AIDS, Reversal of the Demographic Transition and Economic Development: Evidence from Africa*

Sebnem Kalemli-Ozcan

University of Houston and NBER

August 2006

Abstract

Using a panel of African countries during 1985−2000, I show that HIV/AIDS affects fertility rates positively and enrollment rates negatively. The evidence provides support for models of fertility transition emphasizing the demand for children, highlighting a specific mechanism through which demographic transition affects economic growth. Parents who are faced with high mortality rates for adolescents choose to have more children and provide each of them with less education. The empirical estimates predict that a country with a high level of HIV/AIDS prevalence, such as Congo, have 2 more children per woman and 38 percentage points less school enrollment compared to a country with a low level of HIV/AIDS prevalence, such as Madagascar.

JEL Classification: O11, I12, J11, J13
Keywords: HIV/AIDS, Quality-Quantity Trade-Off, Economic Growth

*I thank Daron Acemoglu, David Bloom, David Canning, Aimee Chin, Andrew Francis, Chinhui Juhn, Gerhard Gloom, David Meltzer, Emily Oster, Yona Rubinstein, Bent Sorensen, Michele Tertilt, Rebecca Thornton, Dietz Vollrath, David Weil, and participants of the May 2005 conference on "Health, Demographics and Economic Development" at Stanford University for valuable comments and suggestions.

1 Introduction

The scope of the worldwide AIDS epidemic is staggering. As of 2005 there were an estimated 38 million people living with HIV/AIDS, with more then 90 percent of the infected people living in developing countries. Africa alone accounts for the two-thirds of the world total and almost all of the infected children.[1] In the 35 highly affected countries of Africa, life expectancy at birth dropped by 7 to 10 years in the last decade. As shown in figure 1a, in the five countries with the highest HIV/AIDS prevalence (Botswana, Uganda, South Africa, Zambia and Zimbabwe), life expectancies for females (similar picture for males) are now at their 1950 levels. In Botswana life expectancy for females has dropped from 62 years in 1985 to 38 years in 2000 and is projected to fall to 30 years by 2010. For males, it has dropped from 58 years to 40 since 1985. Some of these changes in life expectancy at birth might be driven by infant mortality. Thus, figure 1b plots the female adult mortality rate over time, which captures the mortality rate after age 20, for the same set of countries. As shown, these countries' adult mortality rates were at 300-400 per 1000 adults before the epidemic and by 2000 they reached to the extreme levels of 700-800 per 1000 adults. Figures 2a and 2b plot HIV prevalence and AIDS incidence over time to show the spread of the epidemic during the last 15 years in these countries.

Recently, there has been an increase in the number of research papers investigating the impact of HIV/AIDS on economic growth. The results vary extensively. While most of the researchers find negative effects of the epidemic on economic growth, some find no effect and some even find positive effects.[2] The results of Lorentzen, McMillan, and Wacziarg (2004) imply significant long-run costs of the AIDS epidemic on various dimensions. Bloom and Mahal (1997) run cross-country regressions of growth of GDP per capita on HIV/AIDS prevalence and find no effect, whereas Bonnel (2000) finds a negative effect within a similar framework. Over (1992), who also uses cross-country data, finds a reduction of 0.5 percent per year in per capita growth rates as a result of the epidemic. Papageorgiou and Stoytcheva (2004) find that an increase in AIDS incidence by 100 in 100,000 people is associated with a 0.4 percent reduction in income per worker. Werker, Ahuja, and Wendell (2006) instrument HIV/AIDS prevalence by national circumcision rates and show that there is no effect of the epidemic on growth of the African countries. Corrigan, Gloom, and Mendez

[1]See UNAIDS Global report (2006).

[2]See UNAIDS Global report (2004) for a summary of micro and macro empirical evidence together with various simulation exercises of demographic models that show 0.5−1.5 percent reduction in yearly growth rates for various countries. See also Wehrwein (2000).

(2005) show calibration results that imply large negative effects of the epidemic on growth. Using micro data from South Africa, Young (2005) argues that the HIV/AIDS epidemic increases the growth and welfare of future generations in South Africa due to its negative impact on population growth.

One reason for these different results might be that there are numerous channels through which AIDS affects economic development.[3] These channels might differ both country to country and over time and hence estimating the direct effect of AIDS on economic growth would be misleading. Families who are experiencing the disease and the death must cope with it, must care for the sick, and hence must re-allocate their savings. Private and public businesses lose workers and overall productivity decreases. School enrollments decline and the epidemic puts tremendous pressure on government budgets. On top of these domestic problems, foreign investors might refrain from investing in a country with high HIV/AIDS prevalence rates.[4]

In order to make the right policy recommendations, we must investigate each channel separately. For example, many think that HIV/AIDS will substantially reduce population growth rates. In their 2004 global report, UNAIDS argues that the negative effects of the epidemic on production are counterbalanced by similar reductions in consumption and resource use due to lower population growth. As a result, they argue, the epidemic's impact on per-capita GDP is relatively small, even positive in some of the scenarios considered. Arguing along similar lines and drawing on parallels between AIDS and the "Black Death," Young (2005) shows that as a result of the significant decrease in population, AIDS will increase the welfare of the future generations in South Africa by increasing their per capita income. While Young (2005) accepts the detrimental impact of the epidemic on human capital accumulation, he claims that in South Africa infection lowers fertility both through a reduction in the willingness to engage in unprotected sexual activity and by increasing the scarcity of labor. He argues that the fertility effect dominates.[5]

This paper argues the contrary. Given the stylized facts of the demographic transition, one expects to find a negative effect of the HIV/AIDS epidemic on economic growth through the fertility

[3]Acemoglu and Johnson (2005) investigate the direct effect of life expectancy on growth using pre-intervention distribution of mortality from various diseases and dates of global interventions as instruments. They do not include AIDS among the diseases they consider.

[4]See Over (1992) and Haacker (2002).

[5]Bell, Shantayanan, and Gersbach (2003), using similar data from South Africa argue that the long-term economic costs of AIDS could be devastating because of the cumulative weakening from generation to generation of human capital. See also Ferreira and Pessoa (2003), who document significant reductions in schooling. Young's (2005) findings for South Africa are also at odds with Lorentzen, McMillan, and Wacziarg's (2004) findings, who claim that South Africa is one of the outlier observations and leaving it out results in a more statistically significant coefficient for the effect of adult mortality on economic growth.

channel. At the start of the demographic transition mortality rates decline, and are then followed by a decline in fertility rates. Eventually the decline in fertility rates overwhelms the decline in mortality rates, causing an inverted U-shaped pattern for net fertility, and hence for population growth. The question is thus: Is HIV/AIDS reversing the demographic transition? I show that the answer is yes. The mortality rates are clearly increasing. The epidemic is also causing an increase in fertility, countervailing the decline in the population growth rate due to increased mortality.

I estimate the effect of HIV/AIDS prevalence on total fertility rates and school enrollment rates using panel data on 44 countries from Africa for the period 1985−2000.[6] AIDS represents an exogenous change in the health environment to which parents respond by changing their fertility behavior. The results are twofold. First, as a result of the epidemic the total fertility rate increases and human capital investment decreases. The empirical estimates predict that a country with a high level of HIV/AIDS prevalence, such as Congo, have 2 more children and 38 percentage points less school enrollment compared to a country with a low level of HIV/AIDS prevalence, such as Madagascar. Taken together these effects have a substantial negative effect on economic development. Second, the evidence provides support for the models of fertility transition emphasizing the demand for children and for the models of quality-quantity trade-off. The patterns observed in the data are consistent with theoretical models that argue for the existence of a precautionary demand for children in the face of uncertainty about child survival. Parents faced with a high mortality environment for young adults choose to have more children and provide them with less education, leading to a reversal in the fertility transition and a reduction in aggregate human capital investment.[7] This type of "insurance effect" has not been captured in the previous empirical studies. Although there is a very strong positive relationship between child mortality and fertility at the aggregate level, child mortality is endogenous and hence the macro estimates will be biased.[8]

[6]After this paper was substantially completed I became aware of a new working paper by Young (2005b), that undertakes a similar analysis using macro data from DHS surveys for selected African countries and finds a negative effect of HIV on fertility. His data are limited by the survey years and survey countries and hence are not directly comparable to the data used in this paper. I hope that future work will sort out the differences.

[7]For theoretical models based on this mechanism, see Sah (1991) and Kalemli-Ozcan (2003). See also Ehrlich and Lui (1991) for an indirect mechanism that generates a similar result for fertility but not for human capital investment. Sah (1991) and Kalemli-Ozcan (2003) develop models based on precautionary demand for children in the presence of uncertain child survival and can generate a decline in net fertility (after an initial increase) together with a decline in total fertility as a result of a decline in mortality. See also Chakraborty (2004) and Soares (2004) for different ways of modeling the relation between mortality and fertility. There are also models in the spirit of Barro-Becker world where gross fertility might be positively related to mortality but net fertility is negatively related to mortality. Among these models are Doepke (2004) and Boldrin and Jones (2002). Thus the evidence provided in this paper can be viewed as supportive evidence for a broader class of models; See Lorentzen, McMillan, and Wacziarg (2004) for an excellent review of the literature on mortality and fertility.

[8]Schultz (1997) shows a positive effect of child mortality on fertility using panel data from a set of developing

AIDS provides an exogenous source of variation in mortality. More importantly, AIDS mortality takes place much later in life, which makes early insurance against AIDS related deaths extremely important.

The rest of the paper is structured as follows. Section 2 discusses background information on HIV/AIDS and micro evidence on the behavioral responses. Section 3 examines the data on total fertility rates, enrollment rates and HIV/AIDS prevalence. Section 4 presents the empirical analysis. Section 5 concludes.

2 Background: HIV/AIDS Epidemic and the Behavioral Responses

There are four demographic characteristics of AIDS, due to which its economic impact is far greater than other diseases. First, it is universally fatal in Africa. Second, AIDS in Africa is affecting prime-working-aged adults during their most productive years. Third, it is widespread in urban areas and it is the leading cause of death in Africa today. Fourth, unlike other diseases in Africa, AIDS is affecting educated and upper class individuals.

A big part of the aggregate economic impact of AIDS depends on the behavioral responses of individuals to the demographic shocks caused by the epidemic. The demographic impact of the epidemic works through its effect on mortality and fertility. Demographers argue that—assuming no significant change in the fertility rate—the higher death rates due to AIDS will eventually reduce the population growth rate to zero.[9] However, if AIDS does change fertility behavior, it could alter the demographic implications greatly. According to demographers, HIV infection will not shorten the lives of a large enough number of women to reduce national birth rates unless infection lowers the age-specific fertility rates. Demographic models assume that by the time most HIV infected women die, they would already have given birth to several children; thus, total fertility rates at the national level will not be affected. This type of argument assumes that there are no behavioral responses and the aggregate impact will only come from various clinical responses. It is very plausible to think that as a response to the epidemic, individuals will decide to change their fertility behavior, which in turn will affect the aggregate fertility rate.[10]

countries. However, he argues that these type of estimates cannot claim causality due to the endogeneity of child mortality. Micro empirical studies focus on estimating the magnitude of the "replacement effect," which is replacing each death child ex-post instead of ex-ante insurance by having more children.

[9] This effect might change from country to country since it depends on the incubation period—the time from HIV infection to AIDS. Some studies suggest that this period is shorter in Africa. See Ainsworth and Over (1995).

[10] See Kremer (1996) for a model that produces multiple equilibria for the behavior change as a result of the epidemic.

Presumably, people who were completely unaware of the epidemic would not change their behavior. On the other extreme, women who are born with infection or get infected before their child-bearing years and know about their positive status may want to decrease their fertility rather then give birth to infected children. If a large enough number of women behave this way then the effect of the epidemic on the total fertility rate will be negative. However, existing evidence tells us a different story about the knowledge (or perceptions) of the disease and the related behavioral responses. Table 1 shows data from DHS, demographic health surveys for the African countries, where these data are available. As shown in column (1), the percentage of the female population that requests an HIV test, get tested, and received results is very small, the mean being 5.7 percent across the countries shown.[11] As conjectured above, women who know their HIV-positive status might decrease their fertility, i.e., there is a negative correlation (–0.60) between the total fertility rate and the data shown in column (1). Column (3) shows the percentage of female population who received the results of their HIV tests, as a subset of those who are tested in the first place (by request of the person herself or during a clinic visit), which is shown in column (2). Only less than half of the people who are tested receive their results and the percentage of the people who are tested is very small to begin with. As shown in columns (4) and (5), although a large percentage of pregnant women are counseled during their antenatal clinic (ANC) visits, very few of them are tested for HIV during these visits. One reason for the low level of voluntary testing might be because women do not think they are at risk.[12] Figure 3 shows indicators of risk perception for women from DHS, for selected African countries. The percentage of sexually active women (15-49) that perceive themselves not to be at risk of getting AIDS is rather high, with a mean of 48 percent among the countries shown. The percentage of 15-49 years old women who know that HIV can be transmitted from mother to child is also plotted for the same countries, with a mean of 38 percent. The average HIV prevalence among these countries is around 15 percent and the average level of comprehensive knowledge about the disease is only 30 percent.[13] It does not seem to be the case that higher HIV countries necessarily have better knowledge.[14]

[11]Sentinel surveillance programs (a form of surveillance relates to a particular group) monitoring HIV/AIDS epidemic in Africa are not designed to detect and notify at-risk individuals. They are conducted using anonymous and unlinked blood samples from hospital blood donors, pregnant women attending antenatal clinics (ANC), or sexually transmitted disease (STD) clinic attenders. Thus, those with HIV who are tested will not receive a notification of their status.

[12]Other reasons might be not knowing about the availability of such a test or living far from a hospital or clinic.

[13]Comprehensive correct knowledge about AIDS is defined as knowledge of 2 ways to prevent AIDS and be able to reject 3 misconceptions.

[14]Economist (2006) reports that, in the recent trial of Jacob Zuma, South Africa's former deputy president, Jacob Zuma said that he took a shower to minimize the risk of infection after having sex with an HIV-positive woman, who

Oster (2005) argues that the knowledge of one's HIV status appears to be very low in Africa and this suggests no behavior change in response to being HIV-positive. Similarly, Setel (1995) argues that informed HIV positive people make up only a small part of all that are affected by the disease, and that they become informed very late. Thus, they will not live long enough to alter their fertility even if they want to. He cites various studies that test groups of women from individual countries, showing that the ones who came back for a follow up after the HIV testing (the informed) only constitutes 30 percent of all the test subjects. He further argues that people who voluntarily seek testing and counseling are in the minority. Thornton (2006) designed a randomized experiment involving 2700 individuals in Malawi and finds that less than half of the participants attended clinics to learn their HIV status.[15] She reports that the survey data from Malawi shows only 20 percent of the respondents have ever been tested and only half of those tested learned their results.

Biswalo and Lie (1995) claim that for those women who lack the power to negotiate fertility, the HIV-positive ones may also be reluctant to reveal their positive status. They present evidence from interviews with a small sample of HIV-positive women in Tanzania that in spite of being pressed for more children, women did not reveal their status. Higgins et al. (1991) and Green (1994) review studies done for various African countries and find no evidence of HIV testing and counseling on the reproductive behavior of HIV-positive or high risk individuals. Temmerman et al. (1990) find that in Nairobi a single session of counseling—which is common in most African countries—has no effect on the subsequent reproductive behavior of HIV-positive women. Allen et al. (1993) using cohort data from Kigali, Rwanda, find that in the first 2 years of follow-up after HIV testing, HIV-negative women were more likely to become pregnant than HIV-positive women. However, among HIV-positive women, those with no children were more likely to become pregnant than those with children and married women are more likely to become pregnant than unmarried women. The desire to have children among HIV-positive women altogether was 45 percent. Thornton (2006) finds no impact of testing, long counseling sessions, or education about safe sex on HIV-negative persons sexual behavior and finds little impact on HIV-positive ones. The main conclusion of these papers is that the fertility decision of infected people will not depend on their positive status in general, because either women are not aware of their status or there might be other reasons for the

accused him of rape. Subsequently, HIV/AIDS helplines report having a lot of difficulties in dealing with confused callers.

[15] She also finds that if a small monetary incentive is provided then the share of the ones who want to learn their status increased by 50 percent.

informed HIV-positive women not to decrease their fertility.

Uninfected people, or people who think they are not at risk, might behave differently. Although they are uninfected, these people probably know that there is a high level of mortality in their surrounding population. What happens to the sexual behavior over time as a result of the epidemic is a very controversial topic. Data on sexual behavior are available from DHS, however these data are far from being perfect. They are self-reported measures and they are subject to downward biases. The bias is likely to be more serious in the case of Africa due to the traditional roles assigned to women. They are only available since the HIV/AIDS epidemic got underway and hence a comparison between pre-epidemic and post-epidemic sexual behavior is impossible. Nevertheless, Mwaluko et al. (2003), Williams et al. (2003), and Bloom et al. (2000) have investigated a single location over time to observe changes in sexual behavior. Their results suggest very little or no behavioral change at all. Oster (2005), using these DHS data on sexual behavior from 10 African countries where the surveys were run more than once investigates the change in sexual behavior over time. She finds little or no behavior change over time. Combining these data with the HIV rates, she shows that there has been a very small decrease in sexual activity associated with increases in the HIV rate: a 1 percent increase in the HIV rate is associated with a 0.2 percent decrease in the share of single women having premarital sex. Luke and Munshi (2004) find that within Kenya, in a high AIDS prevalence environment married men are no different than single men in the number of non-marital partners. One would expect the number of non-marital partners to fall more for the married men if unprotected sexual activity is an issue or if wives could influence husband's extra-marital sexual activity.[16] Francis (2006) find no evidence of the hypothesis that less illegitimate children will be born due to the decrease in unprotected sex in the U.S. On the other hand, Young (2005) strongly argues that individual fertility rates in South Africa will decrease for everybody since the willingness to engage in unprotected sexual activity will decline due to the HIV/AIDS epidemic. However, as summarized above, there is no systematic evidence that shows the willingness to engage in sexual activity decreases as a result of the epidemic. The evidence is to the contrary.

One plausible strategy for the uninfected parents might be to respond to the higher mortality environment by having more children to guarantee a certain number of survivors. This response of fertility to expected deaths, where parents bear more children than their optimal number of

[16] Sociologists have long argued that in Africa married women don't have a lot of power over their husband's extra-marital sexual activity.

survivors, is based on uncertainty about child survival. This uncertainty leads parents to produce more children, a condition that causes an increase in fertility larger than the average increase in mortality and hence increases the expected number of surviving children. Parents can also undertake a "replacement strategy," where parents replace deceased children.[17] However in the case of HIV/AIDS, where AIDS related deaths come later in life, it will be biologically impossible to replace those dead children.[18] Figure 4 shows data from Botswana, where HIV/AIDS prevalence peaks around age 25−30, implying AIDS mortality to take place much later in life. Figure 5a shows the mortality profile for adults and children as a function of time since infection. In the absence of antiretroviral therapy, the median survival time for adults is 9 years. The estimates also imply that all infected children die by age 12. Figure 5b shows estimates from Feeney (2001) for Zimbabawe. The probability of a 15 year old dying before age 50 shows a sharp increase since late 1980s, implying extremely high mortality for young adults due to the epidemic during this time period.[19] The higher probabilities (around 50%) implied by the household reports might reflect the rapidly rising mortality that is captured in those surveys which are undertaken in 1997 (top x-axis) relative to others that are done earlier. These also reflect the subjective probabilities of the family members who experienced the deaths due to AIDS very closely. The main point of these figures is that AIDS related mortality is very high for young adults and perceived to be high by the family members, which makes the insurance mechanism extremely important.[20] If a large number of women establish a precautionary demand for children then the total fertility rate will increase in the aggregate, causing a "reversal" in the fertility transition that has been underway since 1980. By having more children, parents move along a quality-quantity trade-off and invest less in their education, an action that reduces the aggregate amount of human capital.[21] The aggregate

[17]Doepke (2005) shows that the insurance effect will disappear when replacement is allowed. However, micro studies estimates the replacement effect to be much less than 1. A coefficient of 1 means full replacement, i.e., replacing 1 death child with an alive one. See Schultz (1997).

[18]I am assuming that parents presume their children will be infected via sexual activity, which probably will not start before early teen years.

[19]This probability is defined as q_{15}^{35} in demographic terminology. Records from vital registration, reports from households and reports from surviving siblings all show an upward trend. Feeney (2001) argues the discrepancy between registered deaths and sibling reports comes from the fact that the former is adjusted for underreporting and the latter is not.

[20]Note that HIV/AIDS also causes adult mortality to increase, fecundity to decrease, sex to be more costly and transmission from mother to child to be more likely. All of these will cause a decrease in the demand for children. As argued above the evidence is not supportive of the latter two effects causing a decrease for the demand for children. As to be shown later the empirical exercise will try to control for the first two effects.

[21]The other potential reasons that can be independent of the fertility decision but still lead to a reduction in human capital investment are as follows: 1) Higher mortality implies a lower rate of return to education. Kalemli-Ozcan, Ryder, and Weil (2000) show that 1 percent reduction in mortality leads to 1 percent increase in schooling. Meltzer (1992) argues that AIDS raises mortality of young adults, which is going to have the biggest effect on the rate of return

implications of these effects are higher population growth and lower economic growth.

3 Data

Figures 6a and 6b show a declining trend for the total fertility rates for the African countries during 1985−2000, using data from World Bank, World Development Indicators (2003). However these trends are much weaker in countries with high levels of HIV/AIDS prevalence. The 3 countries that are shown in figure 6a (Central African Republic, Namibia, and Uganda) have HIV prevalence rates among pregnant women that are higher than 20 percent and AIDS incidence that are higher than 30 per 100,000. Among these countries Namibia and Central African Republic have a flat fertility rate since 1992. The second set of countries that are shown in figure 6b, Benin, Comoros, Gambia and Madagascar, have fertility rates that are declining much more quickly. All of these countries have HIV prevalence rates among pregnant women that are less than 2 percent and AIDS incidence per 100,000 that are lower than 5. Although Namibia and Central African Republic had slightly lower levels of fertility, Uganda had a similar level of fertility to countries that are shown in figure 6b at the beginning of the sample.

The picture becomes even more dramatic if one uses data from the DHS, as shown in figures 6c, 6d, and 6e. Most micro economists and demographers would argue that the DHS is a more reliable source for the total fertility rate than data from the World Bank.[22] Each country's survey year falls in the category shown on the x-axis. Figure 6c shows that for the countries with high levels of HIV/AIDS prevalence, the total fertility rate is either flat since 1992 or increasing since 1997 with a clear uptick in the case of Kenya.[23] In fact Westoff and Cross (2006) analyzed this reversal in the fertility transition of Kenya in detail using data from the latest DHS surveys. They take various cuts of the data and show that the stall and the reversal of the fertility transition is not only

on educational investment. He claims for a 30 percent HIV positive population like Botswana, there would be a 6 percent reduction in the rate of return to education relative to no HIV/AIDS; 2) The HIV/AIDS epidemic affects the supply of education by compressing government and households budgets. See Cohen (2002) for an extensive analysis; 3) The epidemic will affect the firm-specific human capital. Engel (2002) shows that 1 percentage point raise in AIDS related mortality reduces the probability of the average 20-year-old worker being trained by 0.7 percentage points.

[22] In principle the World Bank data are based on DHS data, however World Bank data involve some extrapolations using different methods for the years in which the DHS surveys were not conducted. TFR data from the World Bank will be used at 3 and 5 year intervals in the panel analysis since those will be less affected by extrapolations.

[23] For Cote D'Ivoire the average AIDS incidence is 28 per 100,000 during 1985–2000; average HIV prevalence among pregnant women during 1985–2000 is 5.6 percent. For Kenya the average AIDS incidence is 26 per 100,000 during 1985–2000; average HIV prevalence among pregnant women during 1985–2000 is 10.3 percent. For Uganda the average AIDS incidence is 20 per 100,000 during 1985–2000; average HIV prevalence among pregnant women during 1985–2000 is 14.9 percent.

true in the aggregate but also can bee seen for different age groups, regions, ethnicities.[24] They also checked various background characteristics for women and still find the same result, where the increase in fertility is most pronounced for the least educated group of women. They find no change in the use of contraception. They conclude by hypothesizing this puzzling situation might be due to the increased child mortality via HIV/AIDS since they find a significant increase in the percentage of women who wants more children. They did not provide direct empirical evidence though on this channel, a task that is undertaken in this paper.

There is also an uptick for the countries with medium levels of HIV/AIDS prevalence, such as Nigeria and Mozambique, as shown in figure 6d.[25] The countries with low levels of HIV/AIDS prevalence had declining fertility rates as shown in figure 6e. Hence the survey data from DHS indicate the start of a reversal in the fertility transition.

Figures 7b and 7d show that enrollment rates increased throughout the sample period in the low HIV/AIDS countries, using data from World Bank, World Development Indicators (2003). However, for the high HIV/AIDS prevalence countries enrollment rates decreased or stayed constant, as shown in figures 7a and 7c.

The total fertility rate is the sum of age-specific fertility rates (number of children that a woman would have if she lived through all of her child-bearing years and experienced the current age-specific fertility rates at each age); it is an approximation for the average lifetime fertility of women. School enrollment rates are useful measures of participation in education, but they have serious limitations. According to the World Bank, school administrations may overstate rates due to financial incentives. Also, the length of primary education differs across countries. Overage and underage enrollments frequently occur or children's ages at enrollment can be misstated. Repetitions of grades is very common in developing countries, leading to a significant number of overage children enrolled in each grade, raising the enrollment ratio. If the ratio is over 100, this indicates discrepancies between the estimates of school age population and the reported enrollment data due to any or all of the above reasons. As a result, gross enrollment ratios provide an indication of the capacity of each level of the education system and a high ratio usually, but not always, indicates a successful education

[24] Note that the age-specific fertility data from Kenya clearly rules out the story that people marry early and have children at younger ages due to the epidemic leading an increase in the total fertility rate in the aggregate.

[25] For Mali the average AIDS incidence is 3.7 per 100,000 during 1985–2000; average HIV prevalence among pregnant women during 1985–2000 is 2.2 percent. For Mozambique the average AIDS incidence is 9.4 per 100,000 during 1985–2000; average HIV prevalence among pregnant women during 1985–2000 is 4.4 percent. For Niger the average AIDS incidence is 3.4 per 100,000 during 1985–2000; average HIV prevalence among pregnant women during 1985–2000 is 1.4 percent. For Nigeria the average AIDS incidence is 2.2 per 100,000 during 1985–2000; average HIV prevalence among pregnant women during 1985–2000 is 2.6 percent.

system.[26]

The data on AIDS come from UNAIDS/WHO, Epidemiological Fact Sheets (2003). These are the number of reported AIDS cases for each country in every year. I multiply the number of reported incidents by 100,000 and divide by the country's population in each year, to obtain incidence per 100,000 per country per year. According to UNAIDS, AIDS incidence reports come from surveillance systems of varying quality. Reporting rates vary substantially from country to country and low reporting rates are common in developing countries due to weaknesses in the health care and epidemiological systems. AIDS case reporting provides information on transmission patterns and levels of infection approximately 5-10 years in the past, limiting its usefulness for monitoring recent HIV infections. Despite these caveats, AIDS case reporting is useful in estimating the burden of HIV-related mortality, which is the focus of this paper.

The data on HIV prevalence rates among pregnant women are from the U.S. Census Bureau, HIV Surveillance Database (2003). UNAIDS/WHO also provides similar data. Both of these databases collect all studies and estimates of HIV/AIDS prevalence since the early 1980s. They provide information on prevalence, population and other factors and also provide regional estimates. The main indicator for the epidemic is the percent HIV-1 incidence among pregnant women for each country. In principle, it is available on an annual basis, though the data are missing in some years for some countries. I prefer to use the AIDS data for the general population in most of the analysis since the representativeness of the HIV rates for pregnant women for the general population is debatable.[27] As argued in Timberg (2006), HIV rates are overestimated since they are based on the assumption that the extent of the infection among pregnant women who attended prenatal clinics provided a rough proxy for the rate among all working-age adults in a country. In spite of these caveats, I still present results at the country level and at the regional level using the HIV data since these data are used by many researchers. One has to keep in mind that both the AIDS and the HIV data suffer from classical measurement error, which will create an attenuation bias regardless of the outcome variable.

[26]Note that although the net enrollment ratio excludes over-age students, it does not solve the problem completely since some children fall outside the official school age because of early or late entry rather than repetition.

[27]Also, since HIV is transmitted from mothers to infants, it is more likely that fertility and HIV among pregnant women might be simultaneously determined.

4 Empirical Analysis

Table 2 shows the mean, maximum, minimum, and standard deviation (across the 44 countries over 1985−2000) of the total fertility rate, gross primary school enrollment rate, and other independent variables. Fertility rates vary from 2.2 children to 7.6 children. Gross primary school enrollment rates show large variation with the enrollment rate being 5 times higher in the country with the highest enrollment rates than in the country with the lowest enrollment rates. For AIDS incidence, the most affected country has an incidence per 100,000 that is 15000 times higher than that of the least affected country. The difference in the HIV prevalence is 300 times. GDP per capita moves between 101.8 and 6246.4 dollars. The remaining variables also show extensive variation. In table 3, I display the correlation matrix between the regressors. The correlations are in general not so high that it precludes obtaining estimates of the separate impact of the regressors. The highest correlations for the regressors used together are between female and secondary school enrollment and GDP per capita (0.86, 0.83), and between female and secondary school enrollment and infant mortality (–0.71, –0.70). The negative correlation between AIDS and infant/child (age 5) mortality should be interpreted with caution since these correlations are based on averaged data over time and country. Contemporaneous correlations might be misleading since they mask the time lag. One needs to look at the correlation between past HIV infections and current levels of infant/adult mortality. The correlation between HIV/AIDS in 1985 and infant/child mortality in 2000 is in fact 30 percent.

4.1 Cross-Country Regressions: Fertility and AIDS

Theoretical models of the demand for fertility predict four empirical regularities: 1) increased education of women raises the cost of childbearing and reduces fertility; 2) reduced child mortality, assuming the demand for surviving children is price inelastic, is associated with a decline in fertility;[28] 3) increased income per capita increases demand for children if they are normal goods; 4) the net cost of child bearing is greater for parents in urban than in agricultural settings. Thus, I use proxies to control for these variables in a regression of total fertility rate on AIDS incidence. These determinants have been shown to be significant in the other empirical studies.

Table 4 reports Ordinary Least Squares (OLS) regressions of total fertility rate on AIDS inci-

[28]Notice that inelastic demand ceases to be a necessary condition once you introduce uncertainty about child survival into the model. See Kalemli-Ozcan (2003).

dence. The linear regressions are for the equation,

$$TFR_i = \alpha + \beta \log(AIDS_i) + \mathbf{X}_i' \gamma + \epsilon_i, \tag{1}$$

where TFR_i is the total fertility rate, $\log(AIDS_i)$ is the log of AIDS incidence per 100,000, $\mathbf{X}_i$ is a vector of other covariates, and ϵ_i is a random error term. The coefficient of interest is β, the effect of AIDS on fertility.

Table 4 uses the average values of dependent and independent variables over 1985−2000 and show that AIDS incidence is positively significant at 1 percent to 5 percent level depending on the specification.[29] AIDS incidence and GDP per capita are used in logs. Although using the log of AIDS incidence makes the quantitative interpretation harder, it has several econometric advantages such as dampening the outliers and making the estimated coefficient immune to the scale effect due to underreporting. The results are robust (stronger) to using the non-logged AIDS incidence. Secondary schooling for females is negative and significant and primary schooling is insignificant, while GDP per capita is positive and significant only when used with primary schooling due to the high correlation between GDP per capita and secondary schooling. Another important control is infant/child (age 5) mortality, which is positive and significant at 1 percent level. Column (2) shows similar results by using only the countries that are identified by the U.S. Census Bureau as having widespread generalized epidemics. As shown in column (3), using HIV prevalence among pregnant women instead of AIDS incidence does not alter the results. One can also use desired fertility instead of actual fertility as the dependent variable and receive similar results.[30]

To interpret the coefficient on AIDS incidence, I perform the following thought experiment: imagine going from the country with the lowest level of AIDS incidence (Madagascar) to the country with the highest level of AIDS incidence (Congo). This predicts an increase of 1.7 to 1.9 children per woman.[31] For a country like Botswana, where AIDS increased 3000 times from 1985 to 2000, a coefficient of 0.18 (0.20) implies an increase of 1.4 (1.5) births. Given the attenuation bias caused by the measurement error in AIDS incidence the actual effect is likely to be much larger.

[29] I use 7 years of data for TFR, namely, 1985, 1987, 1990, 1992, 1995, 1997, 2000. I matched the AIDS data to these years before averaging.

[30] Desired (wanted) fertility is available for 33 countries from DHS. Each country's survey year falls between 1987–2004. If there is more than 1 survey year the data is averaged. The correlation between desired fertility averaged over the survey years and actual fertility averaged over 1985–2000 is 89 percent. The coefficient (standard error) on log(AIDS) is 0.14 (0.06) and R^2 is 0.74 in the regression where desired fertility is on the left hand side. All other controls have similar coefficients and standard errors.

[31] The coefficient 0.18 predicts 1.7 extra children and the coefficient 0.20 predicts 1.9 extra children.

HIV/AIDS is related to sexual behavior and marriage markets, both of which are independently related to fertility. More generally, measuring the impact of HIV/AIDS epidemic on any outcome variable will be problematic given the omitted variable bias due to unobservable factors such as culture, prudence of the parents, and governments' response to the epidemic. These and similar factors can determine AIDS and fertility simultaneously. As shown in the next section, by employing a country fixed effects specification, I am able to control for the unobservable factors that are time-invariant such as religion, climate and culture. The time-varying variable that is most likely to create endogeneity problems is whether or not people are more careful and take less risks as a result of the epidemic. This will lead to lower fertility and a lower incidence of AIDS. Although this is a very controversial topic, as argued in the previous section the evidence so far from micro studies are such that there is no change in sexual behavior as a result of the epidemic. Even if we *assume* there is a decrease in risky sexual behavior and people start using more condoms (or abstaining) because of AIDS then fertility will decrease as a by-product. If this is the case then I should have found a negative relation between fertility and AIDS. Hence the results of this paper constitutes a lower limit for the effect of AIDS on fertility.[32]

There can also be an additional margin. In response to AIDS, members of a couple would have less unprotected extramarital sex, but more unprotected marital sex, which will raise fertility. Alternatively, because of the epidemic more people might decide to get married, which will also lead to higher fertility. Column (6) attempts to control for this to a certain extent by adding marital status. The data on the percent female (15-49) who are married at least 1 year prior to the survey year and still married are from DHS and only available for 30 countries.[33] The data are averaged over the survey years, which fall between 1987–2004 for these 30 countries. All the other variables, including the dependent variable, are the same as before. The variable percent married enters positively but not significantly. The coefficient on AIDS incidence declines but this is because of the reduction in sample size.[34] Hence AIDS is robust to this control. All other controls, such as

[32]If sexual behavior declines for some other reason than AIDS, then this will lead a positive association between fertility and AIDS since both will decline as a result. One cannot rule this out. However it is very unlikely that sexual behavior for a given country in Africa will change for some other reason. There can also be a feedback mechanism over the long run. If sexual behavior changes as a response to AIDS then over the long run this can feedback into AIDS since societies that lower their sexual activity will have less AIDS. I do not expect this effect to be present for the time period that this paper is concerned with. The feedback mechanism cannot be dominating the original response, that is the decline in sexual activity due to AIDS, especially because this is a response that is not supported by systematic micro evidence.

[33]Note that this data is not available from World Bank for more countries.

[34]The regressions with the same 30 countries that does not control for "percent married" yields a coefficient (standard error) of 0.12 (0.04).

population structure, male secondary schooling, urbanization, and adult mortality, turn out to be insignificant. AIDS, infant mortality, and female secondary schooling can explain 77 percent of the cross-country variation in total fertility rates.

I also use data on perceptions about the epidemic instead of the actual prevalence rates.[35] Table 5 reports the results. Women who heard of HIV/AIDS, or more importantly who know someone who died of AIDS, are the ones who should react most by changing their fertility behavior. As shown in columns (1)-(5) this is indeed the case. The data on the percent female between 15-49 who heard of HIV/AIDS and the percent female who know someone personally who has the virus that causes AIDS or has died of AIDS are both from DHS. They are averaged according to the available survey years. In spite of the limited number of countries there is a strong positive association between perceptions about the epidemic and the fertility behavior.[36] The variable "know someone who died of AIDS" can by itself explain 20 percent of the cross-country variation in the fertility behavior.[37] For columns (2)-(5), I use the other control variables one at a time due the fact that there are only 12 countries. The estimated coefficient of 0.02 implies that going from a country where 17 percent of people know someone who died of AIDS, such as South Africa, to a country where 90 percent of people know someone who died of AIDS, such as Uganda, predicts an increase of 1.5 children.

What about the issue of reverse causality? Given that the dependent variable here is fertility and not income I worry about this less. Nevertheless, table 6 reports results from regressions of total fertility rate in 2000 on the 1985 values of the explanatory variables. AIDS in 1985 is similar to an exogenous experiment. In 1985 all countries were different in their fertility rates. Then AIDS hit and affected them differently. Differences in population age structure and educational attainment might have affected the initial spread of the epidemic, and hence I control for these. Table 6 shows that AIDS incidence in 1985 and infant/child mortality in 1985 are important determinants of total fertility rate in 2000.[38] AIDS incidence is positively significant at 10 percent level, whereas infant mortality is positively significant at 1 percent level. Again, using HIV prevalence among

[35] Francis (2006) shows that having a relative with AIDS changed the sexual behavior, desire and the self-reported identity of homosexual man in the U.S.

[36] I have also tried interacting the perception variables with the actual prevalence rates. However due to the high correlation between the HIV/AIDS prevalence rates and the perception variables and also due to the fact that I have limited number of countries the results of those interaction regressions are weaker. The correlation between AIDS incidence (HIV prevalence) and the variable "heard of AIDS" is 63 (55) percent; the correlation between AIDS incidence (HIV prevalence) and the variable "know someone who died of AIDS" is 65 (61) percent.

[37] This is the partial R^2 since the R^2 from a regression with GDP per capita alone is 0.62.

[38] I obtain similar results when I use average fertility rate over 1985–2000 on the left hand side instead of the fertility rate in 2000.

pregnant women in 1985 does not alter the result, but rather strengthens it. The other right hand side variables, such as population structure, male secondary schooling, urbanization, and adult mortality, turn out to be insignificant. The last column of this table also investigates the role of contraception. The contraception data are available only for 27 countries in 2000. The main result does not change; AIDS incidence is still positive and significant. Contraception use is negative and significant at 10 percent level.[39] The results should be interpreted with caution, though. Some researchers have argued that contraception should be treated as endogenous since more than half of the effect of family planning on fertility operates through its impact on child mortality, which then leads to lower fertility.[40] Other studies found that family planning programs explain only 10 percent-40 percent of the decline in developing countries and the rest of the decline is explained by the changes in desired fertility, i.e., the number of children families want to have.[41]

The quantitative impact is still economically significant. Going from the country with the lowest level of AIDS incidence (Madagascar) to the country with the highest level of AIDS incidence (Congo) predicts an increase of 1.2 children. This effect is quite significant given the exogenous nature of AIDS in 1985 and the fact that the estimates are lower bounds given the attenuation bias.

Section 4.5 will perform instrumental variables regressions to investigate the endogeneity issue further.

4.2 Panel Regressions: Fertility and AIDS

Total fertility rates were falling in almost all the African countries before the HIV/AIDS epidemic.[42] The initial pattern of the fertility decline may not be similar among these countries. Demographers emphasize that a fertility transition begins at the point where fertility falls 10 percent below its peak. Once this happens, the pattern of the decline is similar in timing and magnitude in different countries.

To capture this phenomenon, I run a panel regression with country fixed effects and a time trend. Table 7 reports Ordinary Least Squares (OLS) and Weighted Least Squares (WLS) panel

[39] In a bivariate regression, log(AIDS) and contraceptive use have the following coefficients (standard errors): 0.11 (0.04) and -0.05 (0.001).

[40] See Schultz (1997).

[41] See Weil (2003) and Pritchett (1994), who shows that the relation between actual fertility and desired fertility among a cross-section of developing countries are very close and thus there is little scope for reducing fertility in many countries through better provision of contraceptives. As reported earlier the correlation between desired and actual fertility in my sample is 89 percent.

[42] Cohen (1998) shows that a widespread decline in fertility was underway across Africa in the early 1980s.

regressions of total fertility rate on AIDS incidence.[43] The linear regressions are for the equation,

$$TFR_{it} = \mu_i + \lambda TIME_t + \omega \log(AIDS_{it}) + \mathbf{X}'_{it}\theta + \varepsilon_{it}, \tag{2}$$

where TFR_{it} is the total fertility rate, μ_i is the country fixed effect, $TIME_t$ is the time trend, $\log(AIDS_{it})$ is the log of AIDS incidence per 100,000, $\mathbf{X}_{it}$ is a vector of other covariates, and ε_i is a random error term. The coefficient of interest is ω, the effect of AIDS on fertility. The country fixed effects are essential to control for the time-invariant unobservable factors. I also run a regression both with country and time fixed effects as shown below.

The time trend is significant and negative; it captures the declining trend of fertility in the absence of AIDS. Thus, while other factors contributed to the decline in fertility, AIDS has the opposite effect. AIDS incidence is positive and highly significant in all of the specifications. One thing to notice is that the specifications that are estimated without the country fixed effects (columns (1) and (5)) posit larger coefficients compared to the ones that are estimated with country fixed effects as shown in columns (3) and (7). This is because the regressions without country fixed effects exploit both the *within* and *between* variations whereas the country fixed effects regressions exploit only the *within* variation. In addition, panel regressions suffer more from attenuation bias caused by measurement error than cross-section regressions, where the bias might be dampened via averaging. Figure 8 plots the partial correlation plot based on column (3). The slope of the fitted line is 0.03 and it is evident from the figure that the positive effect of AIDS on the total fertility rate is not driven by outliers. Using HIV prevalence among pregnant women yields similar results for the specifications without the country fixed effects as shown in columns (2) and (6). But the results turn out to be negative and insignificant in the country fixed effects specifications (columns (4) and (8)). This implies that at the cross-country level, the AIDS and HIV variables are highly correlated and both have predicative power for the fertility behavior. However, when we restrict attention to within country variation, only the variable AIDS can predict the fertility rates.

The coefficient on the time trend implies a decline of 0.09 births per year on average. Cumulated over 1985 to 2000 this coefficient implies a total decline of 1.4 births. For the countries in my sample the increase in AIDS incidence varies from a doubling to an increase of 9000 times. If we use the mean increase of 120 times then a coefficient of 0.03 implies an increase of 0.2 births since 1985.

[43]The WLS is a 2-step estimation where all observations are weighted in the second step with the inverse of the estimated standard deviations from the first step. Weighting by country's population yields similar results.

The impact of infant/child mortality on fertility becomes insignificant in the country fixed effects framework.[44] Female schooling and GDP per capita are both highly significant with the expected signs. The coefficient on GDP per capita of -0.23 implies that a country that doubles its GDP per capita is going to have 0.16 less births on average. Again the change in GDP per capita from 1985 to 2000 varies between no change to a quadrupling in this sample of African countries. If we use the average change of 1.1 times, a coefficient of -0.23 implies 0.02 less births on average. The change in the female primary and secondary schooling from 1985 to 2000 varies between 65 percentage points to -25 percentage points, the mean being 7 percentage points. Thus the coefficient of -0.004 implies 0.01 fewer births as a result of the mean increase in female schooling during the sample period. As a result, based on column (7), the estimates multiplied by the changes from 1985 to 2000 in the conditioning variables lead to a predicted decline in fertility of 1.3. Fertility actually fell by 1.1 in this sample of countries between 1985 and 2000. Overall AIDS incidence slowed down the decline in fertility during the sample period and together with other variables it explains 78 percent of the variation in fertility rates. These results imply a potential reversal of the fertility transition in the coming decades.

Table 8 reports robustness results. Column (1) uses a full set of time dummies together with country fixed effects instead of a linear time trend yielding similar results. The response of the total fertility rate to the time trend may be non-linear and hence I use a quadratic and a cubic trend. The results are similar. Column (2) shows the quadratic trend, which is negative but insignificant. There may also be a non-linear relationship between AIDS and the time trend thus I interact the two, and this also turns out to be insignificant. The rest of the columns add different explanatory variables or use different samples. Column (3) uses countries with GDP per capita levels that are below the sample mean. Female schooling becomes insignificant in this sample. Experimenting with samples above the mean and below/above the median level GDP per capita gives similar results. AIDS is also robust to the addition of other control variables, such as urbanization, population age structure and adult mortality, all of which might have affected the initial spread of the epidemic but come in as insignificant. Male secondary schooling is significant with the expected sign. Column (8) uses all the available data, including the countries where the data on the schooling variables are missing, and column (9) omits South Africa, which might be atypical since due to the abolition of apartheid there are some discrete changes in the South Africa variables. Results are similar.

[44]This is a typical result out of the fixed effects estimation; See Schultz (1997).

4.3 Comparison to Young's (2005) Results

Using micro level data from South Africa, Young (2005) shows a negative effect of HIV prevalence on fertility. My country level data are consistent with Young (2005) findings. Figures 9 and 10 show macro times series data from South Africa. It is clear from figure 9 that the total fertility rate is falling in spite of the increase in the HIV/AIDS epidemic. Primary and secondary school enrollment rates are rising before 1990. Figure 10 plots the total fertility rate against AIDS incidence (top x-axis) and HIV prevalence among pregnant women (bottom x-axis) over time for South Africa. It seems that there is a weak negative relation between HIV/AIDS and the total fertility rate.

There can be several reasons why I find a positive relation between HIV/AIDS in a panel of African countries, whereas Young (2005) finds a negative relation within South Africa.

Is South Africa representative? The effect of HIV for South Africa may not apply to the rest of the Sub-Saharan Africa. In fact, as shown in figure 11, different countries show different time variation for the relationship between TFR and the epidemic. The demographics of HIV/AIDS might vary from country to country and time path of the epidemic also might vary from country to country. Hence we cannot generalize results based on 1 country or a limited set of countries. My analysis uses data for 44 Sub-Saharan African countries and might lead to more representative results.

Cohort-Specific Trends: Young's (2005) identification comes from variation in HIV exposure by age and cohort. He controls for secular effects of age and cohort using linear (and sometimes polynomial) trends in birth year, age and time, all of which will control for a smooth trend. In a country like South Africa one can imagine the existence of more complicated trends due to the abolition of apartheid, which is a discrete change. This type of cohort-specific trends may not be captured by Young's methods.

Spillovers between Cohorts: One important issue might be the effect of one cohort on another, which is not captured by Young (2005). Women of a given cohort have social interactions with people outside their cohort as well, such as with parents and siblings. For example, a young woman may have witnessed siblings' death from AIDS which might affect her own fertility choices.

Omitted Variables: Education affects fertility only through wages in Young's (2005) model. If there is a direct negative effect of education on fertility, then Young's (2005) estimates will be biased downwards.[45] Another omitted variable which might be important is urbanization. Before the

[45]The correlation between education and AIDS is positive as shown in table 3 and the partial correlation between female education and fertility is negative as shown in table 4.

abolition of apartheid only male migrants were allowed to go to urban areas. Since 1988, mobility has been free. So urbanization was not smooth over the last 30 years and it is plausible that this type of discrete change will affect cohort-specific trends (See Posel, 2003).[46] Still another omitted variable might be individual preferences, which might cause a negative bias if we are willing to accept that people who are more likely to have AIDS via extramarital unprotected sex are also less likely to want to have children. Overall, to the extent that macro data can control for these omitted variables, the estimate in this paper will be a lower bound for the effect of AIDS on total fertility rate. Given that I found a positive effect, it is more plausible that AIDS will cause an increase in the total fertility rate on average in Africa.

4.4 Panel Regressions: Human Capital Investment and AIDS

What is the effect of the HIV/AIDS epidemic on human capital investment? The answer to this question is as important as knowing the effect of the epidemic on the fertility behavior in order to investigate the total impact of HIV/AIDS on economic development. There are many channels through which AIDS may affect human capital investment. First and foremost, parents' fertility and human capital investment decisions are linked. Having more children as a result of AIDS implies parents move along a quality-quantity trade-off investing less in their education. This will in turn reduce the aggregate amount of human capital. Second, a high mortality environment can have a direct effect on educational investment in addition to the indirect effect that is related to the fertility decision. The reason for this is that higher mortality implies a lower rate of return to education. Both of these channels will cause a decrease in the demand for education. The HIV/AIDS epidemic also affects the supply of education by compressing government and household budgets. It is also possible that children become orphans, schools close down since the teachers die. As a result we should expect to find a negative effect of HIV/AIDS epidemic on educational investment. The answer to the question of which one of these is the most important channel for the effect of HIV/AIDS on aggregate human capital investment is beyond the scope of this study.

As argued in the data section, human capital investment had an increasing trend for most of the countries throughout the sample period. Thus, I run a panel regression with country fixed effects and a time trend, controlling for other potential determinants of human capital investment.[47] I

[46]The correlation between urbanization and AIDS is positive as shown in the table 3 and the partial correlation between urbanization and fertility is negative as shown in table 4.

[47]AIDS turns out to be insignificant in the cross-sectional regressions of human capital investment, whereas GDP per capita is highly positively significant. The insignificance of AIDS in the cross-section can be due to small number

also run a regression with both country and time fixed effects instead of a linear trend as shown below.

Table 9 reports Ordinary Least Squares (OLS) and Weighted Least Squares (WLS) regressions of gross primary school enrollment rates on AIDS incidence. The linear regressions are for the equation,

$$ENROLLMENT_{it} = \kappa_i + \tau TIME_t + \varphi \log(AIDS_{it}) + \mathbf{X}_{it}'\zeta + \eta_{it}, \tag{3}$$

where $ENROLLMENT_{it}$ is the gross primary school enrollment rate, κ_i is the country fixed effect, $TIME_t$ is a time trend, $\log(AIDS_{it})$ is the log of AIDS incidence per 100,000, $\mathbf{X}_{it}$ is a vector of other covariates, and η_{it} is a random error term. The coefficient of interest is φ, the effect of AIDS on educational investment.

The time trend is always positively significant and it captures the rising trend of the primary school enrollment rates in the absence of AIDS. AIDS per capita though, is highly negatively and significant in all of the specifications, with similar sized point estimates. Using HIV prevalence instead of AIDS incidence does not change the results. Figure 12 plots the partial correlation plot that corresponds to column (5). The slope of the fitted line is −3.93. It is evident that the significant negative relation between AIDS incidence and enrollment rates is not driven by outliers.

According to the estimated time trend, each country has an increase of 2.2 percentage points in the enrollment rates every year, implying an almost 36 percentage points increase over the sample. For a country where AIDS doubles, on the other hand, the enrollment rates are going to decline 3 percentage points.[48] Using the average increase of AIDS incidence of 120 times over the sample period in Africa, a coefficient of −3.93 (–4.25) implies a 18 (20) percentage points decrease in human capital investment. For a country like Botswana, that experienced an increase in AIDS of 3000 times, the estimated coefficient of –3.93 (–4.25) implies a decrease in enrollment of 30 (34) percentage points. Alternatively going from the country with the lowest level of AIDS incidence (Madagascar) to the country with the highest level of AIDS incidence (Congo) predicts a decline in the enrollment rates of 38 percentage points.

The impact of the other variables are again in line with the existing empirical literature. A country that doubles its GDP per capita is going to have 18 percentage points more enrollment in

of countries and limited variation in the human capital investment variables across countries.

[48]This result might be comparable to Bleakley (2003) to a certain extent. He finds that an infection rate of hookworm of 50 percent as opposed to 0 percent leads to decline in the school enrollment rate of 5 percentage points. One should keep in mind that hookworm is a disease that affects children's health directly and hence the school enrollment, whereas in the case of AIDS there might be various direct and indirect channels.

the primary school. Using the mean increase of 1.1 times in GDP per capita, we have an increase of 2.5 percentage points in the enrollment rates. A decline in infant mortality from 150 to 50 thousand live births is associated with an increase in the enrollment rates of 92 percentage points. However the average decline in infant mortality is 10 more live births implying a 9.2 percentage points increase in the enrollment rates. Adding these together, column (5) implies an increase of 15.7 percentage points in primary school enrollment rates over the sample period on average. The actual change is 16 percentage points.

Table 10 performs the same type of sensitivity analysis as in table 8. Including a full set of time dummies instead of a linear time trend does not change the results. Quadratic trend, urbanization, adult mortality and population age structure turn out to be insignificant. Restricting sample to the relatively poor countries only also does not make a difference. Infant mortality also becomes insignificant when I use the secondary school enrollment rate as a dependent variable as shown in column (7). This regression that uses secondary school enrollment as the dependent variable also posits much lower R^2.

4.5 IV Regressions

As discussed in detail in section 4.1, endogeneity can be an issue given the potential country-specific omitted variables and reverse causality. So far, I show that the results are robust to a country fixed effects specification and also using initial values (1985) of the independent variables on the right hand side. Nevertheless, this section presents the results from instrumental variables regressions for robustness. One caveat is that the sample size is reduced in most of the specifications due to the limited availability of data for the instruments.

Table 11 reports the results from various 2SLS specifications. Column (1) instruments average AIDS incidence over 1985–2000 with the circumcision rate—the percent of male between ages 15–59 who are circumcised— in the cross-country fertility regression.[49] The data is from Werker et al. (2006).[50] They use the same instrument for HIV/AIDS in a cross-country growth regression.[51]

[49]Using HIV instead of AIDS yields similar results.

[50]Werker et al. (2006) assemble national circumcision rates for African nations using data from various sources and by matching ethnographic practices at the tribal level with the demographic breakdowns of countries by tribe. For their first stage regression, they regress percent of adults living with HIV/AIDS in 1997 on the national circumcision rates and controls. They report a coefficient (standard error) of –15.52 (2.51) and an R^2 of 0.57. They interpret the coefficient as follows: going from a totally uncircumcised country to a totaly circumcised country predicts a decrease in the infection rate of HIV/AIDS by over 15 percentage points. See Werker et al. (2006) for details.

[51]Note that circumcision rates will be a bad instrument if the cultural practices change over time as a response to AIDS. For my purposes they should be fine given the fact that I use the rates when the epidemic began.

Note that we have 40 countries instead of our base sample of 41 since there is no circumcision data for Mauritius. Hence we need to compare the IV regression that is reported in column (1) to the corresponding OLS regression with 40 countries, which delivers a coefficient (standard error) of 0.12 (0.06) on log of average AIDS incidence. The coefficient on column (1) is positive and significant although the significance level is a little lower. Notice that the coefficient is higher than 0.12, due to the fact that the IV regression corrects for the measurement error which leads to attenuation bias in the OLS regression.[52] To interpret the coefficient of 0.13, I perform the same thought experiment as before: going from the country with the lowest level of AIDS incidence (Madagascar) to the country with the highest level of AIDS incidence (Congo) predicts an increase of 1.3 children per woman. This is a little lower than the effect estimated from the OLS regression that uses average AIDS incidence but higher than the ones that are estimated from the OLS regression using the initial (1985) values of AIDS incidence and HIV prevalence. The reason is that the attenuation bias is stronger with a single year of data.

Column (2) uses 2 instruments, "STD" and "premarital." "STD" is the percent of female between ages 15–49 who has a sexually transmitted disease and not treated. This variable is averaged over 1995–2005 depending on the survey year. "Premarital" is the percent of female between ages 15–29 who has premarital sex. This variable is averaged over 1985–2005 again depending on the survey year. Both of these data are from DHS. Oster (2005) shows that sexually transmitted infections are the main reason why African nations have much higher infection rates compared to the U.S. Hence I use STD rate as an instrument together with the premarital sex rate that is supposed to capture sexual habits. However these data are only available for 17 countries.

The time series dimension of the instruments are extremely limited due the fact that these variables come from DHS surveys and both questions were not asked at the surveys that are undertaken in the earlier years.[53] Nevertheless we can group the premarital sex variable for 1985, 1995, 2005 given the survey years around these years. Column (3) shows 2SLS results for 21 countries and 3 years, where I have used the premarital sex variable as an instrument, in a panel regression with country fixed effects. The coefficient on log AIDS incidence is positive and significant although the significance level is slightly lower when compared to the OLS panel regressions. One should interpret these results with caution, though, since now I have 63 observations instead of 228.

[52]The corresponding first stage regression of log AIDS incidence on the circumcision rate delivers a coefficient of –0.60 (0.17) for the circumcision rate and an R^2 of 0.31. All other controls turn out to be insignificant in the first stage regression.

[53]Circumcision rates are not available on a time series dimension.

In fact the corresponding OLS panel regression with 63 observations shows that only the time trend variable is significant. This might be due to low number of observations and/or the attenuation bias.[54] Finally the last column, presents the 2SLS results for the human capital investment in a panel regression framework. In general the results are similar to the ones reported from the OLS panel regressions but the coefficient is higher in the 2SLS. The corresponding OLS panel regression with 63 observations shows that only the time trend variable is significant, which might again be due to limited number of observations and/or attenuation bias. Overall, the IV results provide support that the HIV/AIDS epidemic causes fertility to increase in Africa over the last 15 years.

4.6 Regional Evidence

This section provides additional supporting evidence for the positive effect of the epidemic on fertility using regional data on fertility and HIV from the African countries where the data are available. I have data on 41 regions from 8 countries.[55] These are the regions with overlapping data on total fertility rates and HIV prevalence rates. Regional total fertility rates are from DHS. Regional HIV prevalence rates among pregnant women come from the U.S. Census Bureau, HIV Surveillance Database (2003). Each country's survey year falls between 1998–2004. If there is more than 1 survey year during this period, than the data on the total fertility rate is averaged. I regress the regional total fertility rates averaged over 1998–2004 on the logarithm of regional HIV prevalence rates among pregnant women averaged over 1985–1990, with and without country dummies.

Table 12 shows the results. Columns (2) and (4) are estimated by weighted OLS. In order to limit the influence of small regions, the data used in these columns are weighted by the logarithm of regional population from DHS, averaged over the survey years.[56] All specifications show a positive significant effect (at 1 percent level) of HIV prevalence on fertility. When country dummies are not included, I obtain a larger coefficient, 0.40, compared to 0.28, which is obtained from the regression with country dummies.[57]

The quantitative impact is large and significant and similar to the country regressions. Going

[54] The corresponding first stage regression of log AIDS incidence on premarital sex variable delivers a coefficient of 1.91 (0.50) for the premarital sex variable and an R^2 of 0.76. All other controls are insignificant except the time trend in the first stage regression.

[55] See the data appendix for the regions.

[56] Note that this is similar to the "Weighted LS" panel regressions using country level data.

[57] Note that the results shown in columns (3) and (4) include only the dummies that are significant. If I include all the 7 country dummies then I get a coefficient of 0.28 with a t-stat of 1.9.

from the region with the lowest level of HIV (Western Cape Province of South Africa) to the region with the highest level of HIV (Manicaland region of Zimbabwe), implies 1.7 to 2.5 more births per woman. These effects are very dramatic given the attenuation bias and the fact that columns (3)-(4) control for country effects. Overall regional results provide strong evidence for the positive effect of the epidemic on fertility.[58]

5 Conclusion

This paper presents empirical evidence on a specific mechanism through which the demographic transition affects economic growth. Using a panel of African countries from 1985 to 2000, I show that the HIV/AIDS prevalence affects total fertility rates positively and school enrollment rates negatively. These patterns are consistent with theoretical models that argue that a precautionary demand for children exists in the face of low probabilities of child survival. Parents, who are faced with a high mortality environment for young adults due to HIV/AIDS, choose to have more children and provide each of them with less education, leading to a reversal in the fertility transition and a reduction in the aggregate amount of human capital investment. Thus the paper also provides evidence on the quality-quantity trade-off mechanism.

Overall the impact of the HIV/AIDS epidemic on fertility and educational investment is statistically and economically significant and robust. The empirical estimates predict that, ceteris paribus, a country with a high level of HIV/AIDS prevalence such as Congo have 2 more children per woman and 38 percentage points less school enrollment compared to a country with a low level of HIV/AIDS prevalence such as Madagascar. The IV regressions show that this effect is causal. The results imply that in the coming decades AIDS can cause a reversal in the fertility transition and a substantial decrease in human capital investment, implying a tremendous negative effect on economic development. In fact the latest survey data from countries such as Kenya and Uganda show a reversal in the fertility transition, which is interpreted as puzzling by the policy circles.

[58] Additional supporting evidence that shows a positive relation between the forecast error, which is the difference between the actual TFR in 2000 and the projected TFR for 2000, and the HIV/AIDS prevalence is also available at Kalemli-Ozcan (2005).

Data Appendix

Countries: Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo Democratic Republic, Congo Republic, Cote D'Ivoire, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe.

- *AIDS*: The AIDS data come from UNAIDS/WHO, Epidemiological Fact Sheets (2003). These are the number of reported AIDS cases for each country in every year and available for 44 African countries for 1985−2000. I multiply these number of reported incidents by 100,000 and divide by the country's population in each year, converting them to incidence per 100,000 per country per year. WHO-UNAIDS definition of AIDS (Acquired Immunodeficiency Syndrome) is that AIDS is the most severe manifestation of infection with the HIV (human immunodeficiency virus). The Centers for Disease Control and Prevention (CDC) lists numerous opportunistic infections and neoplasms (cancers) that, in the presence of HIV infection, constitute an AIDS diagnosis. There are also instances of presumptive diagnoses when a person's HIV status is unknown or not sought. This was especially true before 1985 when there was no HIV-antibody test. In 1993, CDC expanded the criteria for an AIDS diagnosis to include CD4+ T-cell count at or below 200 cells per microlitre in the presence of HIV infection. In persons (aged 5 and older) with normally functioning immune systems, CD4+ T-cell counts usually range from 500 to 1500 cells per microlitre. Persons living with AIDS often have infections of the lungs, brain, eyes and other organs, and frequently suffer debilitating weight loss, diarrhoea, and a type of cancer called Kaposi's sarcoma.

- *Circumcision*: The data on the circumcision rates are from Werker et al. (2006). The data are on the percent of males between ages 15–59 who are circumcised and available for 40 countries. Werker et al. (2006) assemble national circumcision rates for African nations using data from various sources and by matching ethnographic practices at the tribal level with the demographic breakdowns of countries by tribe.

- *HIV*: The HIV data come from U.S. Census Bureau, HIV Surveillance Database (2003) and available for 44 African countries for 1985−2000. This is the percent HIV-1 incidence among pregnant women for each country and year. HIV is the retrovirus isolated and recognized as the etiologic (i.e. causing or contributing to the cause of a disease) agent of AIDS. HIV-1 is classified as a lentivirus in a subgroup of retroviruses. Most viruses and all bacteria, plants, and animals have genetic codes made up of DNA, which uses RNA to build specific proteins. The genetic material of a retrovirus such as HIV is the RNA itself. HIV inserts its own RNA into the host cell's DNA, preventing the host cell from carrying out its natural functions and turning it into an HIV factory. HIV-2 is a virus closely related to HIV-1 that has also been found to cause AIDS. It was first isolated in West Africa. Although HIV-1 and HIV-2 are similar in their viral structure, modes of transmission, and resulting opportunistic infections, they have differed in their geographical patterns of infection.

- *Enrollment Rates*: School enrollment rates are from World Bank, Word Development Indicators (2003). They are available for 42 countries and 6 years (1985, 1990, 1992, 1995, 1997, 2000).

- *Heard of AIDS*: The data are on the percent female between 15-49 who heard of HIV/AIDS are from DHS, www.measuredhs.com, MEASURE DHS, Macro International Inc. The data are available for 33 countries whose survey years fall between 1988–2004. If there is more than 1 survey year then the data are averaged.

- *GDP per capita*: GDP per capita (PPP 1995 $s) is from World Bank, World Development Indicators (2003) and available for 44 countries for 1985–2000.

- *Infant Mortality, Age 5 Mortality, Adult Mortality*: Infant mortality, age 5 mortality, adult mortality are the rates per 1000 births ad per 1000 adults and from World Bank, World Development Indicators (2003). The data are available for 44 countries and 7 years (1985, 1987, 1990, 1992, 1995, 1997, 2000).

- *Know Someone Died of AIDS*: The data on the percent female who know someone personally who has the virus that causes AIDS or has died of AIDS are from DHS, www.measuredhs.com, MEASURE DHS, Macro International Inc. The data are available for 12 countries whose survey years fall between 1993–2003. If there is more than 1 survey year then the data are averaged.

- *Population*: Population is from World Bank, World Development Indicators (2003) and available for 44 countries for 1960–2000.

- *Premarital Sex*: The data on the percent of female between ages 15–29 who has premarital sex are from DHS, www.measuredhs.com, MEASURE DHS, Macro International Inc. The data are available for 21 countries whose survey years fall between 1988–2004. The data can be grouped around 3 survey years: 1985, 1995, 2004.

- *STD*: The data on the percent of female between ages 15–49 who has a sexually transmitted disease and not treated are from DHS, www.measuredhs.com, MEASURE DHS, Macro International Inc. The data are available for 21 countries whose survey years fall between 1995–2004. If there is more than 1 survey year then the data are averaged. Specifically it is the percentage of women reporting an sexually transmitted infection (STI) or symptoms of an STI 12 months preceding the survey, who did not receive any advice or treatment. Symptoms of an STI are an abnormal genital discharge, a genital sore or a genital ulcer.

- *Total Fertility Rate*: The data on total fertility rate are from World Development Indicators, WB (2003) and available for 44 countries and 7 years (1985, 1987, 1990, 1992, 1995, 1997, 2000).

- *Urbanization*: Urbanization is the percent of urban population in total population and from World Bank, World Development Indicators (2003). Available for 44 countries and for 1960–2000.

Regions:

Ethiopia: Addis Ababa, Dire Dawa, Gambella, Harari.

Ghana: Accra, Northern region, Upper East region, Upper West region.

Lesotho: Maseru, Leribe district, Mafeteng district, Quthing district, Mokhotlong.

Malawi: Lilongwe, Blantyre, Mangochi, Mulanje, Mzimba, Thyolo.

Nigeria: North East zone, North West zone, South East zone, South West zone.

South Africa: Eastern Cape Province, Free State Province, Gauteng Province, Mpumalanga Province, Northern Cape Province, Northern Province, North-West Province, Western Cape Province.

Tanzania: Dar es Salaam, Rukwa region, Arusha region, Zanzibar area.

Zimbabwe: Harare, Bulawayo, Manicaland, Masvingo, Mashonaland West Province, Matabeleland South.

References

Acemoglu, Daron and Simon Johnson, "Disease and Development: The Effect of Life Expectancy on Economic Growth," MIT, mimeo (2005).

Ainsworth, Martha and Mead Over, "AIDS and African Development," *World Bank Research Observer* 9 (1995), 203–241.

Allen, S., Serufilira, V., Gruber, S., Kegeles, P., Van de Perre, M., Carael , and T.J. Coates, "Pregnancy and Contraception Use among Urban Rwandan Women after HIV Testing and Counseling," *American Journal of Public Health* 83 (5) (1993), 705–710.

Biswalo, P. M., and G. T. Lie, "Hospital-Based Counselling of HIV-infected people and AIDS patients," In: (eds.) K. I. Klepp, P. M. Biswalo, and A. Talle, *Young People at Risk: Fighting AIDS in Northern Tanzania*, Oslo, Scandinavian University Press (1995).

Bell Clive, Devarajan Shantayanan, and Hans Gersbach, "The long-run economic costs of AIDS: theory and application to South Africa," June draft. University of Heidelberg, World Bank (2003).

Bleakley, Hoyt, "Disease and Development: Evidence from the American South," *Journal of the European Economic Association* 1 (2003), 376–86.

Bloom, David and Ajay Mahal, "Does the AIDS Epidemic threaten Economic Growth" *Journal of Econometrics* 77 (1997), 105–124.

Bloom, Shelah, Charles Banda, Gloria Songolo, Samantha Mulendema, Amy Cunningham, and J. Ties Boerma, "Looking for Change in Response to the AIDS Epidemic: Trends in AIDS Knowledge and Sexual Behavior in Zambia, 1990 through 1998," *Journal of Acquired Immune Deficiency Syndrome* XXV (2000), 77–85.

Bonnel, Rene, "HIV/AIDS: Does it Increase or Decrease Growth in Africa?" World Bank, mimeo (2000).

Boldrin, Michele and Larry E. Jones, "Mortality, Fertility, and Saving in a Malthusian Economy," *Review of Economic Dynamics* 5 (4) (2002), 775–814.

Botswana Sentinel Survey, (2001).

Chakraborty, Shankha, "Endogenous Lifetime and Economic Growth," *Journal of Economic Theory* 116 (2004), 34–67.

Cohen, Barney, "The Emerging Fertility Transition in Sub-Saharan Africa," *World Development* 26 (1998), 1431–1461.

Cohen, Desmond, "Human Capital and the HIV Epidemic in Sub-Saharan Africa," World Bank (2002).

Corrigan, Paul, Gerhard Gloom, and Fabio Mendez, "AIDS Crisis and Growth," *Journal of Development Economics* forthcoming (2005).

Doepke, Matthias, "Child Mortality and Fertility Decline: Does the Barro-Becker Model Fit the Facts?" *Journal of Population Economics* 18–2 (2005), 337–366.

Economist, "The Shower Method, " April 22 (2006).

Ehrlich, Isaac, and Francis T. Lui, "Intergenerational Trade, Longevity, Intrafamily Transfers and Economic Growth," *Journal of Political Economy* 99 (1991), 1029–1059.

Engel, Rozlyn Coleman, "Life, Death, and Human Capital: HIV/AIDS and On-the-Job Training in Sub-Saharan Africa," Columbia University, mimeo (2002).

Feeney, Griffith, "The Impact of HIV/AIDS on Adult Mortality in Zimbabwe," *Population and Development Review* 27–4 (2001), 771–780.

Ferreira, Pedro C., and Samuel D. Pessoa, "The Long-Run Economic Impact of AIDS," SSRN Working Paper, (2003).

Francis, Andrew, M., "The Economics of Sexuality: The Effect of HIV/AIDS on Homosexual Behavior, Desire, and Identity in the United States," University of Chicago, mimeo, (2006).

Green, G., "The reproductive careers of a cohort of men and women following an HIV-positive diagnosis," *Journal of Biosocial Sciences* 26–3 (1994), 409–415.

Haacker, Markus, "The Economic Consequences of HIV/AIDS in South Africa," IMF Working Paper, (2002).

Higgins, D. L., C. Galavotti, K. R. O'Reilly, D. J. Schnell, M. Moore, D. L. Rugg and R. Johnson, "Evidence for the effects of HIV antibody counselling and testing on risk behaviors," *Journal of the American Medical Association* 26617 (1991), 2419–2429.

Kalemli-Ozcan, Sebnem, "A Stochastic Model of Mortality, Fertility and Human Capital Investment," *Journal of Development Economics* 62 (2003).

Kalemli-Ozcan, Sebnem, "Does Mortality Decline Promote Economic Growth?" *Journal of Economic Growth* 7 (2002).

Kalemli-Ozcan, Sebnem, Harl Ryder, and David N. Weil, "Mortality Decline, Human Capital Investment and Economic Growth," *Journal of Development Economics* 62 (2000).

Kalemli-Ozcan, Sebnem, "AIDS, Reversal of the Demographic Transition and Economic Development: Evidence from Africa," CDRLL Working Paper, Stanford University, May (2005), http://www.stanford.edu/ wacziarg/demogworkshop.html.

Kremer, Michael, "Integrating Behavioral Choice into Epidemiological Models of the AIDS Epidemic, " *Quarterly Journal of Economics* 111–2 (1996), 549–573.

Luke, Nancy and Kaivan Munshi, "New Roles for Marriage in Urban Africa: Sexual Activity and Labor Market Outcomes in Kisumu", Brown University, mimeo (2004).

Lorentzen, Peter, John McMillan, and Romain Wacziarg, "Death and Development," Stanford University, mimeo (2004).

Meltzer, David, "Mortality Decline, the Demographic Transition and Economic Growth," Ph.D Dissertation, University of Chicago (1992).

Mwaluko, Gabriel, Mark Urassa, Raphael Isingo, Basia Zaba, and J. Ties Boerma, "Trends in HIV and Sexual Behavior in a Longitudinal Study in a Rural Population in Tanzania, 1994–2000," *AIDS* XVII (2003), 2645–2651.

Oster, Emily, "Sexually Transmitted Infections, Sexual Behavior, and the HIV/AIDS Epidemic, " *Quarterly Journal of Economics* May (2005), 467–514.

Over, Mead, "The Macroeconomic Impact of AIDS in Sub-Saharan Africa", World Bank Working Paper (1992).

Papageorgiou, Chris and Petia Stoytcheva "What Do We Know About the Impact of AIDS on Cross-Country Income So Far?," LSU, mimeo (2004).

Posel, Dorrit "Have Migration Patterns in post-Apartheid South Africa Changed?" University of Natal, mimeo (2003).

Pritchett, Lant H., "Desired Fertility and the Impact of Population Policies," *Population and Development Review* 1 (1994).

Sah, K. Raaj, "The Effects of Child Mortality Changes on Fertility Choice and Parental Welfare," *Journal of Political Economy* 99 (1991), 582–606.

Schultz, T. Paul, "Demand for Children in Low Income Countries." In Mark R. Rosenzweig and Oded Stark (eds), *Handbook of Population and Family Economics*, (1997) Amsterdam: Elsevier Science.

Setel. Philip, "The Effects of HIV and AIDS on Fertility in East and Central Africa," *Health Transition Review* 5 (1995), 179–189.

Soares, Rodrigo, "Mortality Reductions, Educational Attainment, and Fertility Choice," *American Economic Review* forthcoming (2004).

Temmerman, M. S. Moses, D. Kiragu, S. Fusallah, I. A. Wamola, and P. Piot, "Impact of single session post-partum counselling of HIV infected women on their subsequent reproductive behavior," *AIDS* 2 (1990), 247–252.

Timberg, Craig, "How AIDS in Africa Was Overstated," Washington Post, April 6 (2006).

Thornton, Rebecca, "The Demand for and Impact of Learning HIV Status: Evidence from a Field Experiment," Harvard University, mimeo (2006).

United Nations Population Division, *Population Prospects, (2003).*

UNAIDS/WHO, *Global Report (2000).*

UNAIDS/WHO, *Global Report (2004).*

UNAIDS/WHO, *Global Report (2006).*

UNAIDS/WHO, *Epidemiological Fact Sheets (2003).*

U.S. Census Bureau, *HIV Surveillance DataBase (2003).*

UNAIDS Reference Group on Estimates, Modelling and Projections, "Improved methods and assumptions for estimation of the HIV/AIDS epidemic and its impact," *AIDS* (2002), W1-W14.

Wehrwein, Peter, "The Economic Impact of AIDS in Africa," *Harvard AIDS Review* Fall 1999/Winter 2000.

Weil, David N., *Economic Growth* (2003), Addison-Wesley.

Werker, Eric, Amrita Ahuja, and Brian Wendell, "Male Circumcision and the Economic Impact of AIDS in Africa, " Harvard Business School, mimeo (2006).

Westoff, Charles, and Anne Cross, "The Stall in the Fertility Transition in Kenya," DHS Analytical Studies No. 9, (2006).

Williams, Brian, Dirk Taljaard, Catherine Campbell, Eleanor Gouws, Lewis Ndhlovu, Johannes Van Dam, Michael Carael, and Bertran Auvert, "Changing Patterns of Knowledge, Reported Behavior and Sexually Transmitted Infections in a South African Gold Mining Community," *AIDS* XVII (2003), 2099–2107.

World Bank, *World Development Indicators (2003).*

Young, Alwyn, "The Gift of the Dying: The Tragedy of AIDS and the Welfare of Future African Generations," *Quarterly Journal of Economics* (2005), 423–466.

Young, Alwyn, "In Sorrow to Bring Forth Children: Fertility Amidst the Plaque of HIV, " University of Chicago, October, mimeo (2005b).

Table 1: HIV Testing Statistics, 1988–2004

	Female Population requesting a HIV test, receiving a test, and receiving test results	Female Population receiving a test	Female Population receiving test results	Pregnant women counseled for HIV during ANC visit	Pregnant women tested for HIV during ANC visit
Botswana	9				
Burundi	2				
Cameroon	18	21	5	36	9
Cote d'Ivoire	5				
Gambia	6				
Guinea-Bissau	4	15	7		
Kenya	8.5			29	3
Lesotho	9				
Mozambique	3	4	2	51	1
Niger	1				
Nigeria	4	7	3	24	1
Senegal	3				
Sierra Leone	2				
Togo	3				
Zambia	8			43	22

Notes: Data are in percent from DHS, www.measuredhs.com, MEASURE DHS, Macro International Inc. The data for Gambia, Guinea-Bissau, and Sierra Leone are from Multi Indicator Cluster Surveys (MICS) for 2000. Other country's DHS survey years fall between 1988–2004. ANC stands for antenatal clinic.

Table 2: **Descriptive Statistics**

	Mean	Std.dev.	Max	Min
Average Total Fertility Rate, 1985–2000	5.8	1.1	7.6	2.2
Average Primary School Enrollment, 1985–2000 (%)	160.1	56.8	281.6	58.8
Average Secondary School Enrollment, 1985–2000 (%)	49.5	36.9	169.5	10.0
Average AIDS Incidence, 1985–2000 (per 100, 000)	25.6	47.4	298.0	0.02
Average HIV Prevalence, 1985–2000 (%)	6.9	6.3	25.7	0.09
Average GDP per capita, 1985–2000 (PPP 1995 $s)	860.8	1317.4	6246.4	101.8
Average Urban Population, 1985–2000 (%)	31.5	14.2	70.9	5.5
Average Population over 65, 1985–2000 (%)	3.2	0.7	6.0	2.2
Average Infant Mortality, 1985–2000 (per 1000)	103.2	37.3	184.0	15.2
Average Mortality Under 5, 1985–2000 (per 1000)	165.1	65.2	321.4	18.7
Average Adult Mortality, 1985–2000 (per 1000)	465	78.8	579.7	236.7
Average Primary School for Female, 1985–2000 (%)	73.4	31.6	140.7	22.1
Average Secondary School for Female, 1985–2000 (%)	21.6	20.1	90.8	3.2
Average Secondary School for Male, 1985–2000 (%)	28	17.5	78.8	5.7

Notes: All variables are averaged over 1985−2000. Data are for 44 countries and 7 years. Total Fertility Rate is the sum of age-specific fertility rates (number of children that a woman would have if she lived through all of her child-bearing years and experienced the current age-specific fertility rates at each age). Enrollment Rates are the gross primary and secondary school enrollment rates. (Schooling variables for female and male are also gross enrollment rates). AIDS Incidence is the number of reported AIDS cases per 100, 000. HIV Prevalence is the percent HIV-1 incidence among pregnant women. GDP per capita is the Gross Domestic Product (PPP 1995 $) divided by population. Urban Population is the percent of urban population in total population. Population over 65 is the percent of the population who is 65 years or older in total population. Infant Mortality is the infant mortality rate per 1000 births. Mortality under 5 is the age 5 and under mortality per 1000 live births. Adult mortality is the mortality rate per 1000 adults.

Table 3: **Correlation Matrix**

	Log AIDS	Log HIV	Log GDP	Urban Pop.	Pop. over 65	Infant Mort.	Age 5 Mort.	Adult Mort.	Female Prim. School	Female Sec. School	Male Sec. School
Log AIDS	1.00										
Log HIV	0.76	1.00									
Log GDP	0.16	-0.04	1.00								
Urban	0.01	-0.15	0.59	1.00							
Pop65	-0.07	-0.22	0.50	0.47	1.00						
Infant	-0.18	0.04	-0.63	-0.30	-0.34	1.00					
Age 5	-0.18	0.04	-0.66	-0.33	-0.34	0.98	1.00				
Adult	0.43	0.59	-0.25	-0.43	-0.38	0.42	0.44	1.00			
Female Prim.	0.31	0.14	0.69	0.34	0.32	-0.66	-0.68	-0.06	1.00		
Female Sec.	0.19	0.07	0.85	0.49	0.38	-0.71	-0.75	-0.24	0.78	1.00	
Male Sec.	0.22	0.05	0.83	0.62	0.39	-0.70	-0.73	-0.35	0.73	0.93	1.00

Notes: See table 2 for the definitions of the variables.

Table 4: Fertility in a Cross-Section of Countries

Dependent variable is Average Total Fertility Rate, 1985–2000

	Base Sample (1)	Wide-Spread Epidemic (2)	Base Sample (3)	Base Sample (4)	Base Sample (5)	Available Sample (6)	Base Sample (7)	Base Sample (8)	Base Sample (9)	Base Sample (10)
Log Avg. AIDS	0.18	0.21	–	0.20	0.18	0.11	0.18	0.18	0.18	0.20
Incid., 1985–2000	(0.06)	(0.08)	–	(0.07)	(0.06)	(0.04)	(0.06)	(0.06)	(0.06)	(0.06)
Log Avg. HIV	–	–	0.18	–	–	–	–	–	–	–
Prev., 1985–2000	–	–	(0.07)	–	–	–	–	–	–	–
Avg. Female Sec.	–0.02	–0.02	–0.02	–	–0.02	–0.02	–0.02	–0.02	–0.02	–0.02
School, 1985–2000	(0.008)	(0.008)	(0.008)	–	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
Avg. Female Prim.	–	–	–	–0.01	–	–	–	–	–	–
School, 1985–2000	–	–	–	(0.01)	–	–	–	–	–	–
Log Avg. GDP	–0.17	–0.15	–0.07	–0.34	–0.16	–0.10	–0.14	–0.18	–0.10	–0.18
p.c., 1985–2000	(0.13)	(0.14)	(0.14)	(0.12)	(0.13)	(0.13)	(0.14)	(0.18)	(0.10)	(0.17)
Avg. Infant	0.01	0.01	0.01	0.02	–	0.01	0.01	0.01	0.01	0.01
Mort., 1985–2000	(0.003)	(0.003)	(0.003)	(0.004)	–	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Avg. Age 5	–	–	–	–	0.01	–	–	–	–	–
Mort., 1985–2000	–	–	–	–	(0.002)	–	–	–	–	–
Avg. % Married,	–	–	–	–	–	0.008	–	–	–	–
1987–2004	–	–	–	–	–	(0.006)	–	–	–	–
Avg. Urban,	–	–	–	–	–	–	–0.01	–	–	–
Pop., 1985–2000	–	–	–	–	–	–	(0.03)	–	–	–
Avg. Male Sec.	–	–	–	–	–	–	–	0.01	–	–
School, 1985–2000	–	–	–	–	–	–	–	(0.02)	–	–
Avg. Pop. over	–	– –	–	–	–	–	–	–	–0.27	–
65, 1985–2000	–	–	–	–	–	–	–	–	(0.16)	–
Avg. Adult	–	–	–	–	–	–	–	–	–	–0.01
Mort., 1985–2000	–	–	–	–	–	–	–	–	–	(0.02)
R^2	0.77	0.77	0.75	0.75	0.76	0.78	0.76	0.77	0.77	0.79
N	41	38	41	41	41	30	41	41	41	41

Notes: Heteroscedasticity consistent (White correction) standard errors are in parentheses. All regressions include a constant and are estimated by OLS. Base sample is 41 countries out of 44 countries (due to missing observations in schooling variables). Column (2) uses 38 countries that are identified by U.S. Census Bureau as having widespread generalized epidemics. The omitted countries from this column are Comoros, Mauritania, Sudan. Column (6) uses data from DHS on the percent of female 15-49 who are married at least 1 year prior to the survey year and still married (mean: 55.7, std.dev.: 19.6, min: 85.8, max: 13.8). Data are available for 30 countries and averaged according to survey years. See table 2 for the detailed explanation of the variables.

Table 5: Fertility in a Cross-Section of Countries: Perceptions

Dependent variable is Average Total Fertility Rate, 1985–2000

	(1)	(2)	(3)	(4)	(5)
Heard of HIV/AIDS,	0.02	–	–	–	–
1988–2000	(0.007)	–	–	–	–
Know someone died of AIDS,	–	0.02	0.02	0.02	0.02
1993–2000	–	(0.0008)	(0.004)	(0.007)	(0.004)
Average Secondary School	–0.02	–	–	–	–
for Female, 1985–2000	(0.008)	–	–	–	–
Log Average GDP per capita,	–0.04	–	–0.70	–	–0.45
1985–2000	(0.17)	–	(0.13)	–	(0.17)
Average Infant Mortality,	0.01	–	–	0.03	0.01
1985–2000	(0.004)	–	–	(0.005)	(0.005)
R^2	0.75	0.26	0.82	0.78	0.88
N	30	12	12	12	12

Notes: Heteroscedasticity consistent (White correction) standard errors are in parentheses. All regressions include a constant and are estimated by OLS. The data on percent female between 15-49 who heard of HIV/AIDS (mean: 89.2, std dev.: 11.3, max: 100, min: 54) and percent female who know someone personally who has the virus that causes AIDS or has died of AIDS (mean: 50.5, std dev.: 21.3, max: 88.5, min: 17.1) are both from DHS. They are averaged according to the available survey years. See table 2 for the detailed explanation of the variables.

Table 6: Fertility in a Cross-Section of Countries: AIDS in 1985

Dependent variable is Total Fertility Rate in 2000

	Base Sample (1)	Base Sample (2)	Base Sample (3)	Base Sample (4)	Base Sample (5)	Base Sample (6)	Base Sample (7)	Base Sample (8)	Available Sample (9)
Log AIDS Incidence	0.10	–	0.10	0.11	0.10	0.11	0.11	0.11	0.11
in 1985	(0.05)	–	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)
Log HIV Prevalence	–	0.18	–	–	–	–	–	–	–
in 1985	–	(0.06)	–	–	–	–	–	–	–
Secondary School	–0.002	–0.004	–	–0.01	–0.01	–0.01	–0.01	–0.01	–0.01
for Female in 1985	(0.01)	(0.01)	–	(0.05)	(0.05)	(0.05)	(0.17)	(0.18)	(0.10)
Primary School	–	–	0.01	–	–	–	–	–	–
for Female in 1985	–	–	(0.05)	–	–	–	–	–	–
Log GDP per capita	–0.23	–0.10	–0.27	–0.21	–0.19	–0.23	–0.20	–0.23	–0.23
in 1985	(0.14)	(0.14)	(0.11)	(0.21)	(0.120)	(0.20)	(0.19)	(0.22)	(0.22)
Infant Mortality	0.02	0.02	0.02	–	0.02	0.02	0.02	0.01	0.01
in 1985	(0.004)	(0.004)	(0.004)	–	(0.004)	(0.004)	(0.004)	(0.002)	(0.002)
Mortality	–	–	–	0.01	–	–	–	–	–
Age 5 in 1985	–	–	–	(0.004)	–	–	–	–	–
Urban Population	–	–	–	–	–0.01	–	–	–	–
in 1985	–	–	–	–	(0.02)	–	–	–	–
Secondary School	–	–	–	–	–	0.01	–	–	–
for Male in 1985	–	–	–	–	–	(0.01)	–	–	–
Population age 65	– –	–	–	–	–	–	–0.10	–	–
and above in 1985	–	–	–	–	–	–	(0.13)	–	–
Adult Mortality	–	–	–	–	–	–	–	–0.01	–
in 1985	–	–	–	–	–	–	–	(0.02)	
Contraceptive Use	–	–	–	–	–	–	–	–	–0.03
in 2000	–	–	–	–	–	–	–	–	(0.013)
R^2	0.68	0.71	0.68	0.69	0.67	0.68	0.70	0.69	0.81
N	41	41	41	41	41	41	41	41	27

Notes: Heteroscedasticity consistent (White correction) standard errors are in parentheses. All regressions include a constant and are estimated by OLS. The last column adds contraceptive use, which is only available for 27 countries in 2000 (mean: 20.1, std dev.: 18.5, max: 78, min: 1). See table 2 for the detailed explanation of the variables.

Table 7: Fertility in a Panel of Countries

Dependent variable is Total Fertility Rate

	Base Sample (1)	Base Sample (2)	Base Sample (3)	Base Sample (4)	Base Sample (5)	Base Sample (6)	Base Sample (7)	Base Sample (8)	Base Sample (9)	Base Sample (10)
	OLS	OLS	OLS	OLS	WLS	WLS	WLS	WLS	WLS	WLS
Fixed Effects	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Time Trend	–0.09 (0.01)	–0.07 (0.01)	–0.10 (0.01)	–0.08 (0.01)	–0.10 (0.005)	–0.08 (0.004)	–0.09 (0.003)	–0.08 (0.003)	–0.09 (0.003)	–0.09 (0.003)
Log AIDS Incidence	0.07 (0.02)	– –	0.03 (0.01)	– –	0.07 (0.01)	– –	0.02 (0.006)	– –	0.02 (0.006)	0.02 (0.006)
Log HIV Prevalence	– –	0.08 (0.02)	– –	–0.03 (0.03)	– –	0.06 (0.01)	– –	–0.02 (0.02)	– –	– –
Sec. School for Female	–0.02 (0.003)	–0.02 (0.003)	–0.001 (0.003)	–0.001 (0.003)	–0.02 (0.002)	–0.02 (0.002)	–0.004 (0.001)	–0.003 (0.001)	– –	–0.004 (0.001)
Prim. School for Female	– –	– –	– –	– –	– –	– –	– –	– –	–0.003 (0.001)	– –
Log GDP per capita	–0.15 (0.05)	–0.09 (0.05)	–0.21 (0.07)	–0.18 (0.06)	–0.16 (0.03)	–0.16 (0.03)	–0.23 (0.05)	–0.21 (0.04)	–0.22 (0.05)	–0.22 (0.05)
Infant Mort.	0.01 (0.001)	0.01 (0.001)	0.001 (0.003)	0.002 (0.003)	0.01 (0.001)	0.01 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.01)	– –
Mort. under 5	– –	– –	– –	– –	– –	– –	– –	– –	– –	0.001 (0.01)
R^2	0.73	0.74	0.79	0.78	0.73	0.73	0.78	0.79	0.78	0.78
N	228	228	228	228	228	228	228	228	228	228

Notes: Heteroscedasticity consistent (White correction) standard errors are in parentheses. The regressions have a constant term if they do not have country fixed effects. The WLS, "Weighted LS," is a 2-step estimation where all observations are weighted in the second step with the inverse of the estimated standard deviations from the first step. Specifications are estimated with 38 countries and 6 years (due to missing observations in the schooling variables). See table 2 for the detailed explanation of the variables.

Table 8: Fertility in a Panel of Countries: Robustness

Dependent variable is Total Fertility Rate

	Base Sample (1)	Base Sample (2)	No Rich (3)	Base Sample (4)	Base Sample (5)	Base Sample (6)	Base Sample (7)	Whole Africa (8)	No South Africa (9)
	WLS	WLS	WLS	WLS	WLS	WLS	WLS	WLS	WLS
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	No	No	No	No	No	No	No	No
Time Trend	–	–0.09	–0.09	–0.09	–0.09	–0.09	–0.09	–0.09	–0.09
	–	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Time Trend^2	–	–0.001	–	–	–	–	–	–	–
	–	(0.001)	–	–	–	–	–	–	–
Log AIDS Incidence	0.01	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02
	(0.004)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)
Secondary School for Female	–0.004	–0.004	–0.002	–0.004	–0.02	–0.005	–0.003	–	–
	(0.002)	(0.001)	(0.003)	(0.002)	(0.005)	(0.001)	(0.002)	–	–
Log GDP per capita	–0.20	–0.21	–0.08	–0.21	–0.26	–0.22	–0.23	–0.16	–0.16
	(0.04)	(0.04)	(0.007)	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)
Urban Population	–	–	–	0.008	–	–	–	–	–
	–	–	–	(0.01)	–	–	–	–	–
Secondary School for Male	–	–	–	–	0.02	–	–	–	–
	–	–	–	–	(0.01)	–	–	–	–
Population age 65 and above	–	–	–	–	–	–0.008	–	–	–
	–	–	–	–	–	(0.04)	–	–	–
Adult Mortality	–	–	–	–	–	–	–0.001	–	–
	–	–	–	–	–	–	(0.001)	–	–
R^2	0.30	0.78	0.78	0.78	0.76	0.79	0.78	0.78	0.78
N	228	228	198	228	228	228	228	280	273

Notes: Heteroscedasticity consistent (White correction) standard errors are in parentheses. Specification in column (3) is estimated with 33 countries that have GDP per capita levels below the sample average and 6 years. Specification in column (8) is estimated with all the available data (minus outlier countries): 40 countries and 7 years. Specification in column (9) is estimated without South Africa: 39 countries and 7 years. See table 2 for the detailed explanation of the variables.

Table 9: Human Capital Investment in a Panel of Countries

Dependent variable is Gross Primary School Enrollment

	Base Sample (1)	Base Sample (2)	Base Sample (3)	Base Sample (4)	Base Sample (5)
	OLS	OLS	WLS	WLS	WLS
Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Trend	2.50	1.17	2.18	0.96	2.18
	(0.56)	(0.47)	(0.26)	(0.22)	(0.24)
Log AIDS Incidence	–5.04	–	–4.25	–	–3.93
	(1.16)	–	(0.63)	–	(0.58)
Log HIV Prevalence	–	–3.83	–	–2.11	–
	–	(2.09)	–	(1.04)	–
Log GDP per capita	24.64	20.52	26.79	19.64	25.90
	(8.00)	(8.54)	(5.56)	(5.16)	(5.36)
Infant Mortality	–1.19	–1.09	–0.92	–0.71	–
	(0.25)	(0.25)	(0.13)	(0.10)	–
Mortality Under	–	–	–	–	–0.48
Age 5	–	–	–	–	(0.06)
R^2	0.32	0.26	0.32	0.28	0.50
N	228	228	228	228	228

Notes: Heteroscedasticity consistent (White correction) standard errors are in parentheses. Fixed effects are country fixed effects. See table 2 for the detailed explanation of the variables.

Table 10: Human Capital Investment in a Panel of Countries: Robustness

Dependent Variable:	Primary School Enrollment	Primary School Enrollment	Primary School Enrollment	Primary School Enrollment	Primary School Enrollment	Primary School Enrollment	Secondary School Enrollment
	Base Sample (1)	Base Sample (2)	Base Sample (3)	Base Sample (4)	Base Sample (5)	No Rich (6)	Base Sample (7)
	WLS	WLS	WLS	WLS	WLS	WLS	WLS
Country Fix. Eff.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fix. Eff.	Yes	No	No	No	No	No	No
Time Trend	–	2.21	2.30	2.18	2.30	2.46	0.74
	–	(0.26)	(0.38)	(0.30)	(0.27)	(0.30)	(0.17)
Time Trend^2	–	0.04	–	–	–	–	–
	–	(0.02)	–	–	–	–	–
Log AIDS	–2.25	–4.22	–4.64	–4.44	–4.47	–2.43	–0.80
Incidence	(1.05)	(0.61)	(0.64)	(0.67)	(0.61)	(0.61)	(0.40)
Log GDP	19.55	26.99	28.74	26.99	28.24	5.89	20.37
per capita	(5.10)	(5.36)	(5.82)	(5.92)	(5.86)	(6.28)	(2.65)
Infant	–1.10	–0.93	–0.95	–0.98	–0.87	–0.11	–0.03
Mortality	(0.09)	(0.10)	(0.15)	(0.12)	(0.14)	(0.24)	(0.11)
Urban	–	–	0.16	–	–	–	–
Population	–	–	(0.36)	–	–	–	–
Population age	–	–	–	–11.95	–	–	–
65 and above	–	–	–	(3.67)	–	–	–
Adult Mortality	–	–	–	–	–0.01	–	–
	–	–	–	–	(0.01)	–	–
R^2	0.50	0.60	0.59	0.59	0.60	0.59	0.25
N	228	228	228	228	228	198	192

Notes: Notes: Heteroscedasticity consistent (White correction) standard errors are in parentheses. Specification in column (7) is estimated with 32 countries and 6 years. The outliers for this column that are omitted from the base sample are Botswana, Ghana, Namibia, South Africa, Swaziland, Zimbabwe. Specification in column (6) is estimated with 33 countries that have GDP per capita levels below the sample average and 6 years. See table 2 for the detailed explanation of the variables.

Table 11: Instrumental Variable Regressions

Dependent variable:	Average Fertility Rate 1985–2000	Average Fertiltiy Rate 1985–2000	Fertility Rate	Gross Primary School Enrollment
	(1)	(2)	(3)	(4)
Time Trend	–	–	–0.14	9.01
	–	–	(0.03)	(2.91)
Log Average AIDS Incidence, 1985–2000	0.13	0.60	–	–
	(0.08)	(0.31)	–	–
Log AIDS Incidence	–	–	0.09	–10.25
	–	–	(0.05)	(5.93)
Average Secondary School for Female, 1985–2000	–0.02	–0.03	–	–
	(0.01)	(0.02)	–	–
Secondary School for Female	–	–	–0.001	–
	–	–	(0.001)	–
Log Average GDP per capita, 1985–2000	–0.12	–0.04	–	–
	(0.12)	(0.3)	–	–
Log GDP per capita	–	–	0.24	20.74
	–	–	(0.26)	(4.67)
Average Infant Mortality, 1985–2000	0.01	0.02	–	–
	(0.003)	(0.006)	–	–
Infant Mortality	–	–	–0.01	–1.25
	–	–	(0.01)	(0.56)
R^2	0.70	0.34	0.82	0.10
Countries	40	17	21	21
Time	1	1	3	3
N	40	17	63	63
Instrument	circumcision	STD, premarital	premarital	premarital

Notes: Heteroscedasticity consistent (White correction) standard errors are in parentheses. Columns (1) and (2) are cross country regressions using averaged data and including a constant, columns (3) and (4) are panel regressions with a country fixed effect. All columns are estimated by 2SLS. "Circumcision" is the percent of male between ages 15–59 who are circumcised from Werker et al. (2006). "STD" is the percent of female between ages 15–49 who has a sexually transmitted disease and not treated, averaged over 1995–2005 depending on the survey year. "Premarital" is the percent of female between ages 15–29 who has premarital sex, averaged over 1985–2005 depending on the survey year. Both of these data are from DHS. See table 2 for the detailed explanation of the variables.

Table 12: Fertility in a Cross-Section of Regions

Dependent variable is Total Fertility Rate in 1998–2004

	Pooled OLS (1)	Pooled OLS (Weighted) (2)	Pooled OLS (3)	Pooled OLS (Weighted) (4)
Log HIV Prevalence, 1985–1990	0.40	0.43	0.28	0.27
	(0.11)	(0.11)	(0.08)	(0.08)
Country Dummies	No	No	Yes	Yes
R^2	0.17	0.26	0.57	0.69
N	41	41	41	41

Notes: Heteroscedasticity consistent (White correction) standard errors are in parentheses. All regressions include a constant and are estimated by OLS. These are pooled regressions with 41 regions from 8 countries. These are the regions with overlapping data on the total fertility rate and the HIV prevalence rate. Regional total fertility rates are from DHS, various survey years (mean: 4.3, std dev.: 1.5. max: 7.4, min: 1.9). HIV prevalence rates are in percent and come from the U.S. Census Bureau, HIV Surveillance Database (2003). This is the percent HIV-1 incidence among pregnant women for each region (mean: 7.9, std dev.: 9.1, max: 46.0, min: 0.1). Each country's survey year falls between 1998–2004 for the TFR. If there is more than 1 survey year during this period than the data are averaged. HIV prevalence rates are averaged over 1985–1990 or used as a single year during that period depending on the availability. Columns (2) and (4) are estimated by weighted OLS, using weighted data where the weights are the logarithm of regional population from DHS, averaged over the survey years. DHS surveys for the 8 countries are available as follows: Ethiopia (2000), Ghana (1988, 1993, 1998, 2003), Lesotho (2004), Malawi (1992, 2000), Nigeria (1990, 1999, 2003), South Africa (1998), Tanzania (1992, 1996, 1999), Zimbabwe (1988, 1994, 1999).

Figure 1a: Changes in Female Life Expectancy in Selected African Countries with high HIV/AIDS Prevalence, 1950--2000

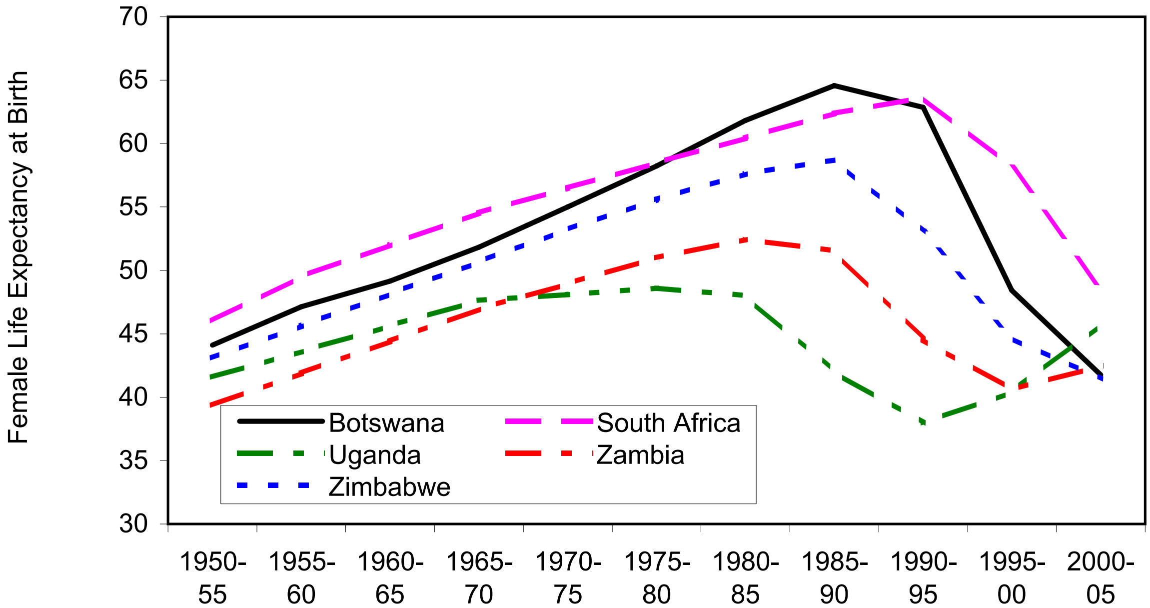
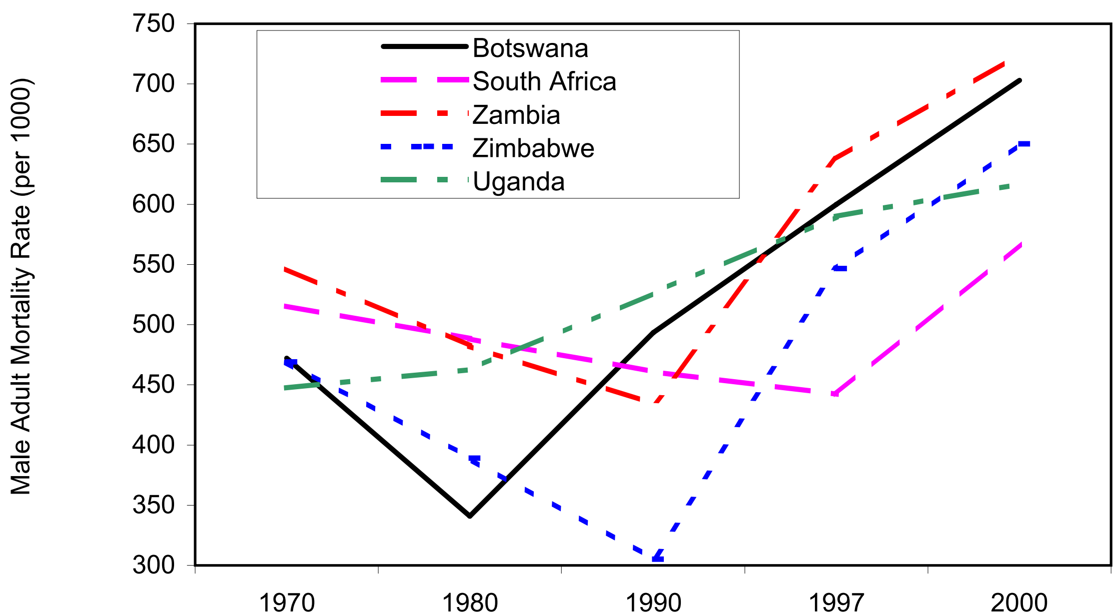


Figure 1b: Changes in Female Adult Mortality in Selected African Countries with high HIV/AIDS Prevalence, 1970--2000



Data: UN Population Statistics (2005).

Figure 2a: AIDS Incidence in Selected African Countries, 1985--2000

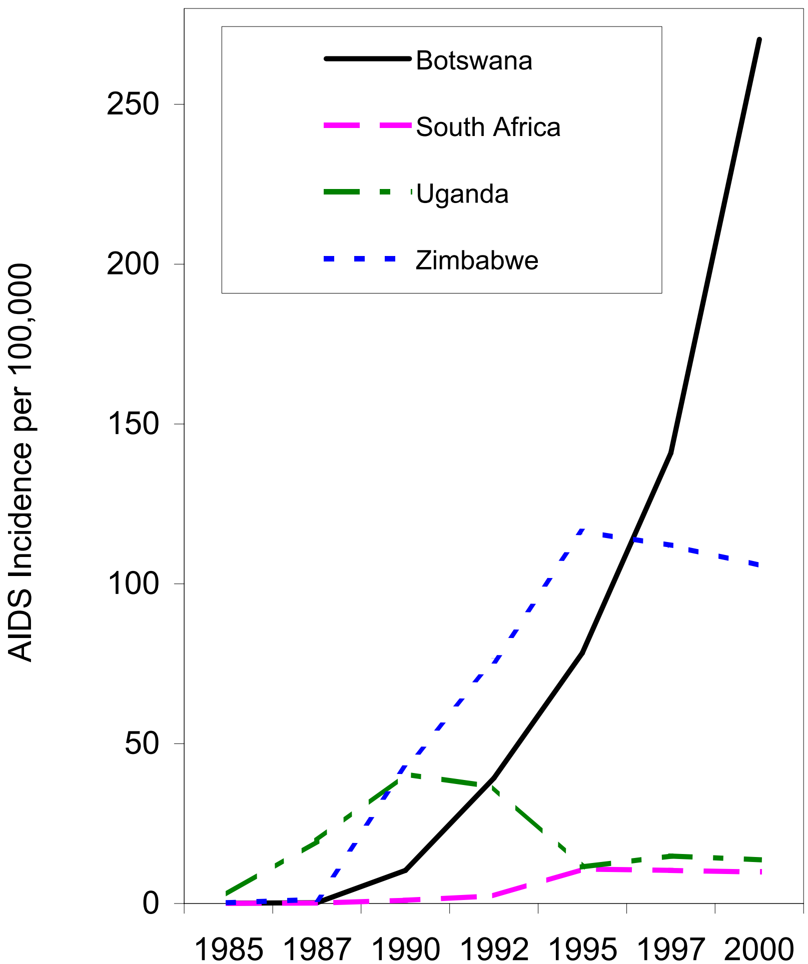
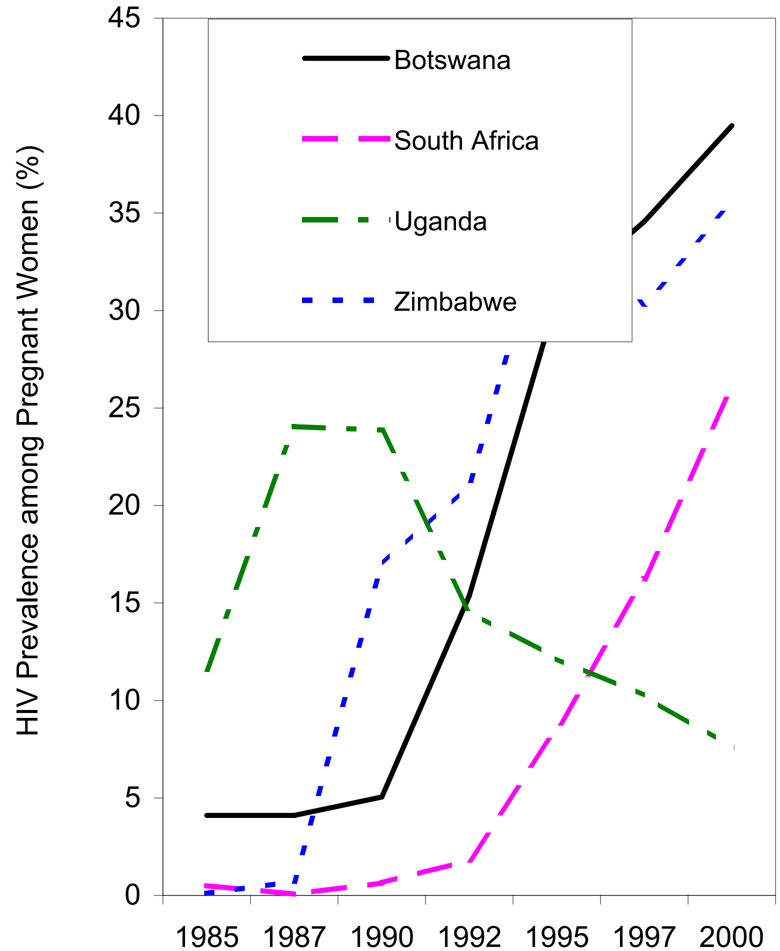
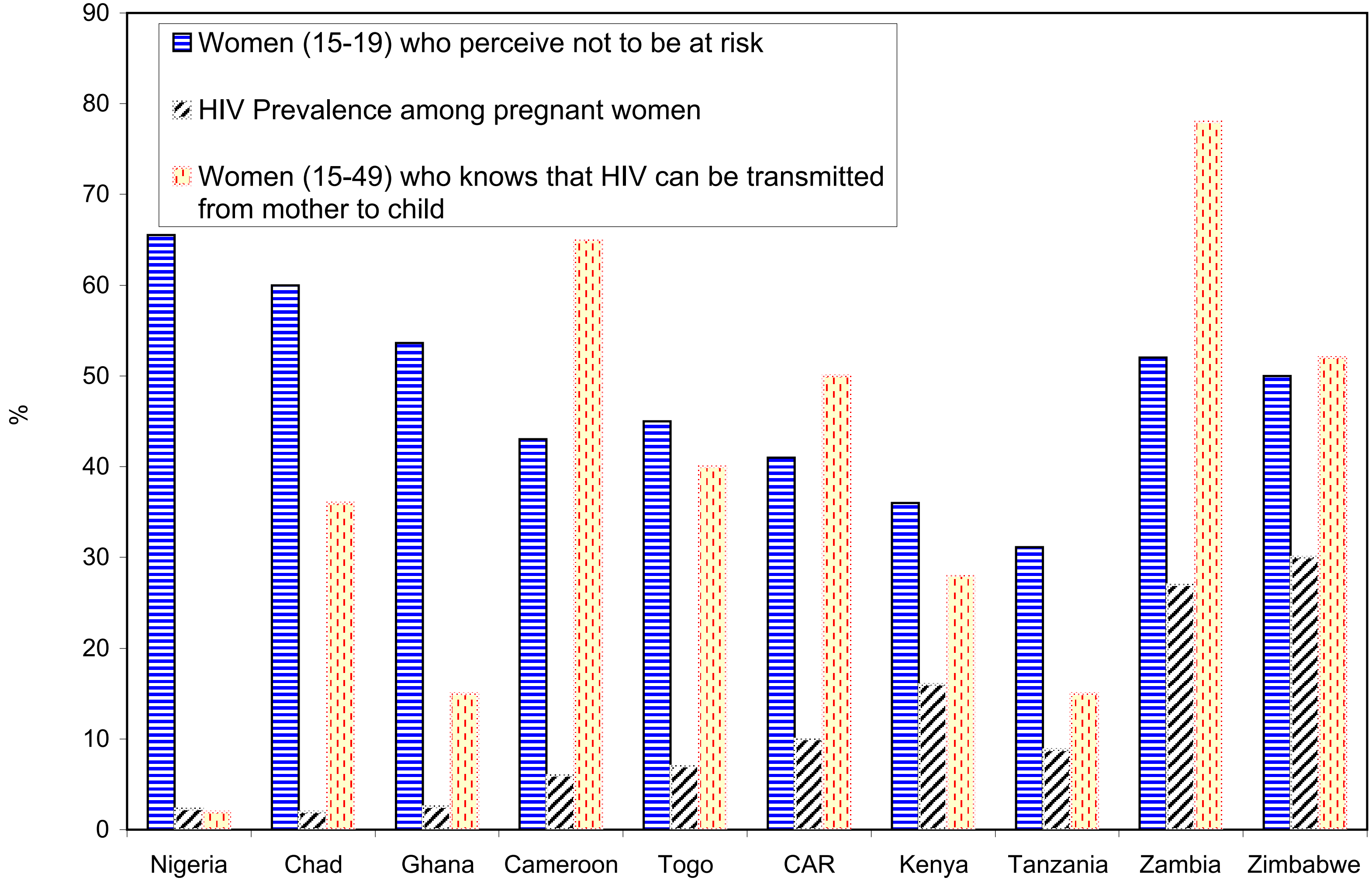


Figure 2b: HIV Prevalence in Selected African Countries, 1985--2000



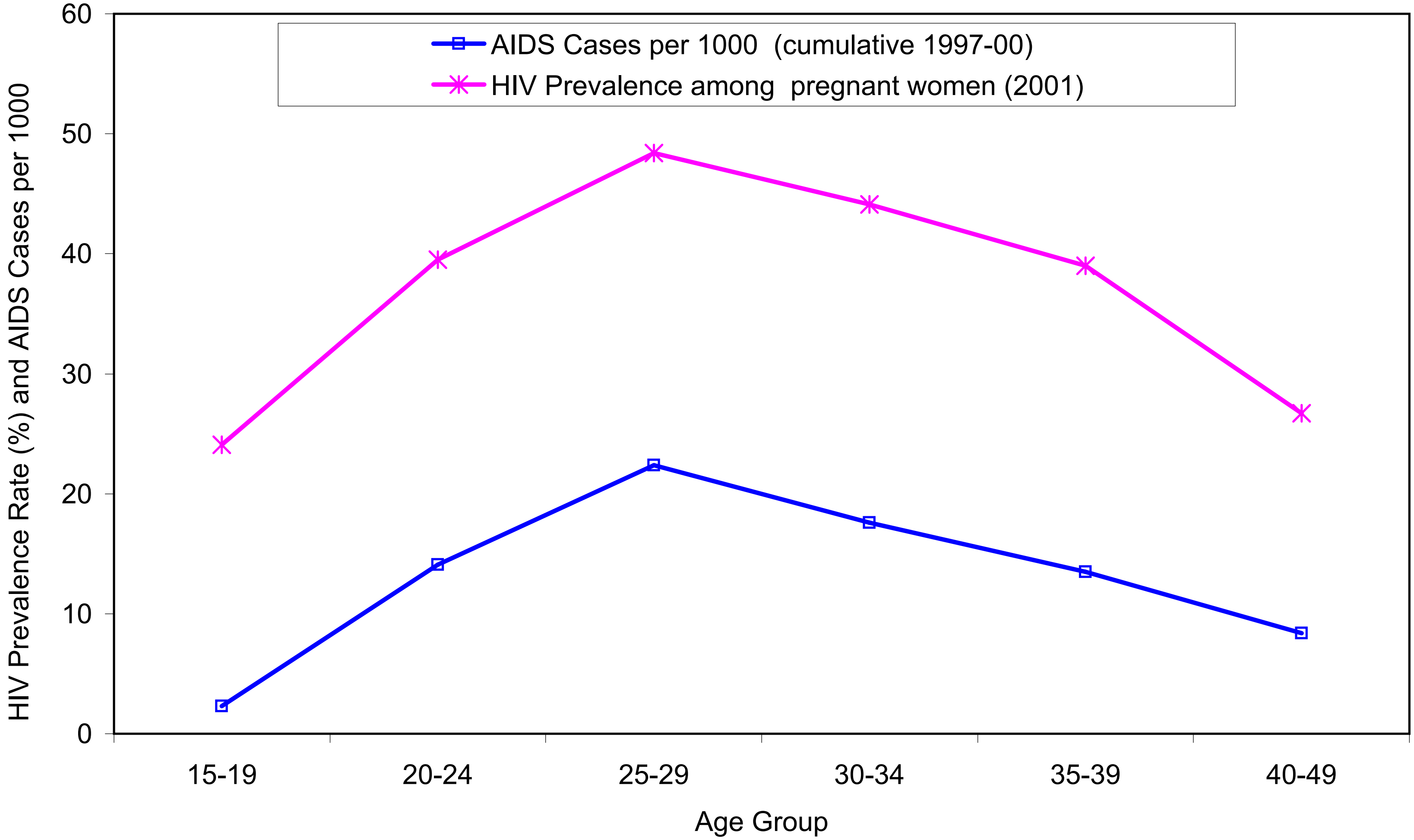
Data: AIDS incidence per 100,000 are from UNAIDS, Epidemiological Fact Sheets, 2003; HIV prevalence among pregnant women are from U.S. Census Bureau, HIV Surveillance Database, 2003.

Figure 3: Risk Perception, Selected African Countries, 1994--2000



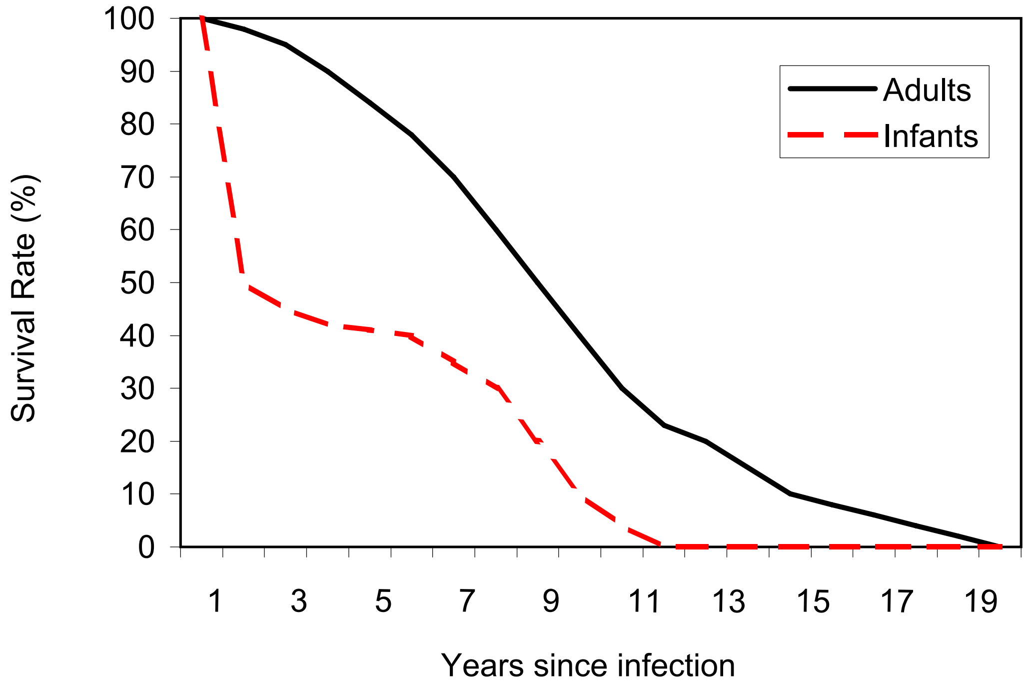
Data: DHS and nationawide surveys, www.measuredhs.com, MEASURE DHS, Macro International Inc.

Figure 4: HIV/AIDS Prevalence by Age in Botswana



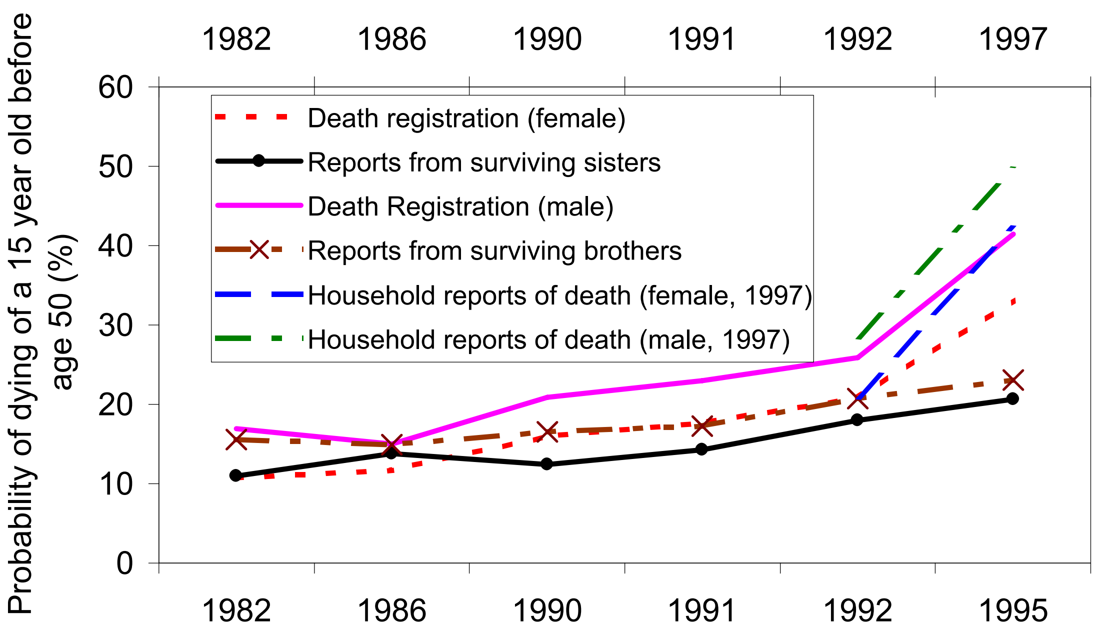
Data: Botswana 2001 HIV Sero-Prevalence (the proportion of persons who have serologic evidence of HIV infection) Sentinel Survey among pregnant women.

Figure 5a: Survival Rates in Low/Mid Income Countries



Data: UNAIDS Reference Group, 2002.

Figure 5b: Probability of a Zimbabwean child aged 15 dying before age 50, 1980--1997, various surveys



Data: Feeney, 2001.

Figure 6a: Total Fertility Rate in Selected African Countries with high HIV/AIDS Prevelance, 1985--2000

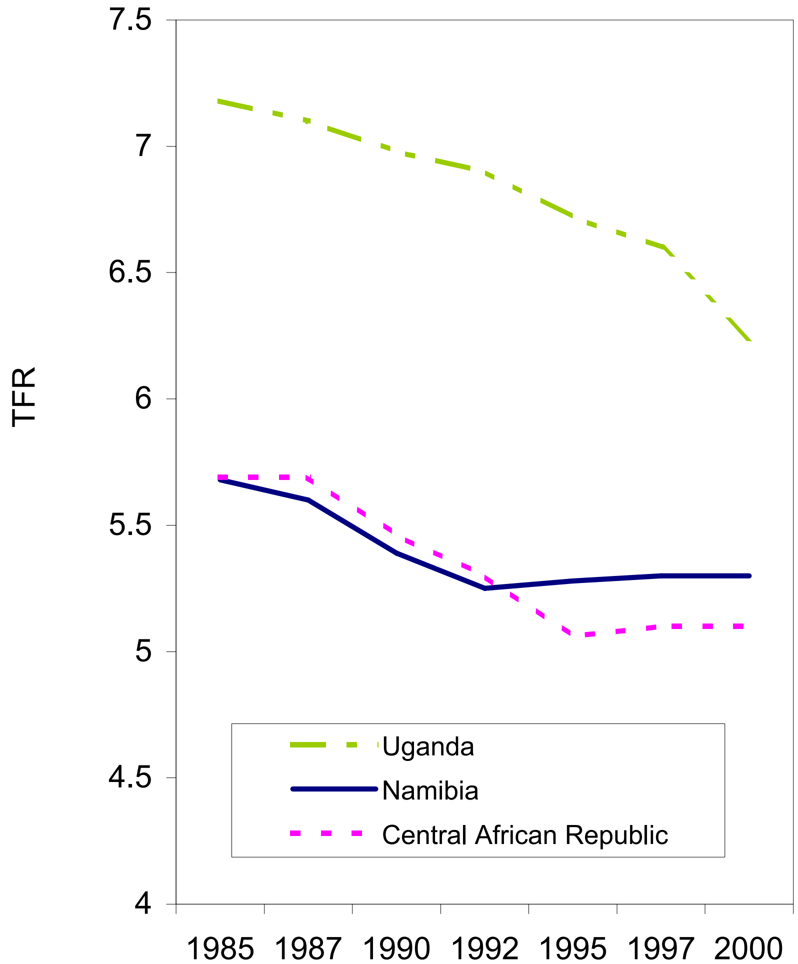
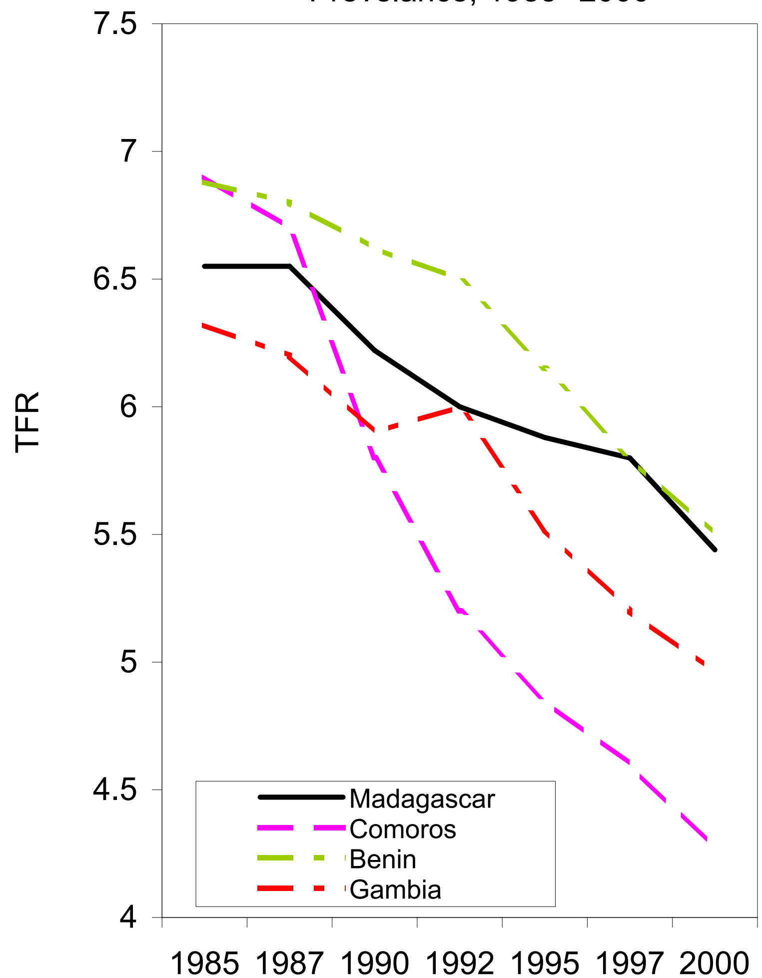


Figure 6b: Total Fertility Rate in Selected African Countries with low HIV/AIDS Prevelance, 1985--2000



Data: World Bank, World Development Indicators, 2003.

Figure 6c: Total Fertility Rate in Selected African Countries with high HIV/AIDS Prevalence, 1983--2004

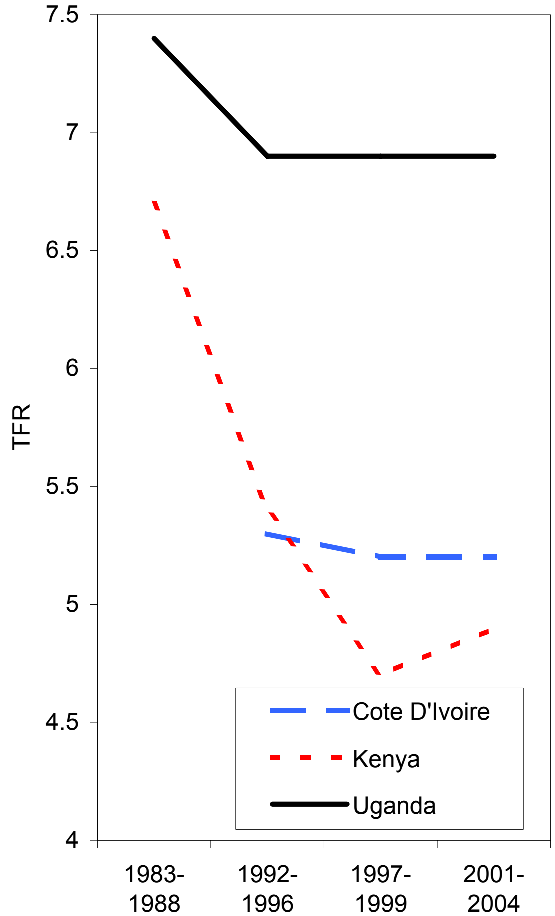


Figure 6d: Total Fertility Rate in Selected African Countries with medium HIV/AIDS Prevalence, 1992--2004

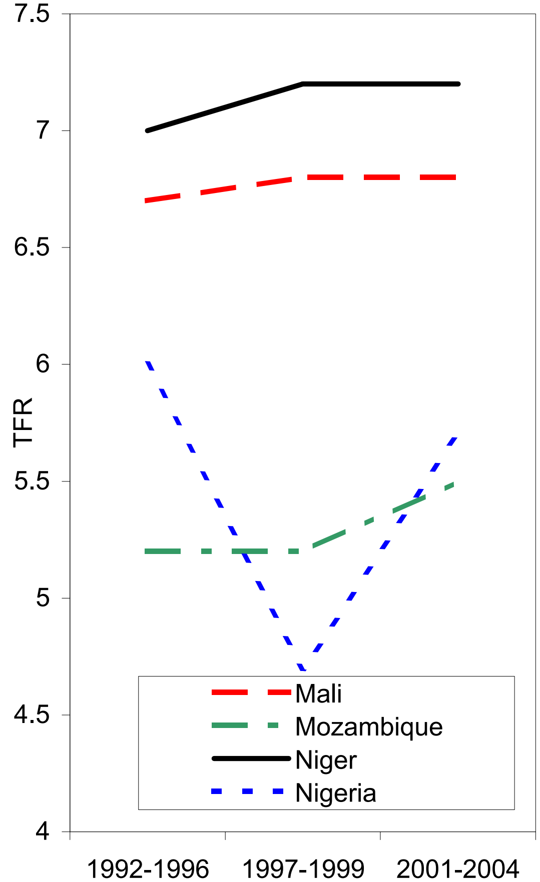
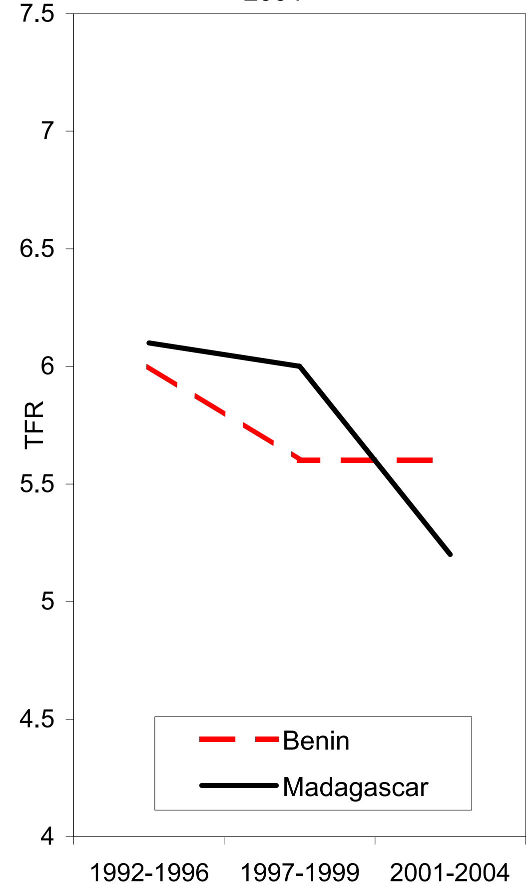


Figure 6e: Total Fertility Rate in Selected African Countries with low HIV/AIDS Prevalence, 1992--2004



Data: DHS data, www.measuredhs.com, MEASURE DHS, Macro International Inc. Each country's survey year falls in the category shown on the x-axis. Survey years are: Cote D'Ivoire (1994, 1999); Kenya (1989, 1993, 1998, 2003); Uganda (1988, 1995, 2001); Mali (1987, 1996, 2001); Mozambique (1997, 2003); Niger (1992, 1998); Nigeria (1990, 1999), Benin (1996, 2001); Madagascar (1992, 1997, 2004).

Figure 7a: Gross Primary School Enrollment in Selected African Countries with high HIV/AIDS Prevelance, 1985--2000

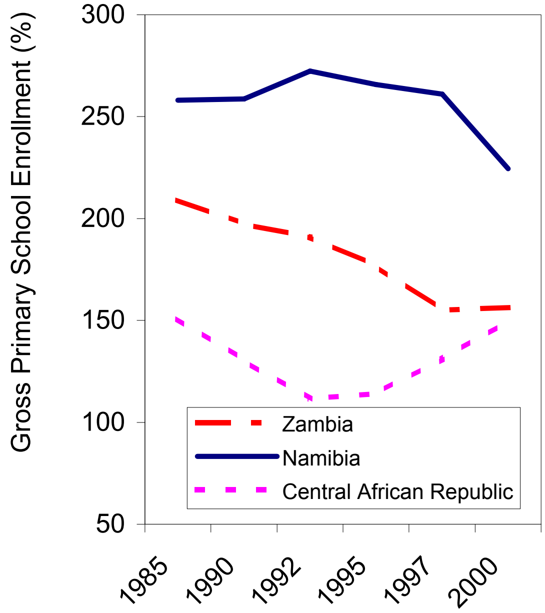


Figure 7b: Gross Primary School Enrollment in Selected African Countries with low HIV/AIDS Prevelance, 1985--2000

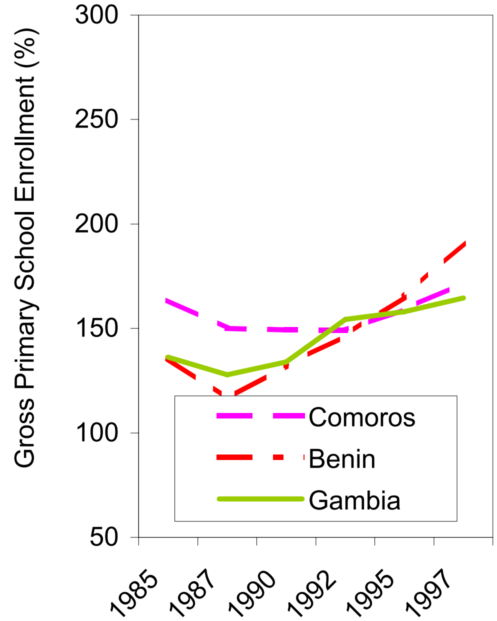


Figure 7c: Gross Secondary School Enrollment in Selected African Countries with high HIV/AIDS Prevelance, 1985--2000

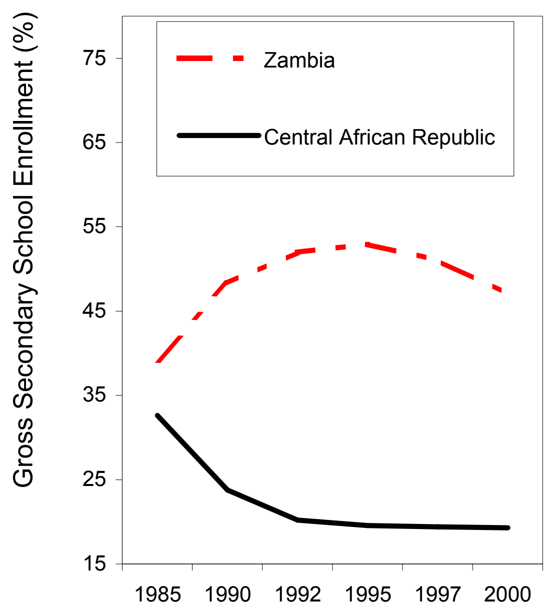
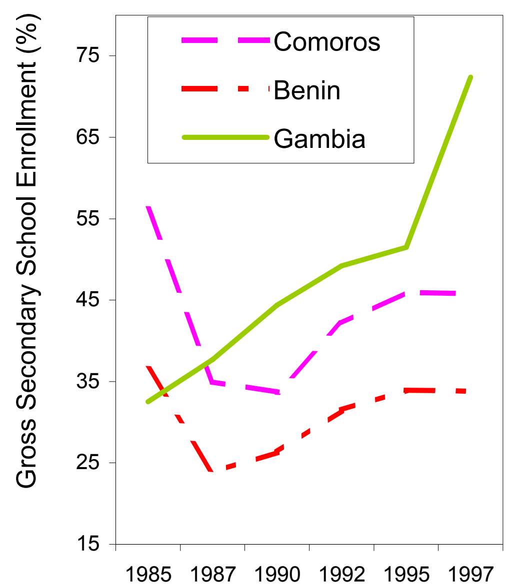


Figure 7d: Gross Secondary School Enrollment in Selected African Countries with low HIV/AIDS Prevelance, 1985--2000



Data: World Bank, World Development Indicators, 2003.

Figure 8: Regression of Total Fertility Rate on AIDS Incidence controlling for other regressors

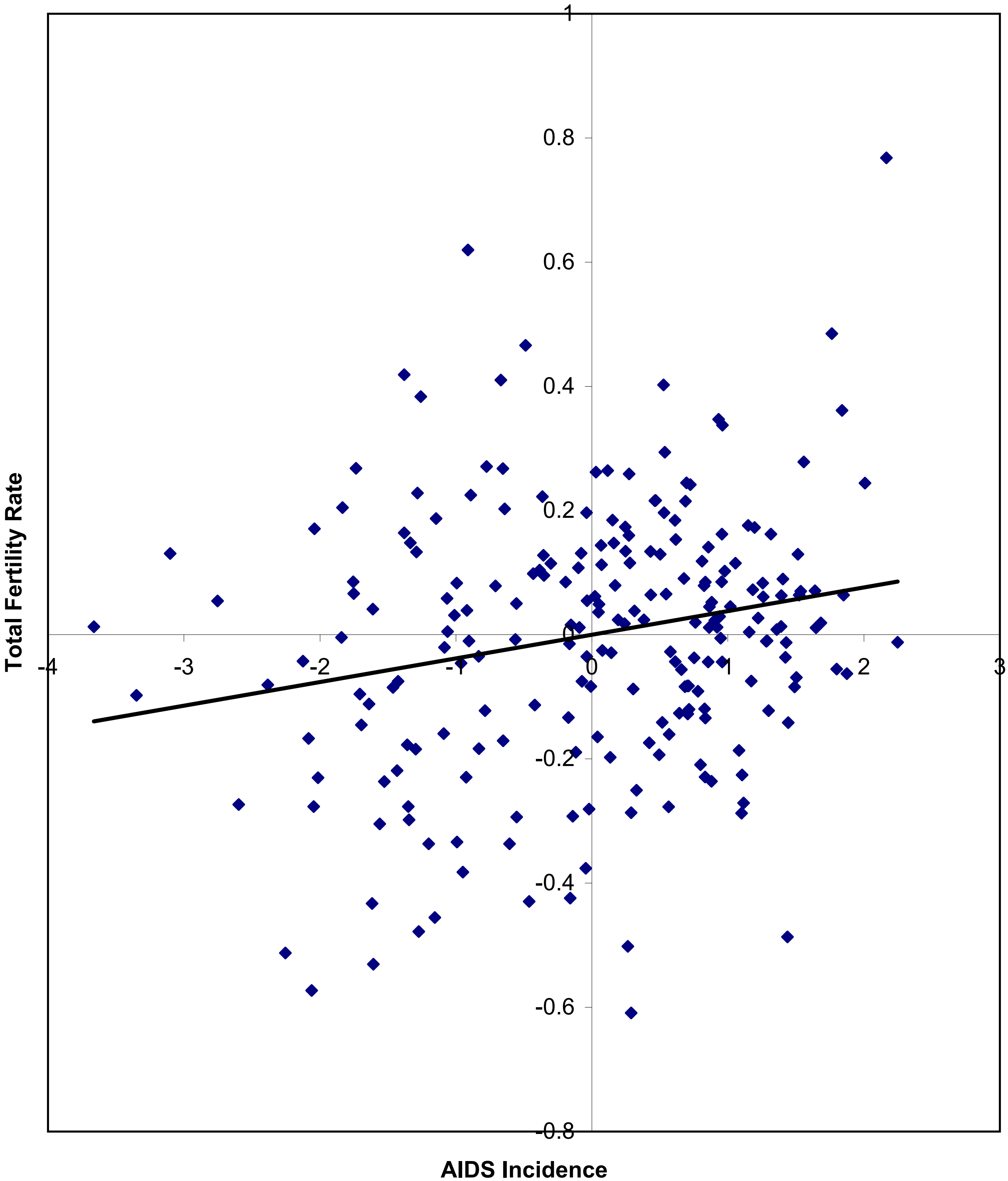


Figure 9a: AIDS Incidence in South Africa, 1985-2000

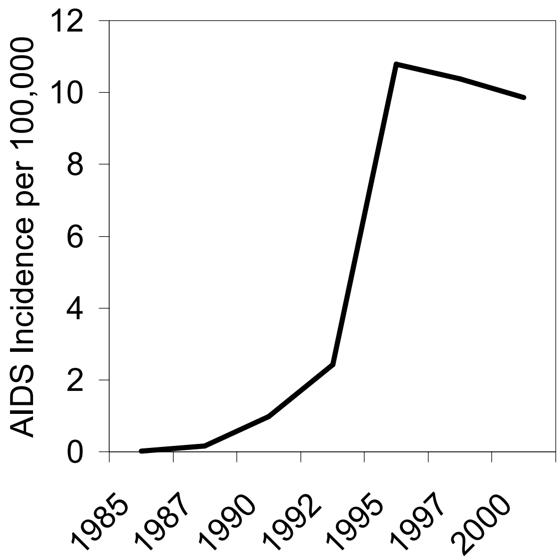


Figure 9b: HIV Prevalence in South Africa, 1985-2000

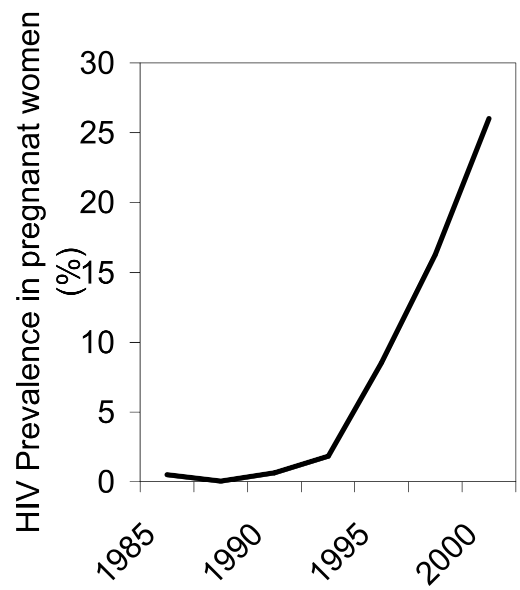


Figure 9c: Total Fertility Rate in South Africa, 1985-2000

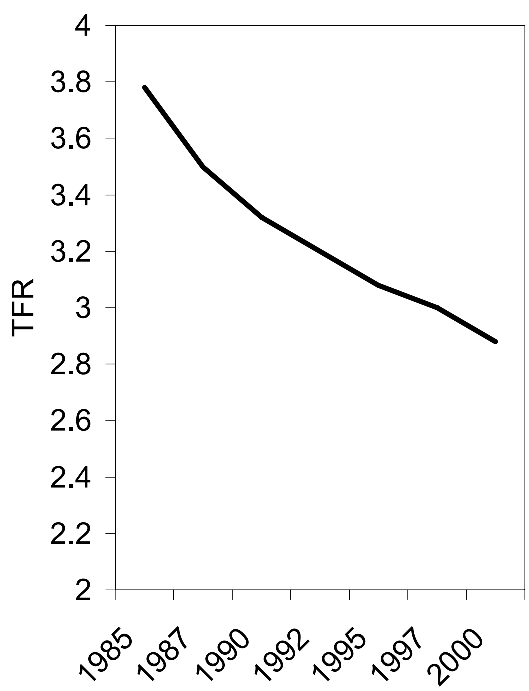


Figure 9d: Total Gross School Enrollment in South Africa, 1985-2000

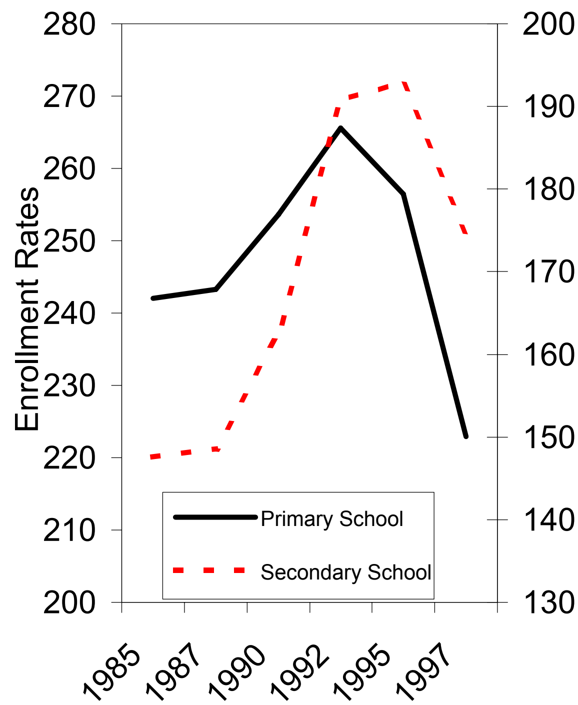


Figure 10: Total Fertility Rate versus HIV/AIDS Prevalence in South Africa

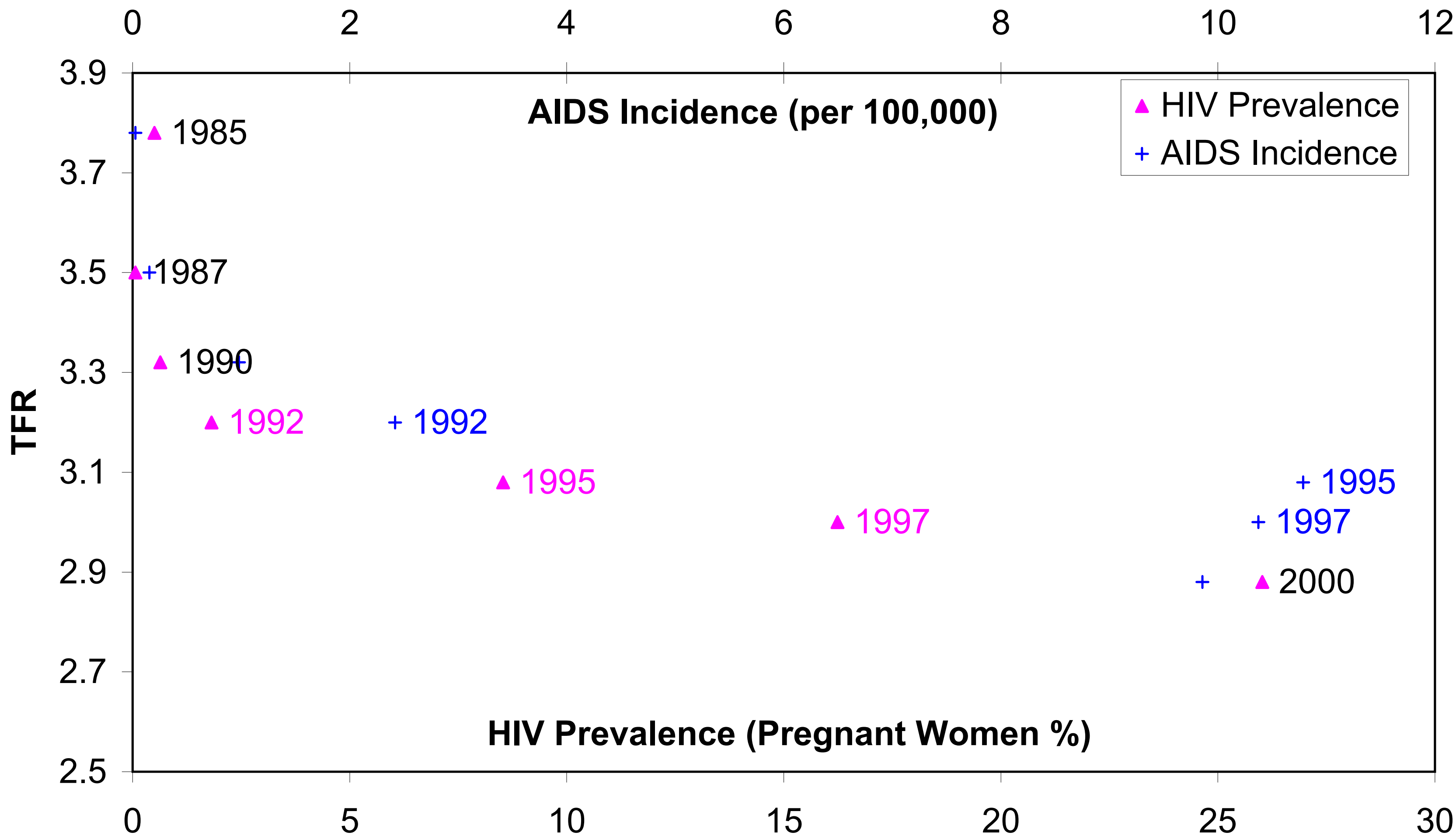


Figure 11a: Total Fertility Rate versus HIV/AIDS Prevalence in Bostwana

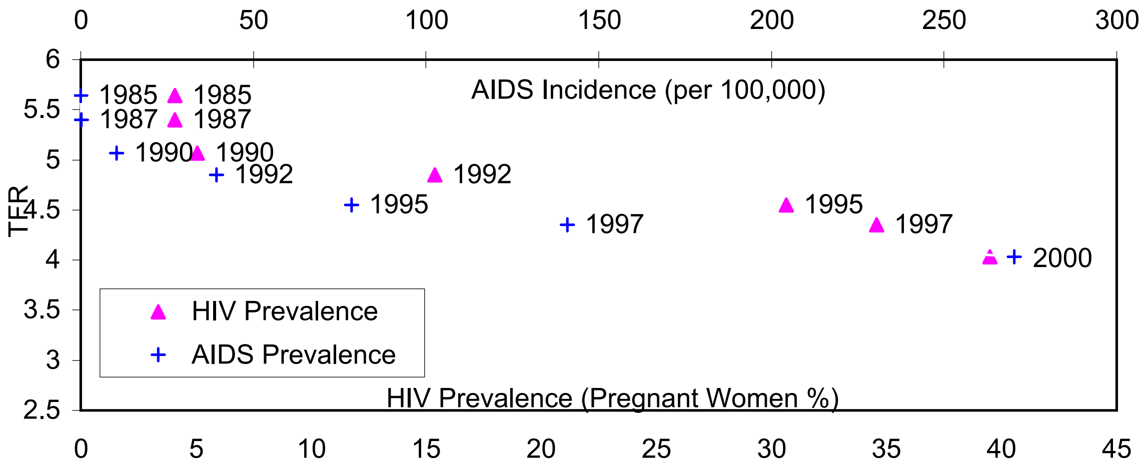


Figure 11b: Total Fertility Rate versus HIV/AIDS Prevalence in Benin

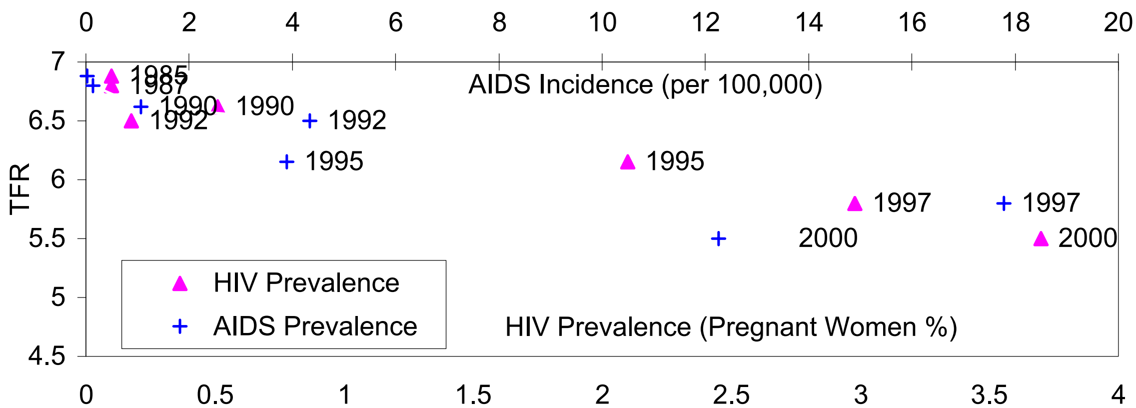


Figure 11c: Total Fertility Rate versus HIV/AIDS Prevalence in Burkina Faso

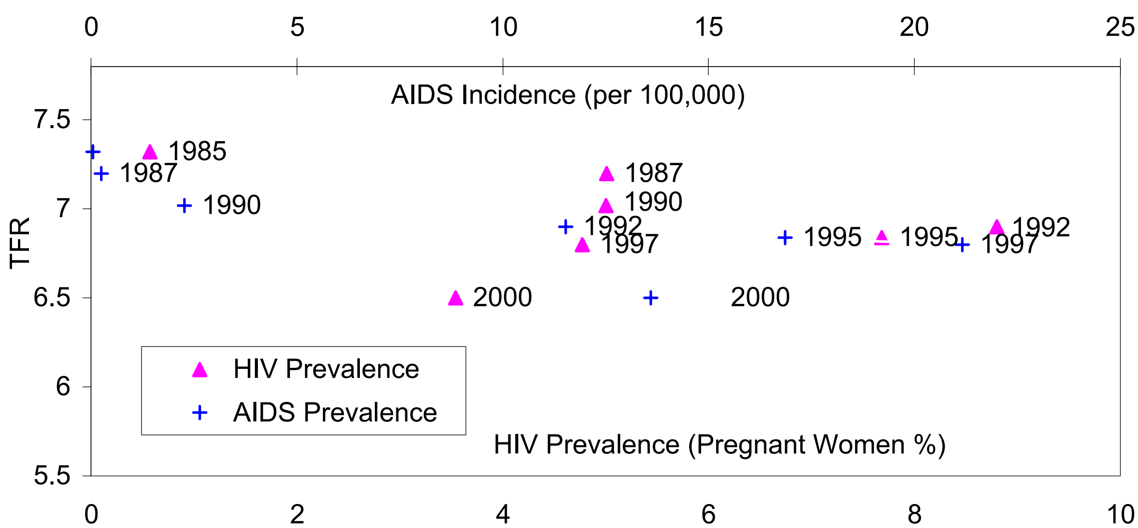


Figure 11d: Total Fertility Rate versus HIV/AIDS Prevalence in Gabon

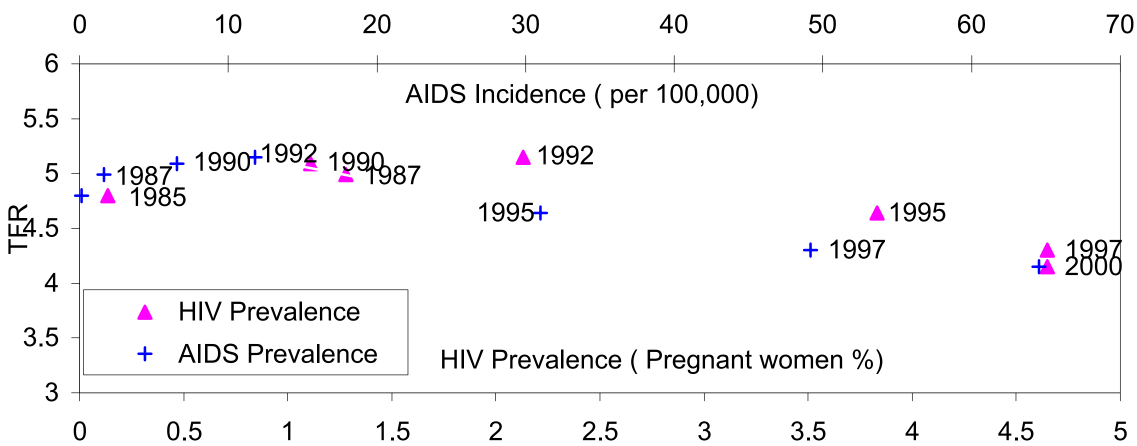


Figure 11e: Total Fertility Rate versus HIV/AIDS Prevalence in Namibia

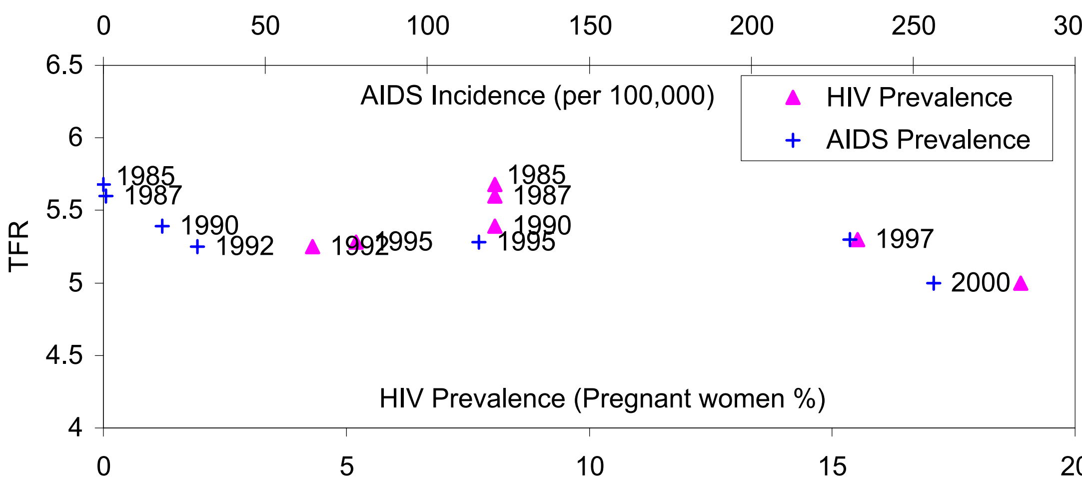


Figure 11f: Total Fertility Rate versus HIV/AIDS Prevalence in Zimbabwe

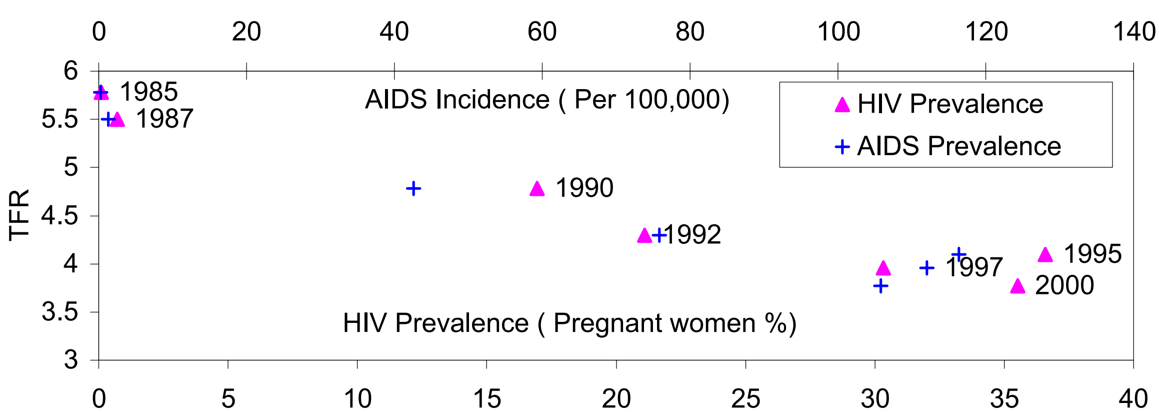


Figure 11g: Total Fertility Rate versus HIV/AIDS Prevalence in Central A

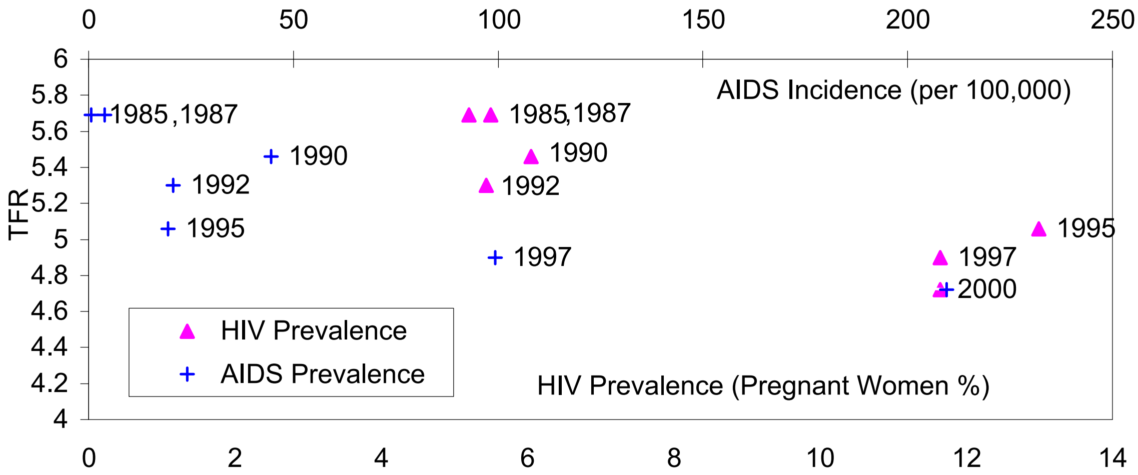


Figure 11h: Total Fertility Rate versus HIV/AIDS Prevalence in Rwanda

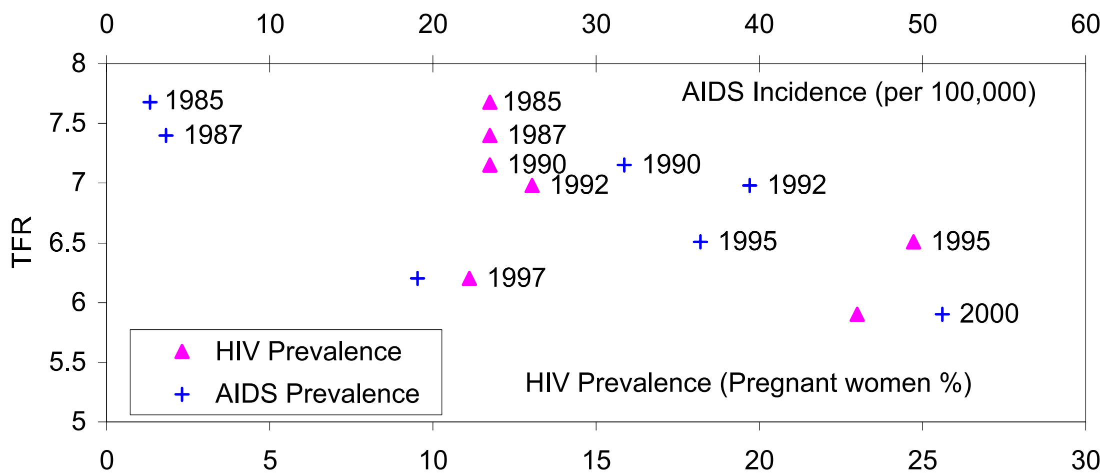


Figure 11j: Total Fertility Rate versus HIV/AIDS Prevalence in Madagascar

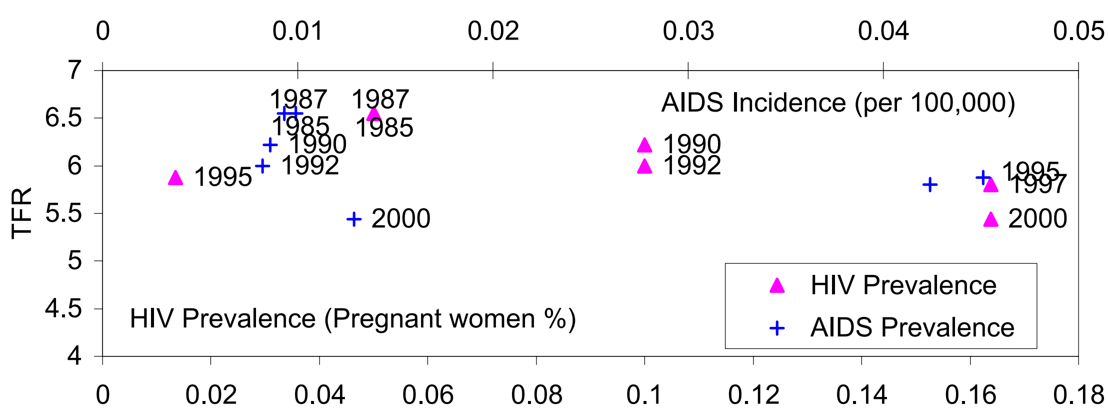


Figure 12: Regression of Human Capital Investment on AIDS Incidence after controlling for other regressors