

We have noted that there could be a difference between the past trend relating life expectancy and education and the future trend attributable to the AIDS epidemic. This is particularly the case if life expectancy in the past was reflecting a range of institutional and policy factors as noted above that would remain relatively constant, or could even improve in countries hit by the epidemic. On the other hand, we cannot be sure that the future relationship will be tighter (and thus worse where life expectancy declines) since the effect of demand for education could be exacerbated by the disproportionate number of adults affected, as compared to the past when increased life expectancy resulted heavily from improvements in infant mortality. Moreover, it is possible that the extent of the epidemic is or will undermine access to or the quality of the preventive health services, as health personnel and other resources are diverted to prevention and care of AIDS victims, and that improved preventive health services have explained at least some of the past increases in life expectancy. In short, though our results are illustrative and certainly not definitive in terms of causality, we believe they should provoke considerable concern about the medium-term if not the immediate effects of declining life expectancy on the demand for education.

Section 3. HIV/AIDS and the Productivity of Africa's Human Capital

AIDS is unlike many other diseases in that it disproportionately affects adults of working age. Furthermore, at least for the first decade of the epidemic, HIV was much more likely to infect the relatively better educated. The epidemic, therefore, will carry off an unprecedented proportion of Africa's existing human capital stock. Even beyond the incalculable human tragedy visited upon those who die prematurely and their loved ones, we can expect these deaths to have effects on the productivity of those who survive.

An agglomeration of skilled workers is much more productive than an equal number of workers acting alone. One of the most dramatic ways in which this principle of increasing marginal returns to human capital is borne out is in the stylized fact of the "brain drain." Skilled workers tend to migrate from places where they are relatively scarce to those where they are relatively abundant, in order to increase their incomes. Indian engineers, for example, can quadruple their incomes by moving from Kerala to Silicon Valley. Similarly, African professionals are likely to be concentrated in urban not rural areas, independent of their birthplace. Another indication of this phenomenon is in the formation of universities, which after all exist because they can offer individuals with particularly specialized skills the opportunity to be in a community with others of similar or complementary skills.

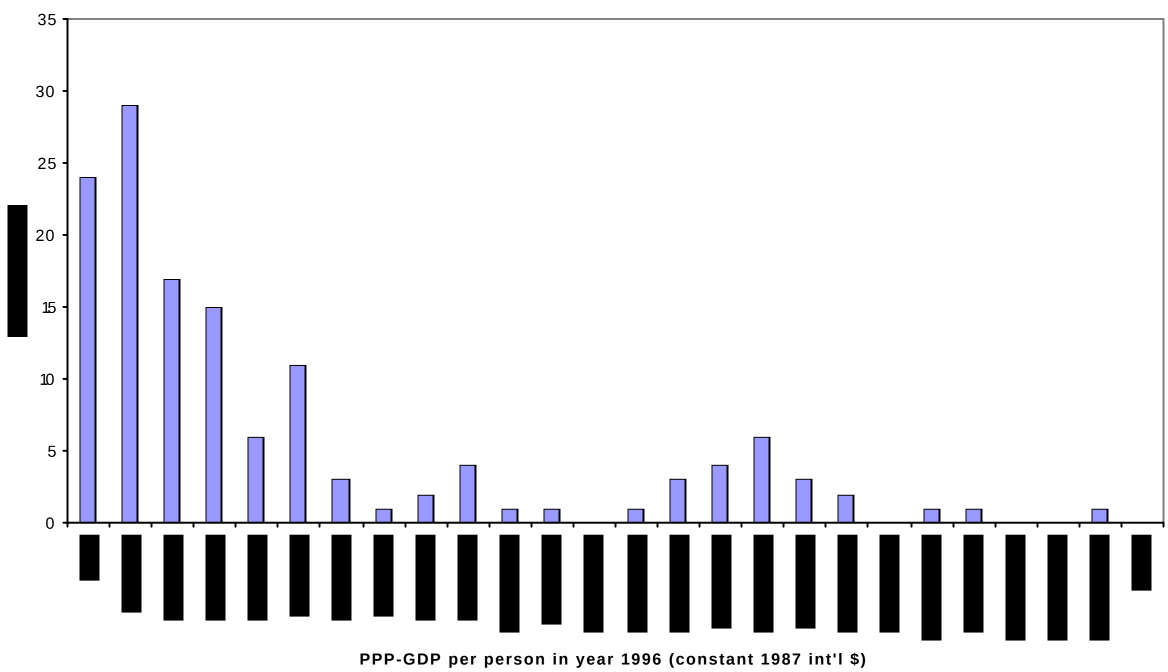
Becker, Murphy, and Tamura (1990) use the idea of increasing returns to human capital in order to generate a model of multiple equilibria in the size, overall schooling, and welfare of households. The reasoning goes that in the high level equilibrium, each household has a smaller quantity of children but invests more heavily in the "quality" of each child. This increases the aggregate human capital in the succeeding generation, which increases the opportunity cost of parents' time and the future returns to skills, thereby inducing parents to have fewer children while increasing the attractiveness of investments in the "quality" of these children, which increases their productivity, leading to the long run persistence of a highly skilled and productive work force. In the low level equilibrium, where skills are relatively scarce, returns to investments in schooling are smaller and the opportunity cost of parents' time is relatively low, and so parents are inclined to invest time and resources in a larger number of children who obtain less schooling, thereby perpetuating the scarcity of skills.[24]

The world does indeed seem to bear out these sorts of stories of multiple equilibria. Consider, for example, the distribution of average incomes among the world's economies. As figure 6 demonstrates, the distribution of average per capita income across countries is nearly perfectly bimodal, with many very poor countries (with per

[24] Empirical evidence offered in studies by Psacharopolous that "private" and "social" rates of return to education are fairly constant across countries might appear to mitigate against such a hypothesis. However, it is important to note that these do not capture the true "social" returns (Birdsall 1996).

capita GDP at or around 1000-2000 dollars), fewer very rich ones (with per capita GDP at or around 16,000-17,000 dollars), and only a smattering of countries in between.

Figure 6



Notes

Distribution of countries by real GDP per person in 1996, corrected for purchasing power parity. PPP-adjusted GDP was taken from World Bank (2001). Countries included are those 136 for which data were available for the year 1996. Thirty-seven of these are in sub-Saharan Africa. The bimodal distribution of incomes is consistent with many "multiple equilibrium" or "poverty trap" stories of the world, in which poor countries remain poor due to some vicious cycle of causation, until the cycle is broken and countries rapidly converge to a new, higher equilibrium. Such stories would predict that at any given time, few countries would be observed between the rich and the poor modes. For more details, see text.

In the case of sub-Saharan Africa, only seven of the 37 countries included in figure 4 are above the second bar, i.e. have PPP-adjusted GDP per capita at or above $2000, and none are above $7000.

The highly bimodal distribution of countries is consistent with the notion of "poverty traps," whereby poor economies remain very poor due to a vicious cycle, until some positive external shock breaks the cycle. A sufficiently large increase in life expectancy could jump-start an economy (Bloom and Canning, 2000), as could a large decline in fertility since the latter subsequently produces a greatly increased (i.e. improved) ratio of workers to youth (Kelley and Schmidt, 1996 and 1999; Williamson, 1998). In these and other cases, the story is generally applied to the case of various of the so-called miracle economies of East Asia, where large gains in life expectancy, declines in fertility, and subsequent huge increases in the number of workers relative to children (and the old) occurred throughout much of the high-growth decades of the 1970s and 1980s.[25] In a case study in Uganda, Bigsten and Kayizzi-Mugerwa (1999) suggest that because of the structural constraints typical of a poverty trap (though they do not use that expression), it is difficult to capture the benefits of globalization in the short run, even with a substantially improved policy environment.

Similarly, the accumulation of human capital beyond some "critical mass" is likely to be one such shock in itself. Lau, Jamison, Liu, and Rivkin (1996), analyzing cross-sectional evidence from Brazilian states, find that the impact of education on total economic output becomes particularly dramatic only after the average level of education of the workforce reaches a certain threshold level; in Brazil, this threshold was reached when the average educational attainment reached about 3-4 years. Most African nations have made progress in building up their own "critical mass" of skills. This has been particularly true in the southern part of the continent. In Botswana, gross secondary school enrollment increased from 19% of the school-aged population at the beginning of the 1980s to 56% in the mid-1990s. Over the same period in Zimbabwe this rate increased from 8% to 47%, and in Malawi from 3% to 98%. Between the early 1970s and mid-1990s, South Africa's gross secondary school enrollment ratios increased from 20% to 84% (World Bank, 2001). The epidemic, however, has hit these nations hardest; prevalence ratios in this region vary from 20% of South Africa's adult population infected with HIV to over 40% of Botswana's (UNAIDS, 2000). By skimming off the most skilled workers in the economy (at least in the first wave), HIV/AIDS threatens to forestall the emergence of a critical mass of the more skilled workers.

These effects are difficult to quantify at the micro level, since they describe a dynamic in which the number of already educated people increases the social (that is, external to

[25] Similarly, Bloom, Canning, and Malaney (1999) for East Asia describe a world of "cumulative causation," in which low incomes and adverse demographic and health conditions in East Asia formed a web of cause and effect until the early 1960s. They attribute the escape from the vicious cycle to rapid improvements in health, which reoriented the causal cycle, resulting in extremely rapid economic growth.

individuals) return to education, but not necessarily the private return. (The measured private return may actually decline, as noted above, as more people are educated and skilled workers become relatively more plentiful. This is what explains Psacharopoulos' finding that private returns, especially to higher education, tend to diminish as country GDP per capita rises.[26] Implicitly, the model presented by Becker, Murphy and Tamura assumes that—other things being equal—some of the positive externalities associated with higher total stock of human capital are reflected at least in the form of higher absolute private returns.) At the aggregate level, however, it is individuals' decisions about these investments which determines the number of educated people. Increasingly sophisticated empirical techniques have been employed to quantify effects in the context of these sorts of causal cycles. In the meantime, however, it is sufficient to understand the qualitative implications of the loss of the positive externalities generated by Africa's stock of skilled and educated workers—first, an increase in the rate of the "brain drain," as skilled workers move to take advantage of these externalities elsewhere; second, a decrease in the average productivity of those workers (unskilled as well as skilled) who do survive; and third, a decline in the demand for schooling among workers in the future, attendant on a decline in the absolute if not the marginal private returns to education.

Section 4. HIV/AIDS, Physical Capital, and Human Capital

Most traditional economic theory treats human and physical capital as substitutes of each other, rather than complements. There is evidence, however, to suggest that this approach does not capture important subtleties. For example, Birdsall, Pinckney and Sabot (1997) posit that where credit markets are incomplete or imperfect, poor households must finance their own investments entirely out of savings. These credit-constrained households, therefore, save not only to buffer against stochastic income shocks, but also to finance investments. Because they only invest when the return exceeds the (relatively high) discount rate, investments available to the poor are likely to have higher returns than those available to the rich. The rich are not able to take

[26] Psacharopoulos (1994) also reports diminishing social returns to education with higher GDP per capita, but this is because he measures the "social" return at the country level as simply the private return minus the country-specific cost of schooling at different levels. See Birdsall, 1996, on this point.

advantage of these investment opportunities because of imperfections in the credit market. This is particularly true of investments in human capital, which though yielding extremely high private returns relative to most other investments, are non-transferable and hence extremely difficult to guarantee—for example, once trained an individual has no reason to fear expropriation of his newly acquired skill, and so in the absence of sophisticated credit monitoring mechanisms, he may choose not to make good on his commitment to repay the training costs. The rich, therefore, supplement investments in their own human capital with investments in third-party instruments including for example equity markets and other traditional instruments. These are easier to guarantee, but are also likely to be less productive than investments of the poor (on their farms and businesses as well as their human capital).[27] In such contexts, if the poor are forced to forego investments in their own education for lack of savings, the potential benefits are lost to the economy.

One of the most salient clinical characteristics of HIV/AIDS is the long period of illness before the infected person finally succumbs to disease. In Africa, the median time from infection to death is about six years—over this period, illness becomes more and more acute, with the last year usually spent in a state of complete incapacity. Since those infected are likely to be adults of working age, this protracted illness hits household savings and investments twice—first, by depriving the household of a wage-earner, and then by requiring an outlay of household resources to care for the infected person. Although some of these outlays are financed by diverting present consumption or by inter-household transfers, evidence suggests that most of it is financed by reductions in savings and the selling off of physical assets (Menon, Wawer, Konde-Lule , Sewankambo and Li, 1998; Béchu, 1998). Poorer households, when they are forced to make these adjustments, are obviously more likely to have to forego investments in the human capital of their children. This effect is exacerbated by the fact that the loss of adults in households often increases the opportunity cost of children's time, as they become more necessary to the ongoing operation of the household (Mutangadura, 2000).

[27] See also Acemoglu (1997) and Acemoglu and Pischke (1999)

Furthermore, using data from Latin America, Behrman, Birdsall and Szekely (2001) find evidence that when and where (using year- and country- specific data) the financial markets in the region are more open to international capital flows, the "skill premium" in wages is higher, i.e. the return to secondary and to higher relative to primary schooling is greater. They infer that skilled labor is complementary to capital, so that new investments in physical capital generate increased demand for skills. Intuitively, the idea that physical and human capital are complementary is appealing—specialized skills are required, for example, in the operation and maintenance of most machines. The epidemic is likely to have a dramatic effect not only on domestic savings (through the foreshortening of time horizons and the increased demand for present consumption to finance medical care) but also on the attractiveness of foreign investment. These effects together are likely to erode the physical capital stock in many of the hardest hit countries. Insofar as this in turn reduces the skill premium, it will reduce incentives for households to invest resources and time in the education of their children beyond the basic, primary level.

Conclusion

This paper explores four channels by which the epidemic of HIV/AIDS in Africa is likely to affect the size, rate of growth, and productivity of the continent's human capital stock. It would be compelling, no doubt, if we could add up the effects of these four channels on both the future expected stock of total human capital, and on economic growth itself via any change in the economy-wide return to the adjusted stock. We have not developed the complex model that might guide us in how to do that, and we believe in any event that the results of any such simulation would be highly sensitive to some basic assumptions about the dynamics of the process. Such models must take into account the likelihood of multiple equilibria, the interactions between general and local characteristics, and other complicating factors about which we still have only very little information. This is true both in terms of the expected total stock and certainly in terms of the expected economic effects.

However, we do believe that the channels described add up to the qualitative conclusion that among the costs of the epidemic is the likelihood that, absent offsetting policies and programs, Africa's dearth of human capital will get worse. The epidemic will have this effect not only from the supply side by reducing the capacity of the educational system to train the next generation, but also from the demand side by making investments in schooling less attractive by foreshortening time horizons and increasing the opportunity costs of children's time. These effects will slow the rate of Africa's *accumulation* of human capital. The epidemic also threatens to decimate the already *existing* human capital stock by killing off many of the continent's most skilled workers, and in so doing reducing the average productivity of those workers who are left behind. Finally, the epidemic threatens to sap away the savings and physical capital assets of households and nations across the continent, thereby reducing the productivity of workers who rely on physical capital to make use of their skills.

Of course, the effects of the epidemic on the accumulation and productivity of human capital in Africa are likely to go beyond those explored in this paper. For example, to the extent that states are forced to reorient their fiscal priorities to health spending in order to care for those infected and dying, education systems may find themselves starved for funding. Furthermore, the orphaning of millions of children across the continent may be expected to leave communities unable to rear children with a traditional level of care or attention. We have emphasized here four effects that are relevant to our understanding of the economics of human capital, and that have potential over the long run, if not offset, to reduce the stock of human capital and the economic gains to the stock, in countries affected by HIV/AIDS.

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Our analysis is not meant to be a counsel of despair. It illustrates the likely need for adjustments, for example in countries' educational policies and priorities, including teacher salaries and placement, class size, spending on student transportation (assuming particular difficulties in staffing small rural schools), and other changes to minimize the effects of AIDS on the availability and quality of schooling. It also illustrates the logic of full information about public efforts to contain the epidemic, and successes in those efforts, which may help maintain demand for schooling in the face of short-term perceptions of declining returns. It has implications for expected growth and thus for fiscal expectations and the sustainability of the high debt stock of many countries in the region. For the countries worst hit by the AIDS epidemic, it reinforces the logic of massive donor support to reduce the probability of the wrong, low-level “poverty trap” equilibrium—by fighting the disease itself and by helping finance the additional costs of meeting education and the other development challenges the region faces.

Finally, for the research economics community, it illustrates the multiple links among health, education, and economic growth, the relevance of the demand as well as the supply side for sustaining and increasing education, and more generally the centrality of human capital to development progress.

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