NBER WORKING PAPER SERIES

THE IMPACT OF THE AIDS PANDEMIC ON HEALTH SERVICES IN AFRICA: EVIDENCE FROM DEMOGRAPHIC AND HEALTH SURVEYS

Anne Case
Christina Paxson

Working Paper 15000
http://www.nber.org/papers/w15000

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
May 2009

We thank Kimberly Bryan for expert research assistance, Jane Fortson for sharing her code and her knowledge of the DHS data, Helen Epstein for helpful discussions, and seminar participants for many useful suggestions. We acknowledge funding from the National Institute of Aging P01 AG005842, and the Demography of Aging Center at Princeton University, funded under the National Institute of Aging grant P30 AG024361. The views expressed herein are those of the author(s) and do not necessarily reflect the views of the National Bureau of Economic Research.

The Impact of the AIDS Pandemic on Health Services in Africa: Evidence from Demographic and Health Surveys

Anne Case and Christina Paxson

NBER Working Paper No. 15000
May 2009
JEL No. I18,O12,O55

ABSTRACT

We document the impact of the AIDS crisis on non-AIDS related health services in fourteen sub-Saharan African countries. Using multiple waves of Demographic and Health Surveys (DHS) for each country, we examine antenatal care, birth deliveries, and rates of immunization for children born between 1988 and 2005. We find deterioration in nearly all of these dimensions of health care over this period. The most recent DHS survey for each country collected data on HIV prevalence, which allows us to examine the association between HIV burden and health care. We find that erosion of health services is highly correlated with increases in AIDS prevalence. Regions of countries that have light AIDS burdens have witnessed small or no declines in health care, using the measures noted above, while those regions currently shouldering the heaviest burdens have seen the largest erosion in treatment for pregnant women and children. Using semi-parametric techniques, we can date the beginning of the divergence in health services between high and low HIV regions to the mid-1990s.

Anne Case
367 Wallace Hall
Princeton University
Princeton, NJ 08544
and NBER
accase@princeton.edu

Christina Paxson
316 Wallace Hall
Princeton University
Princeton, NJ 08544-1022
and NBER
cpaxson@princeton.edu

1. Introduction

In the past twenty years, the AIDS crisis has had crippling effects on the health care systems of many countries in sub-Saharan Africa. On the supply side, the pandemic may have compromised the ability of health systems to deliver care, as health professionals fell ill, or chose to leave for less-risky work elsewhere. The increase in morbidity that accompanies HIV may also have changed the nature of care offered by clinics and hospitals, reinforced by health budgets that shifted resources toward AIDS and the vertical delivery of care for those infected with HIV (Lancet 1995, Jones et al. 2003, Colvin 2005, Easterly 2008). A recent World Bank evaluation (2009) also reports changes in its funding for health, nutrition and population programs (HNP) over the decade from 1997 to 2007, noting that "while the overall levels of lending in HNP have not changed much over the past decade, the composition of the portfolio has shifted rather dramatically toward communicable disease projects, particularly AIDS…" (page 23).

AIDS may also have affected the demand for health services, by placing a large tax on households' budgets. Prime-aged adults who fall ill may need to leave the labor force. Other family members may also find it necessary to change their work patterns, in order to care for the sick. These costs, together with the financial costs of covering illnesses associated with AIDS, can lead to 'medical poverty traps' (McIntyre et al. 2006).

These strains on health systems and households have taken their toll. In this paper, we document the impact of the AIDS crisis on non-AIDS related health services in fourteen sub-Saharan African countries. Using multiple waves of Demographic and Health Surveys (DHS) for each country, we examine antenatal care, birth deliveries, and rates of immunization for children born between 1988 and 2005. We find deterioration in the delivery of nearly all of these dimensions of health care over this period. The most recent DHS survey for each country

collected data on HIV prevalence, which allows us to examine the association between HIV burden and health care. We find that erosion of health services is highly correlated with increases in AIDS prevalence. Regions of countries that have light AIDS burdens have witnessed small or no declines in health care, using the measures noted above, while those regions currently shouldering the heaviest burdens have seen the largest erosion in treatment for pregnant women and children. Using semi-parametric techniques, we can date the beginning of the divergence in health services between high and low HIV regions to the mid-1990s.

We begin in Section 2 by introducing the DHS data we use to examine the impact of HIV on health care delivery. We discuss our estimation strategy in Section 3. We present evidence on the associations between HIV and health services in Section 4, and explore explanations for our findings in Section 5. Section 6 discusses ways in which future health service delivery may be affected by the arrival of antiretroviral therapy (ART), and notes that the design of AIDS care should take into account the fact that persons living in regions most affected by AIDS may not have been receiving adequate medical care for the past 20 years.

2. Demographic and Health Survey Data

Demographic and Health Surveys are large, nationally representative household-based surveys conducted at approximately four to five year intervals in low and middle income countries. Their focus is primarily on population, health and nutrition. Women in the household aged 15 to 49 are asked about their fertility histories, including information on prenatal care, delivery assistance and children's immunizations. In some survey waves, information on antenatal care is available for a woman's most recent birth, and in others it is collected for all births that occurred within a particular time window (within the past three years for some surveys, within the past five years

for others). Appendix Table 1 provides a guide to survey years. Information on these surveys is also available on line at http://www.measuredhs.com/aboutdhs/.

We analyze data from 41 DHS surveys conducted between 1988 and 2006 in fourteen countries in sub-Saharan Africa. We have data from eight West African countries where HIV prevalence rates are relatively low – Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Guinea, Mali, Niger and Senegal – and six countries in East and Southern Africa where rates are higher – Ethiopia, Kenya, Malawi, Tanzania, Zambia, and Zimbabwe.[1] (The exception to this geographic generalization is Ethiopia, where prevalence rates are much like those observed for Burkina Faso and Ghana.) We selected these countries because they have conducted multiple DHS surveys since 1988, and because their latest round of DHS data collection included HIV testing. We do not use the 1988 survey from Ghana and the 1991-92 survey from Tanzania, because the geo-coding of within-country regions changed between these and later surveys.

Table 1 reports on the DHS data we use, including survey years, the birth years of children covered in each survey year, and the number of observations in each survey.[2] For each birth year from 1988 to 2005, we have observations from at least seven countries we are studying. For 1988 and 1989, 7 and 8 countries are represented. In all years beyond that, information is available from at least 9 countries for each birth year.

Our analysis will focus on the association between health service delivery on one hand, and HIV prevalence rates on the other. For this, we match HIV prevalence at the *region* level. All countries are divided into regions that can be consistently identified across survey years.

[1] All results presented here are robust to the exclusion of Zimbabwe, which may have seen more upheaval and displacement of persons than other countries examined.

[2] We exclude 133 cases where information on mother's education is missing and 3509 cases where information on the HIV prevalence in the region of birth is unknown for the child's birth year.

Countries vary in the number of regions (3 in Cameroon and in Malawi for example, 10 in Zimbabwe, 20 in Tanzania), and in total we analyze data from 119 regions.

Antenatal Care

Outcome measures for antenatal care are presented in Table 2. We present averages for each country, taken over all DHS waves, on women's reports that they received any antenatal care (in the form of at least one antenatal visit). For women who report antenatal care, each is asked whether their urine and blood was tested, and whether measurements of their blood pressure and weight were taken. With the exception of Ethiopia, over 90 percent of women surveyed in East and Southern Africa report some form of antenatal care, true for a smaller fraction of women in West Africa. In most countries in our sample, more than 90 percent of women report that they were weighed, conditional on reporting prenatal care, and the vast majority report their blood pressure was taken. Blood tests and urine analysis are much less likely to be reported in some countries (Ethiopia, Malawi, Mali, Niger, Zambia) than in others (Cameroon, Ghana, Zimbabwe).

Figure 1 shows a marked decline in the tests and measurements taken during antenatal visits in East and Southern Africa, by country and birth year, particularly for tests involving bodily fluids. Results for urine and blood tests during antenatal care, shown in the upper panel of Figure 1, suggest that use of these tests declined in all high HIV-prevalence countries we are following (Kenya, KE; Malawi, MW; Tanzania, TZ; Zambia, ZM; and Zimbabwe, ZW). In Malawi, for example, the percentage of women reporting that their blood was tested as part of their prenatal care declined from 54 percent in 1995, to 20 percent in 2005. Reports that blood pressure was taken during an antenatal visit held constant in West Africa (estimated but not

reported in Figure 1), but fell in East and Southern Africa, as can be seen in the bottom left panel of Figure 1. In Kenya, for example, reports of blood pressure being taken fell from 88 percent in 1998 to 80 percent in 2003, and in Tanzania from 75 percent in 2000 to 64 percent in 2005. Even reports of being weighed, an inexpensive measure that takes little clinic time, declined over this period (although from a very high base – note that the graphing scales used are different for different procedures.) We do not know how declines in these services have translated in to declines in health outcomes for women and their children—for example, it may be that the measurement of weight during pregnancy has little effect on birth outcomes. However, declines in blood testing during pregnancy may be a particular problem, if a lack of blood tests prevents HIV positive mothers from being identified and vertical transmission of AIDS from being prevented.

Birth deliveries

Outcome measures for birth deliveries are presented in Table 3. In almost all countries under study, approximately half of all births are attended by a trained professional. Approximately a third of all births occurred in public clinics, and ten percent in private clinics. (The largest outlier here is Ethiopia, where reports of clinic births and having a trained professional at the birth are substantially lower.)

That these patterns have been changing over time in high prevalence countries can be seen in Figure 2, which presents delivery details, by country and year, for the five high prevalence countries we follow in East and Southern Africa. The top left graph presents trends in whether the birth occurred in a clinic (public or private) and the top right on whether it was attended by a trained professional. All of these countries saw a decline in the presence of a

trained professional at the delivery. In Zambia, this declined from 51 to 37 percent between 1988 and 2002. In Malawi, the attendance of a trained professional fell from 72 percent to 59 percent between 1988 and 2005. Private clinic delivery in high HIV-prevalence countries held fairly steady over this period, while reports of delivery in public clinics declined.

Childhood immunizations

The rates of childhood immunization against polio, measles, BCG, and DPT are reported by country in Table 4. DHS evidence on vaccinations is categorized as: no vaccine; mother reports vaccine (no card); vaccine recorded on card (no date); and vaccine is dated on card. There are many ways to categorize these reports. Our interest is in children missing vaccines, and for this reason we code variables equal to '1' if the child is reported – either by the mother or on the health card – not to be vaccinated , and equal to '0' if the mother reports the vaccine, or evidence of the vaccine is recorded on the child's health card. Table 4 shows that approximately half of all children were reported not to have had a polio vaccine shortly after birth, but that this lack of vaccination falls to between 10 to and 30 percent of children at older ages in most countries. Between a 30 and 50 percent of all children are not vaccinated against measles, and between 10 and 20 percent have not received BCG vaccines. Non-vaccination rates are generally higher in West African countries.

HIV prevalence

The HIV prevalence rates we use in our analysis were calculated using HIV test results from the most recent DHS surveys listed in Table 1. We use this information to calculate prevalence rates at the country-region level. Differences in prevalence between countries, and between regions

within countries, can be seen in Figure 3, where weighted averages of HIV prevalence are presented by region for eight of the countries in our sample. HIV prevalence varies a great deal both across countries, and across regions within countries. The lowest prevalence rates are in Niger, Senegal and Mali, with values in all regions under 2.1 percent. There is substantial regional variation in HIV rates in the higher-HIV countries of Kenya, Malawi, Tanzania, and Zambia. In Zimbabwe, rates are uniformly high (12 percent or more). We turn, in Section 3, to the methods we will use to examine whether health services for pregnant women and children deteriorated in regions in which HIV prevalence grew most quickly.

3. Methods

Our key concern is whether higher HIV prevalence within regions is associated with lower quality health care for mothers and their children. As noted above, we do not observe HIV prevalence over multiple years, but only in the year in which the most recent survey was conducted. We follow two general strategies for estimating the relationship between prevalence and health care. Our first strategy is to regress each health care measure on imputed HIV prevalence in the region in the child's year of birth, and on other control variables, including indicators for year of birth and country-region fixed effects. We impute HIV prevalence by assuming that regional HIV prevalence has increased linearly from a value of 0 in 1980 to the value observed in the most recent survey.[3] Our second strategy is to regress each health care measure on a set of interactions between the child's year of birth and the measure of HIV prevalence in the most recent survey. This permits us to examine whether the evolution of health

[3] Although it is difficult to date the beginning of the AIDS crisis in Africa, there is evidence of a "marked increase in cases in Africa during the late 1970's and early 1980's" (Quinn et al. 1986). The countries we study reported their first cases of AIDS in the early- to mid-1980's. Below, we discuss how our results change if we use a later date, of 1985 rather than 1980, to impute regional HIV prevalence.

outcomes from the late 1980s to the early 21st century is different in regions with high HIV prevalence rates when compared to regions with low prevalence rates. As we show below, the second of these strategies is simply a less restrictive variant of the first: it does not require an assumption about the start of the epidemic, nor does it rely on the assumption that HIV prevalence increased linearly.

The first step is to impute HIV prevalence in each year in which children's births are observed. Let $H_{r\tau}$ denote the prevalence of HIV measured in region r in year τ, where τ is the most recent survey year (which exceeds 1980) and r denotes a country-region. The estimated prevalence of HIV in region r in year t, denoted h_{rt}, is assumed to be:

$$(1) \quad h_{rt} = H_{r\tau}\left[\frac{t-1980}{\tau-1980}\right].$$

We then estimate regressions of the following form for each of the health outcomes discussed above:

$$(2) \quad y_{irt} = \delta_r + \gamma_t + \beta h_{rt} + X_{irt}\theta + \varepsilon_{irt},$$

where y_{irt} is a health care measure associated with child i, either a measure of the quality of the care the child's mother received before or at the birth of the child, or a measure of the quality of care the child has received. In addition to the prevalence measure, equation (2) contains a set of region fixed effects (δ_r), which capture time invariant features of the region, including determinants of quality of care that do not change over time. As seen in Figures 1 and 2, there are pronounced differences in the levels of the measures we examine, even though many have similar trends. We also include a set of birth year effects (γ_t), which capture changes over time that are common to all regions, and a set of controls for characteristics of the mother and child (X_{irt}). These controls include the mother's years of education, her age in years, the child's age in months (or, if the child has died, the age in months the child would have been at the time of the

survey had he or she lived), an indicator for the child's sex, and an indicator for whether the household lives in an urban area. The parameter of interest, β, provides an estimate of how changes in HIV prevalence in a region influence health care outcomes.[4]

Equation (2) incorporates two assumptions: one, that HIV prevalence increased linearly from 1980 to the current time period, and two, that HIV prevalence has a linear effect on health care quality. These assumptions can be loosened, by estimating models of the following form:

$$(3) \quad y_{irt} = \delta_r^* + \gamma_t^* + \beta_t^* H_{r\tau} + \alpha^* X_{irt} + \varepsilon_{irt},$$

where all variables are defined as above, only the actual prevalence in year τ has replaced estimated prevalence in year t, and the coefficient on actual prevalence is permitted to vary by year. Because the prevalence measure does not vary over time within regions, and region fixed effects are included, the value of β_t^* must be set to zero for one of the years.

In what follows, we present estimates of (2) and (3). It is straightforward to see that (3) is a less restrictive version of (2). First, substitute (1) into (2) to obtain:

$$y_{irt} = \left[\delta_r - \beta \frac{H_{r\tau} 1980}{\tau - 1980}\right] + \gamma_t + \left[\frac{\beta}{\tau - 1980}\right] H_{r\tau} t + X_{irt}\theta + \varepsilon_{irt}$$

which, if:

$$\delta_r^* = \left[\delta_r - \beta \frac{H_{r\tau} 1980}{\tau - 1980}\right]$$

and

$$\beta^* = \frac{\beta}{\tau - 1980}$$

can be expressed as:

$$(4) \quad y_{irt} = \delta_r^* + \gamma_t^* + \beta^* H_{r\tau} t + \alpha^* X_{irt} + \varepsilon_{irt}.$$

[4] All results reported in Tables 5, 6 and 7 are robust to additionally allowing unobservables to be clustered at the region level.

In (4), the inclusion of an interaction term between the prevalence in year τ and the year of birth permits a linear trend in the outcome (over and above the year effects γ_t^*) that varies with HIV prevalence. The only difference between (4) and (3) is that, in (3), different time patterns in areas with high and low HIV prevalence are not restricted to a linear trend. In the results that follow, we test whether this linear restriction can be rejected.

To see how estimates of equation (3) should be interpreted, consider predicted values of the outcome at two time periods, 1 and 2. Ignoring the control variables X_{irt}, the difference in the predicted value of the outcome in region r will be:

$$(5) \quad \hat{y}_{r2} - \hat{y}_{r1} = (\hat{\gamma}_2^* - \hat{\gamma}_1^*) + (\hat{\beta}_2^* - \hat{\beta}_1^*)H_{r\tau}.$$

The year-to-year change in the outcome contains a component that is common to all regions, and another component that is scaled by the region's HIV prevalence in year τ.

One concern is that not all outcomes are observed in all countries in all years of birth. For example, the indicator that a child did not receive a polio vaccine at birth is available only in Niger in 1988. By a birth year of 1993, information on this vaccine is available for four countries, and by 1995 it is available for 13 countries. To prevent the birth year effects from reflecting the experience of only a few countries, we "trim" the sample for each outcome, so that regressions exclude birth years that do not have observations from at least four countries. As a result of this trimming, estimates of models for specific antenatal care procedures cover the 1995-2005 period; and polio at birth covers the 1993 to 2005 period. All other estimates cover the 1988-2005 period.

4. Results

Table 5 presents estimates of equation (2), which measure the association between estimated HIV prevalence in the year of birth and antenatal care. We present the coefficient on HIV prevalence from OLS regressions for whether a woman reports having had prenatal care (column 1) and, conditional on reporting care, that she reports having had a urine test, a blood test, blood pressure measured, and her weight measured (columns 2 to 5). The first row presents estimates from equation (2) where, in addition to estimated HIV prevalence, the only other controls are birth year indicators. The second row presents estimates from regressions that also include country-region fixed effects, and mother and child characteristics.[5] HIV prevalence is also associated with fewer Women in regions with high HIV prevalence are significantly more likely to report prenatal care. Relative to living in a region with zero prevalence, women living in a region with 10 percent HIV prevalence are 26 percentage points more likely to report antenatal care (top panel, column 1). However, when we include country-region fixed effects, so that identification comes from change in HIV prevalence within a region over time, we find that higher HIV prevalence is associated with a significantly lower probability of reporting antenatal care. This suggests that, on average, higher prevalence areas started from higher levels of prenatal care, and that HIV has taken a greater toll on service delivery there than in regions with low levels of HIV prevalence.[6]

Increases in HIV prevalence are also associated with declines in the the types of procedures conducted during antenatal care. Conditional on reporting antenatal care, women in

[5] Estimates using probit models yield similar results.

[6] Our result on reporting any antenatal care is also robust to the inclusion of country-by-year fixed effects.

regions with higher HIV prevalence are observed with lower probabilities of having urine tests, and of reporting that their blood pressure was taken. Controlling for country-region fixed effects magnifies these differences, so that all four of the measures of quality of prenatal care are significantly lower over time within a region as HIV prevalence rises. For example, within a region where HIV prevalence increased by 10 percentage points between 1995 and 2005, a woman is 21 percentage points less likely on average to report that her blood pressure was taken during prenatal care if she was pregnant in 2005, relative a woman who was pregnant in 1995. Because antenatal care is itself negatively associated with HIV prevalence (controlling for country-region fixed effects), these effects are magnified when we estimate models that do not condition on the receipt of antenatal care. For example, as shown in Table 5, the coefficient on HIV prevalence for having had a urine test is –2.22 when we restrict the sample to those who reported antenatal care. It falls to –5.96 when we use the full sample of all births.

Table 6 presents results on the association between estimated HIV prevalence in the year of birth and the quality of birth deliveries. Specifically, we estimate the association of HIV prevalence with an indicator that the birth occurred in a clinic (column 1) and, conditional on a clinic delivery, whether the clinic was public (column 2). In addition, we estimate the association between HIV prevalence and a trained attendant being present at the birth (column 3). Again, the results are markedly different with and without country-region fixed effects. In the absence of fixed effects (row 1), we find delivery at a clinic is significantly more likely in regions with high HIV prevalence. However, over time within a region (row 2), we find clinic delivery is significantly less likely to be reported as HIV prevalence increases. Without fixed effects, conditional on being a clinic birth, delivery is are significantly less likely to be at a public clinic. This coefficient, while still negative and significant, falls by two-thirds when country-region

fixed effects are included. A disturbing finding in Table 6 is that, within regions over time, those with higher HIV prevalence see a significant drop in the probability that a trained birth attendant was present for the delivery. On average, a region that experienced a 10 percentage point increase in the rate of HIV prevalence witnessed a 14 percentage point drop in the probability of a trained attendant at the birth. Part of this drop is due to the lower probability that the delivery took place in a clinic (column 1), and part of this drop is due to the lower probability of an attendant, even conditioning on clinic delivery (column 4).

Table 7 turns to children's health care outcomes, and presents estimates of the association between HIV prevalence and children not reported to have had a polio vaccine soon after birth (column 1), or to have ever been immunized against polio, measles, BCG and DPT (columns 2 to 5). With the exception of the polio vaccine at birth, high estimated HIV prevalence in the year of birth is significantly associated with ever having been immunized – remembering that a negative number is associated with higher vaccination rates (row 1). However, within regions over time, children in regions of high HIV prevalence are significantly less likely to be vaccinated against any of these diseases. Relative to children born in a particular region with zero HIV prevalence in 1988, those born in the same region in 2005 would be almost 30 percentage points less likely to be immunized against polio, measles and DPT, and 20 percentage points less likely to be immunized against BCG if the prevalence rate had risen to 10 percent in 2005.[7] This lack of immunization is occurring in areas in which individuals are quite vulnerable – in Kenya, for example, news has been released of the first reported case of polio in the past 20 years (Associated Press, February 25, 2009).

[7] Our results on vaccines are robust to additionally including country-by-year fixed effects.

In summary, it appears that regions that are bearing the heaviest HIV burdens have become less able to care for pregnant women, provide trained attendants for birth deliveries, and immunize children.

These results are built on the assumptions that HIV prevalence has increased linearly over time since 1980, and that prevalence has a linear relationship with our health care measures of interest. To check the robustness of our results to the assumption that the epidemic started in 1980, we repeat the analyses described above, but assumed that HIV prevalence increased linearly from 1985 rather than 1980. In models with country-region fixed effects, this change has the effect of reducing the coefficients (in absolute value) so that HIV prevalence has a smaller association with each of the health outcomes. However, the reductions are not large. For example, the coefficient on prevalence in the regression for antenatal care declines in absolute value from –1.73 (as shown in Table 5) to –1.42. The coefficient on prevalence in the regression for "no polio vaccine at birth" falls from 7.02 (as shown in Table 7) to 5.56. All coefficients remain statistically significant.

Next, we completely relax these assumptions of linearity, by estimating models of the form of equation (3), reproduced here for convenience:

$$(3) \quad y_{irt} = \delta_r^* + \gamma_t^* + \beta_t^* H_{r\tau} + \alpha^* X_{irt} + \varepsilon_{irt}\,.$$

Our estimates are shown graphically. Specifically, after estimating equation (3) for each health outcome, we predict what the value of the outcome would be in each birth year, for four HIV prevalence rates ($H_{r\tau}$ equal to 0, 5, 10 and 20 percent.) For these predictions, the region fixed effects δ_r^* are averaged across all regions, and values of X_{irt} are replaced by their grand sample means. We then graph the predicted values of the outcomes over time, at the four prevalence levels. To interpret these graphs, it is important to note that we have set 1997 to be

the omitted birth-year category for both γ_t^* and β_t^*, so that predicted values are equal, by definition, in 1997 for all prevalence rates. Specifically, the predicted value in 1997 will equal:

$$\hat{y}_{1997} = \frac{1}{R}\sum_{r=1}^{R} \hat{\delta}_r^* + \hat{\alpha}^* \bar{X}$$

Although this normalization vertically "centers" the graphed lines around realistic values of the outcomes, it should be kept in mind that this normalization is arbitrary. Indeed, as shown in Tables 2 through 4, average values of the health care outcomes differ widely across countries. Our interest is not particularly in the levels of predicted values, but rather how predicted values change over time, and how these changes vary with $H_{r\tau}$. It is also important to keep in mind that, in the discussion of these estimates, "HIV prevalence" refers to $H_{r\tau}$, the actual prevalence in a region, measured using data from the most recent DHS survey.

Figure 4 shows results for the indicator of whether the mother received antenatal care. Consistent with the estimates of equation (2), the figure indicates that in low prevalence regions, the use of antenatal care increased over time—by approximately 20 percentage points from 1988 to 2005. However, this upward trend is less pronounced for higher prevalence rates. At 20 percent prevalence, antenatal care is relatively constant from 1988 to 1995, and then declines by approximately 5 percentage points. Test statistics from the regression underlying Figure 4 are shown in the first row of Table 8. These indicate that the hypothesis that the birth year effects γ_t^* are jointly insignificant can be rejected, as can the hypothesis that the birth year/HIV prevalence interactions β_t^* are jointly insignificant.

The last column in Table 8 shows the results of tests of the hypothesis that the birth year/HIV prevalence interactions follow a linear trend—or, in other words, that the parameter restrictions imposed in equation (4) are valid. This hypothesis is rejected. This is not surprising,

given that the changes in antenatal care at different prevalence rates shown in Figure 4 do not begin to diverge until the late-1990's. The rejection of the hypothesis of a linear trend could be due to two factors. First, it could be that the evolution of HIV prevalence was non-linear. Second, it could be that the adverse effects of HIV on antenatal care have increased since the mid-1990's. Without data on HIV prevalence over time, we cannot distinguish between these two factors.

Results for the procedures women receive during antenatal care are shown in Figure 5. Consistent with the results in Table 5, differences in all of these procedures are apparent across high and low HIV prevalence regions, with the largest differences observed for urine tests and blood pressure. The use of blood tests is predicted to decline for all HIV prevalence rates shown, although more so for high HIV regions. The linearity restrictions are also rejected for these measures of care.

Results for delivery care, in Figure 6, indicate that the largest differences across higher and lower HIV prevalence regions occur for the presence of a trained birth attendant. At 20 percent prevalence, the presence of a trained birth attendant declines almost continuously, by more than 15 percentage points from 1988 to 2005. At zero prevalence, the presence of a trained birth attendant declines from 1988 to 1993, before leveling off and then increasing after 1999. Consistent with the results in Table 6, there are smaller differences across high and low prevalence regions for the indicators for whether the mother delivered in a clinic, whether clinic deliveries occurred in a public clinic, and whether trained attendants were present for clinic deliveries.

Results for children's vaccines are presented in Figures 7 and 8. In high HIV regions, mothers were increasingly likely to report that their child had not received a polio vaccine

shortly after birth. For example, at 10 percent prevalence, the fraction of mothers who report no vaccine is estimated to have increased by 20 percentage points from 1993 to 2005. In contrast, low HIV prevalence regions made gains in vaccinating children against polio shortly after birth. The figures for the other vaccines are noisier, but show the same general pattern.

Overall, the estimates of the less restrictive models, using equation (3), are consistent with those reported in Tables 5 to 7: regions with high HIV prevalence rates experienced greater deterioration in antenatal care, and larger declines in the use of trained birth attendants and vaccinations, relative to low HIV regions. Estimates of the less restrictive models also allow us to date when health care quality began to diverge across higher and lower HIV regions. For both the use of antenatal care and for children's vaccines, this divergence began in the mid-1990s. This timing is also consistent with reports issued about deterioration in health care delivery in sub-Saharan Africa in the mid-1990s, summarized by the Lancet (1995).

5. Discussion

There are several possible, non-competing explanations for the deterioration of non-HIV related health services observed in high prevalence regions. AIDS may have affected access to care. AIDS may also have reduced the demand for non-HIV related health services through its effect on households' incomes. Alternatively, AIDS may have had little effect on demand for care, or access to care, but have had a large effect on the quality of care available. We discuss these in turn.

Access to care

AIDS-related illnesses may have crowded out access to medical care between 1995 and 2005. This would have been prior to the arrival of antiretroviral therapy in nearly all regions, and it is possible that the high morbidity rates among those infected with HIV took an ever larger toll on access to care. High HIV burdens may have reduced funding for non-HIV-related medical care, producing closures of clinics or reductions in the range of services offered. Alternatively, high HIV burdens could put upward pressure on user fees charged for non-HIV related services.

The DHS surveys provide some information on the problems women experienced with access to services. Specifically, in the most recent surveys for all countries we examine (with the exception of Kenya), mothers are asked about problems they face accessing medical care. Specifically, they are asked which of the following items were "a big problem with access to medical care": (1) not knowing where to go for care; (2) the distance required to get to care; (3) the lack of money to pay for medical care; and (4) the lack of transportation to get to a facility. If HIV burdens were responsible for forcing women to travel farther, or spend more to attend clinics, we would expect to see a difference in responses among women in West Africa, where HIV rates are low, and those in East and Southern Africa, where rates are high.

Tabulations of responses to these questions are in Table 9. For each outcome, we find a uniform pattern across countries. Approximately 10 to 20 percent of women report not knowing where to go for medical care; 40 percent report that distance is a problem; 60 percent say money is an issue; and 40 percent say transportation is a problem. However, there is no divide between high and low HIV countries. We also ran regressions of each of these variables on HIV prevalence in the region, and a set of country indicators, and found no evidence that mothers living in high-prevalence regions within countries reported worse access to care.

This result—that access to care measures are similar across low- and high-HIV countries and regions within countries—provides suggestive but not conclusive evidence that HIV has not altered access to care. It is possible that high-HIV countries (or regions within countries) had better access to care prior to the HIV crisis, and that they have experienced more rapid deteriorations in these measures of access. Indeed, our results on health care use presented earlier indicate that, without controlling for region fixed effects, health care measures often look better in high-HIV regions. However, once country-region fixed effects are included—so we are essentially looking at changes over time within regions—we see a negative association between HIV prevalence and health care. The same could be true for access to care. As more rounds of DHS data are collected, it will be possible to examine within-region changes in access measures.

Demand for health services

Households in high-HIV regions may have become poorer, because of lost income due to illness, increases in funeral expenses, or greater demands on household resources that result from having to care for orphans. Lower wealth could, in turn, be responsible for the deterioration in health care in high-HIV regions. If so, we would expect that the estimated associations between regional prevalence and health care will become smaller, in absolute value, when we control for household wealth.

The DHS surveys do not contain measures of financial wealth. However, they do collect information on household assets – ownership of bicycles, refrigerators, and radios, for example. We construct a measure of household assets equal to the sum of indicators for the ownership of a radio, television, refrigerator, bicycle, motorcycle and car. We first examine whether asset ownership declined with HIV prevalence within regions. To test whether the HIV-prevalence

effect might be working through household resources, we re-ran equation (2), including a control for the number of assets. We also estimated variants that included indicators for ownership of each of the six assets separately.

Our results do not support the hypothesis that declines in wealth (as measured by assets) in high-HIV regions account for the deterioration in the quality of health care. It is not the case that the asset index declined significantly over time in high-HIV regions. Using a sample of mothers (rather than births), we regressed the asset index on a set of survey year indicators, country-region indicators, mother's age and education, an indicator for urban status, and estimated HIV prevalence in the survey year. The coefficient on HIV prevalence was positive (0.919) rather than negative, although not significantly different from zero. The samples are somewhat smaller than those used previously, since some waves of data did not contain comparable asset information. However, in all cases, the addition of asset information has only small effects on the coefficient on HIV prevalence.

Our results might be explained by HIV positive mothers being less likely to seek antenatal and other medical care, either because they are ill, or because they are poorer due to illness, or because clinics do not welcome them. We can explore this, using the last round of DHS data for each of the countries in our sample, because in those datasets we know whether mothers are HIV positive. We estimated regressions as in equation (2) for antenatal care, birth deliveries and children's immunizations, which included a set of country-region fixed effects and an indicator for whether the woman was HIV positive. We find that HIV positive mothers are 1.5 percentage points more likely to report having had antenatal care, with or without a control for the estimated regional HIV prevalence in the child's birth year. Similarly, with or without controls for regional prevalence, HIV positive mothers are also significantly more likely to report

having had urine and blood tested, and blood pressure taken. They are 3.5 percentage points more likely to report a clinic delivery, and 3 percentage points more likely to report the presence of a trained professional at the delivery. Children of HIV positive mothers are no more or less likely than other children to have been immunized against polio, measles, BCG and DPT. We take this as evidence against lower demand for health care by HIV positive mothers. If anything, the results suggest that HIV positive women are more likely than others to seek medical care during pregnancy, or are given higher priority and better service in clinics.

Quality of health services

Our parametric and semi-parametric results suggest that the quality of services available plays a large role in the decline in care we observe in our data. Women who attend antenatal care clinics are receiving significantly fewer diagnostic tests during their visits – even tests as inexpensive as having weight taken. Those who report delivering children in clinics are significantly less likely to have a trained attendant at the delivery.

These declines in quality could be due to a reduction in the supply of trained personnel as a consequence of the pandemic, or to a redirection of funds for supplies and trained medical professionals to care for HIV patients. The latter interpretation is consistent with findings of a qualitative-quantitative study conducted in Malawi and Ethiopia among health workers and NGOs, which found the introduction of support from the Global Fund to Fight AIDS, Malaria and Tuberculosis has led "to an increasing focus on the three focal diseases, rather than increased attention to broader health systems strengthening. As a result, existing health system challenges have been overlooked in many cases, and to some extent, other health priorities have been overshadowed" (Schott, Stillman and Bennett 2005, page 39).

Grépin (2009) examines whether the influx of foreign aid earmarked to HIV/AIDS exacerbated a diversion of resources away from non-AIDS health care. Using data from 1990 to 2006, she finds a negative association between country's receipt of foreign aid for HIV/AIDS and measures of the quality of care. However, it is unlikely that the expansion of AIDS-targeted foreign aid explains a large part of what we see in our data. Grépin's numbers indicate that foreign aid for AIDS grew little until the year 2000, and then escalated rapidly as funds for ART became available through PEPFAR and other programs. This pattern is consistent with increases in access to ART. The number of people in Sub-Saharan Africa receiving ART is estimated to have been only 100,000 in 2003, but then rose to 1.375 million in 2006, and 2.12 million in 2007 (World Health Organization, 2008). Our results indicate that the divergence in the quality of care between high- and low-AIDS regions began in the early- to mid-1990's, before foreign aid for AIDS was significant, and when very few Africans were receiving ART. The expansion of ART is so recent that the data needed to examine its effects on health services are not yet available.

6. Conclusions

The next round of DHS data sets will be in the field after the arrival of ART in many regions of Africa. When these data sets become available, it may be possible to assess whether ART improves the quality of care received by pregnant women and children– either directly, through provision of resources for medical care more broadly – or indirectly, through a reduction in morbidity among HIV positive patients, or whether it crowds out non-AIDS-related medical care. Unfortunately, women and children in sub-Saharan Africa cannot wait for another round of

DHS surveys to come on line. We must find alternative ways to investigate the roots of this erosion in services.

In the interim, care providers should take into account the fact that medical care in high prevalence regions has not been adequate since the mid-1990s, which may affect the diseases children face (measles, polio, DPT) and the quality of the care their mothers receive during pregnancy and delivery.

References

Associated Press. 2009. "Kenya toddler is first polio infection in 20 years." accessed online on February 28, 2009 at http://www.nytimes.com/aponline/2009/02/25/world/AP-AF-Kenya-Polio.html?_r=1 .

Colvin, Mark. 2005. "Impact of AIDS – the health care burden." Chapter 22 in *HIV/AIDS in South Africa,* Salim Karim and Quarraisha Karim (eds.), Cambridge University Press. 336-350.

Easterly, William. 2008. "Can the West save Africa?" National Bureau of Economic Research Working Paper 14363, forthcoming in the *Journal of Economic Literature*.

Grépin, Karen.2009. "Too much of a good thing? The effects of HIV/AIDS funding on African health systems." Harvard University, manuscript.

Jones, Gareth, Richard W. Steketee, Robert E. Black, Zulfiqar A. Bhutta, Saul S. Morris and the Bellagio Child Survival Study Group. 2003. "How many child deaths can we prevent this year?" *Lancet* 362(9377): 65-71.

Lancet. 1995. "Impact of HIV delivery of health care in sub-Saharan Africa: A tale of secrecy and inertia" [editorial]. 345(8961): 1315-7.

McIntyre, Diane, Michael Thiede, Göran Dahlgren, and Margaret Whitehead. 2006. "What are the economic consequences for households of illness and of paying for health care in low- and middle-income country contexts?" *Social Science & Medicine* 62(4): 858-65.

Quinn, Thomas C., Jonathan M. Mann, James W. Curran, and Peter Piot. 1986. "AIDS in Africa: An epidemiologic paradigm." *Science* 234: 955-963.

Schott, Whitney, Kate Stillman, and Sara Bennett. September 2005. *Effects of the Global Fund on Reproductive Health in Ethiopia and Malawi: Baseline Findings.* Bethesda, MD: The Partners for Health Reform*plus* Project, Abt Associates Inc.

The World Bank. 2009. *Improving Effectiveness and Outcomes for the Poor in Health, Nutrition, and Population: An Evaluation of the World Bank Group Support Since 1997*. Washington D.C.

World Health Organization. 2008. *Towards Universal Access: Scaling Up Priority HIV/AIDS Interventions in the Health Sector.* Geneva: World Health Organization.

Appendix Table 1: Type of births for which variables are available in all survey rounds.

	Most Recent Birth Only	All Births, Last Five Years	All Births, Last Three Years
Antenatal Care	BF4,CM4, ET4, ET3, GH4, GN4, KE4, ML5, ML4, MW4, MW3, NI5, SN4, TZ4, TZ2, ZM4, ZW5, ZW4	BF3,BF2, CI5, CI4, CM2, GH3, GN3, KE2, MW2, NI2, SN2, SN1, TZ1, ZM3, ZM2	CI3, CM3, GH2, KE3, ML3, NI3, ZW3
Antenatal Procedures	CM4, BF4, ET4, ET3, GH4, GN4, KE4, ML5, ML4, MW4, MW3, NI5, SN4, TZ4, ZM4, ZW5, ZW4	GH3	
Polio vaccine shortly after birth		BF4(alive only), B3(alive only), CI4 (alive only), CM4 (alive only), ET4(alive only), ET3 (alive only), GH4(alive only), GH3 (alive only), GN4 (alive only), GN3(alive only), KE4 (alive only), ML5 (alive only), ML4 (alive only), MW4(alive only), MW3 (alive only), NI5 (alive only), NI2 (all), SN4 (alive only), TZ4 (alive only), TZ2 (alive only), TZ1 (alive only), ZM4 (alive only),	CM3 (alive only), KE3(alive only), ML3 (alive only), NI3 (alive only)
Vaccines other than Polio shortly after birth		BF4(alive only), B3(alive only), BF2(all), CI4 (alive only), CM4(alive only), CM2(all), ET4(alive only), ET3 (alive only), GH4 (alive only), GH3(alive only), GN4 (alive only), GN3(alive only), KE4(alive only), KE2(all), KE1(alive only), ML5 (alive only), ML4 (alive only), MW4 (alive only), MW3 (alive only), MW2 (all), NI5 (alive only), NI2 (all), SN4 (alive only), SN1 (all), SN (alive only), TZ4 (alive only), TZ2 (alive only), TZ1 (alive only), ZM4 (alive only), ZM3 (alive only), ZM2 (all), ZW5 (alive only), ZW4 (alive only), ZW2(alive only)	CI3 (alive only), CM3 (alive only), GH2(all), KE3(alive only), ML3 (alive only), NI3 (alive only), ZW3 (alive only)
Trained birth attendant		BF4, BF3, BF2, CI5, CI4, CM4, CM2, ET4, ET3, GH4, GH3, GN4, GN3, KE4, KE2, KE1, ML5, ML4, MW4, MW3, MW2, NI5, NI2, SN4, SN2, SN1, SN, TZ4, TZ2, TZ1, ZM4, ZM3, ZM2, ZW5, ZW4, ZW2,	CI3, CM3, GH2, KE3, ML3, NI3, ZW3
Place of delivery		BF4, BF3, BF2, CI5, CI4, CM4, CM2, ET4, ET3, GH4, GH3, GN4, GN3, KE4, KE2, KE1, ML5, ML4, MW4, MW3, MW2, NI5, NI2, SN4, SN2, SN1, TZ4, TZ2, TZ1, ZM4, ZM3, ZM2, ZW5, ZW4, ZW2,	CI3, CM3, GH2, KE3, ML3, NI3, ZW3

Notes: BF=Burkina Faso, CM=Cameroon, CI=Cote d'Ivoire, ET=Ethiopia, GH=Ghana, GN=Guinea, KE=Kenya, MW=Malawi, ML=Mali, NI=Niger, SE=Senegal, TZ=Tanzania, ZM=Zambia, ZW=Zimbabwe. Numbers are each country code refer to the survey wave, as defined by DHS.

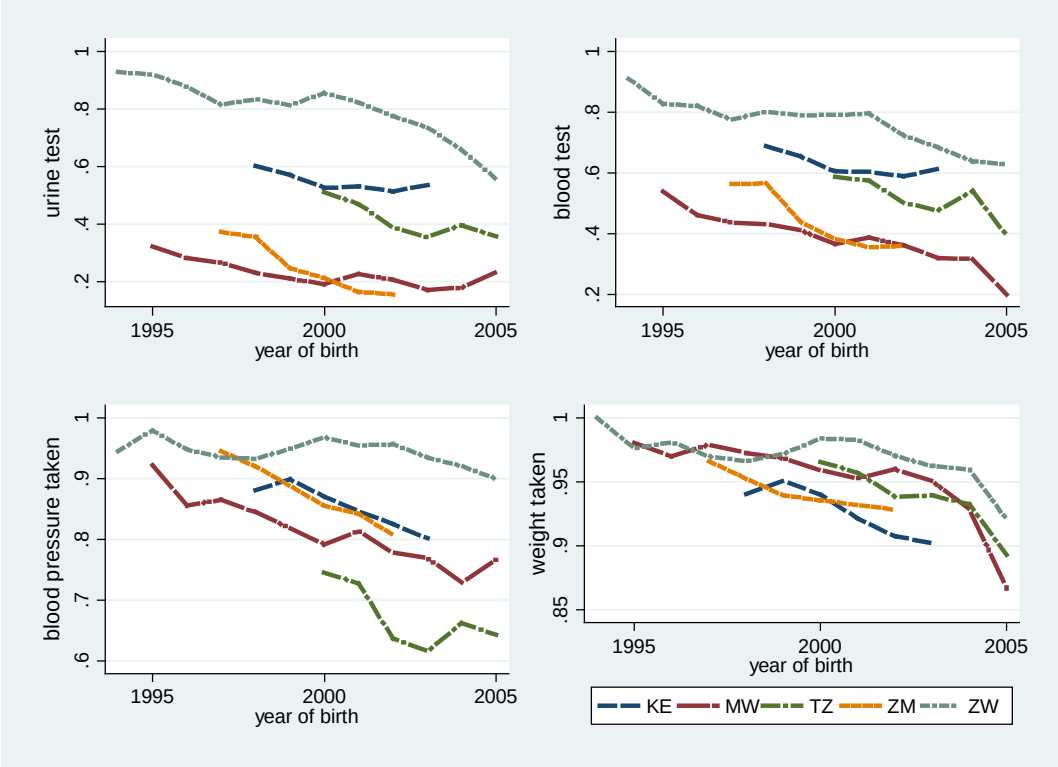

Figure 1. Prenatal care in high prevalence countries: urine tests, blood tests, blood pressure taken and weight taken, by country and birth year

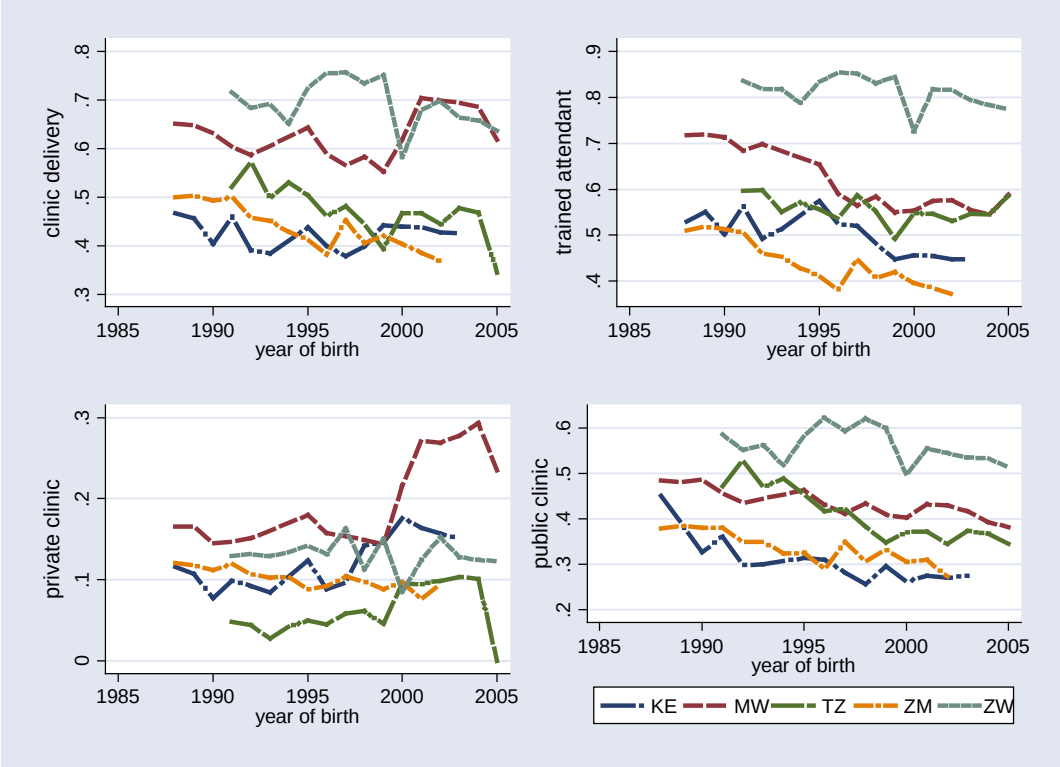

Figure 2. Birth deliveries in high prevalence countries: delivery in a clinic, attended by a trained professional, delivery in a private clinic, and delivery in a public clinic, by country and birth year

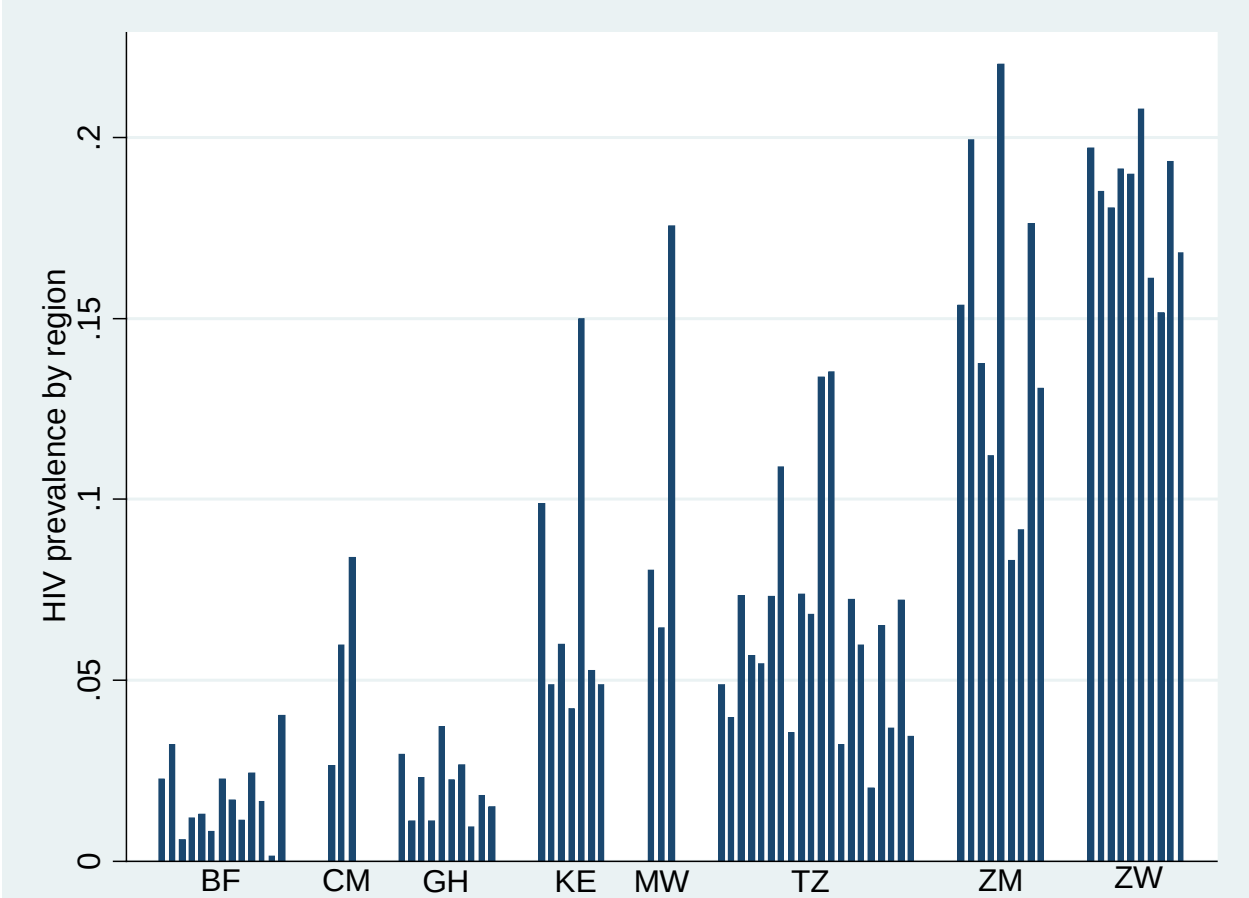

Figure 3. Regional HIV prevalence rates for selected countries
Notes: Burkina Faso (BF); Cameroon (CM); Ghana (GH); Kenya (KE); Malawi (MW); Tanzania (TZ); Zambia (ZM) and Zimbabwe (ZW)

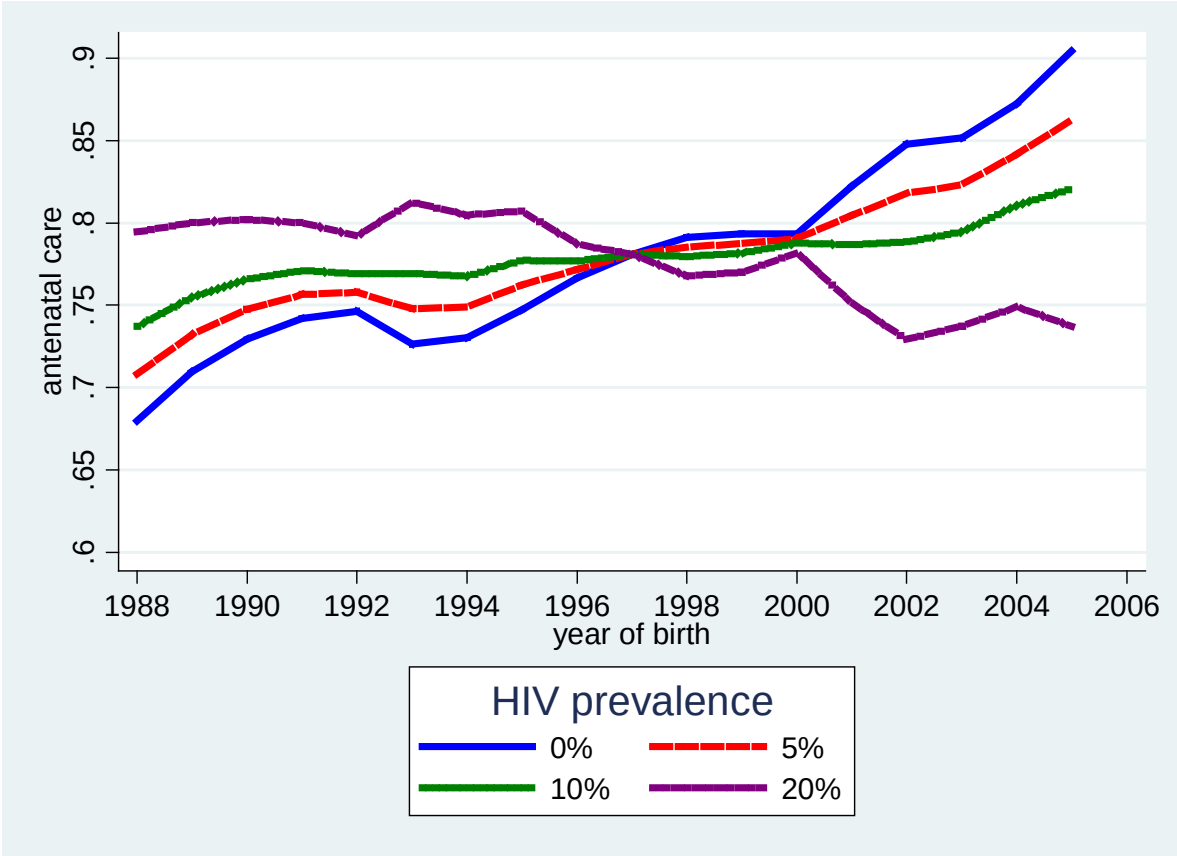

Figure 4: Predicted changes in antenatal care, by HIV prevalence

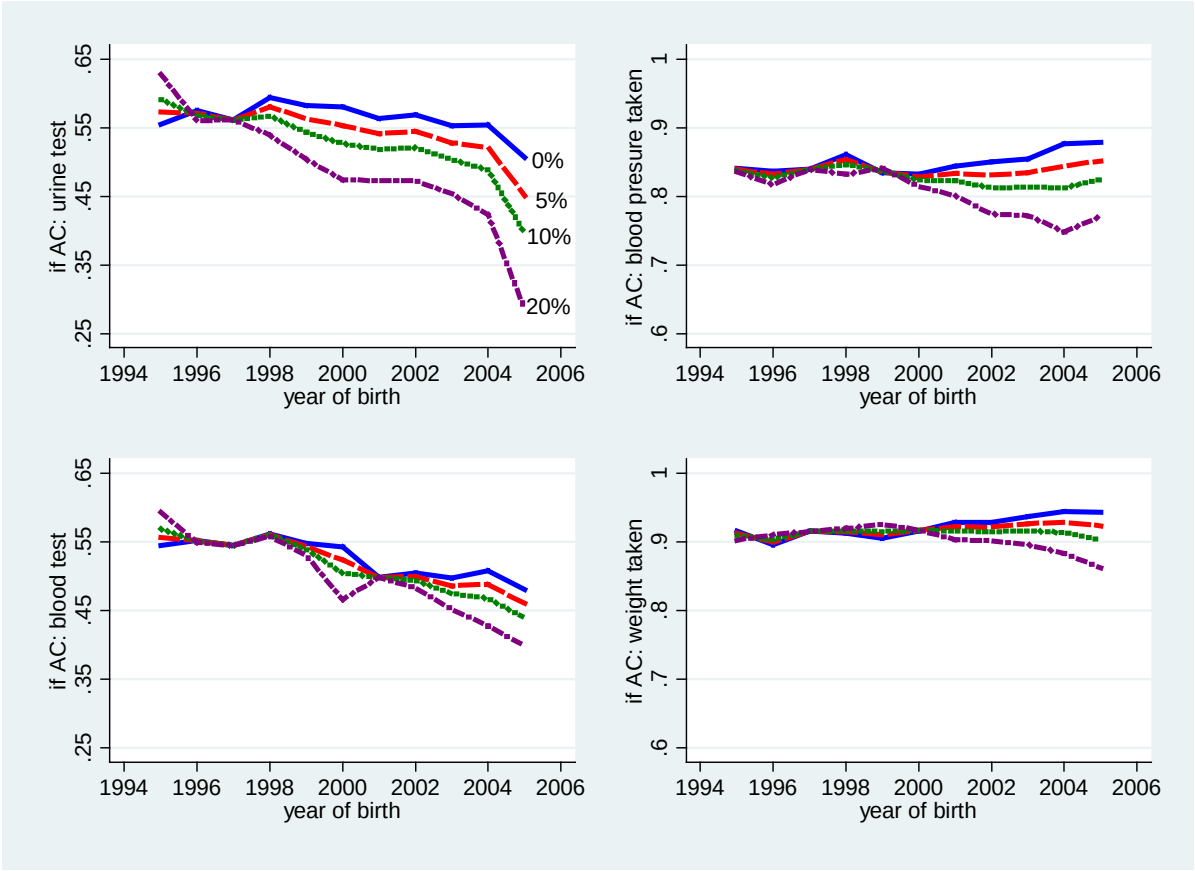

Figure 5: Predicted changes in antenatal services, by HIV prevalence

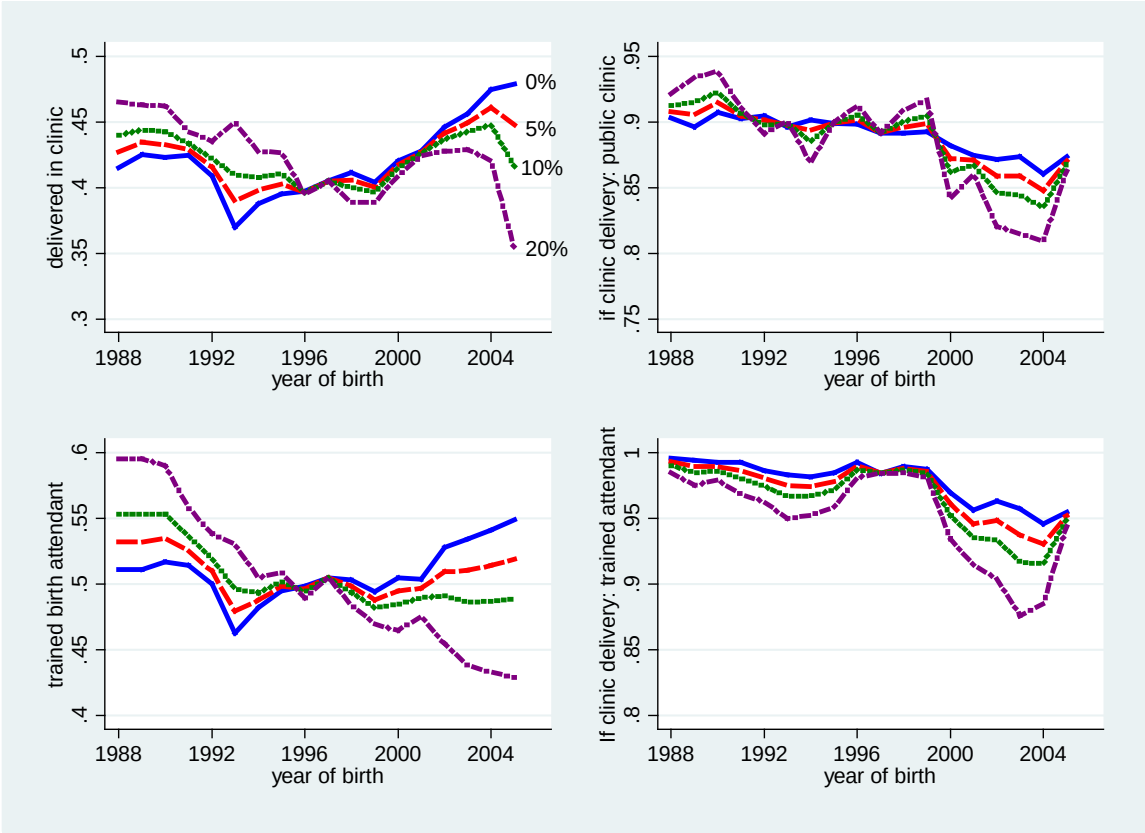

Figure 6: Predicted changes in care at birth, by HIV prevalence

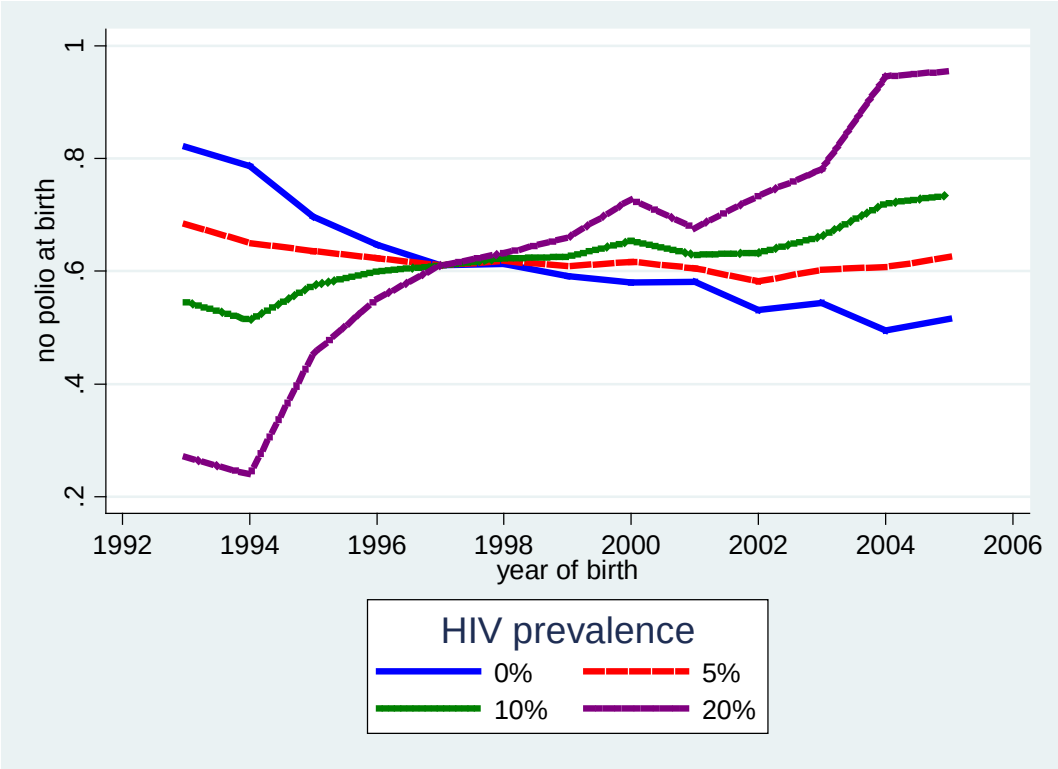

Figure 7: Predicated changes in “no polio vaccine shortly after birth,” by HIV prevalence

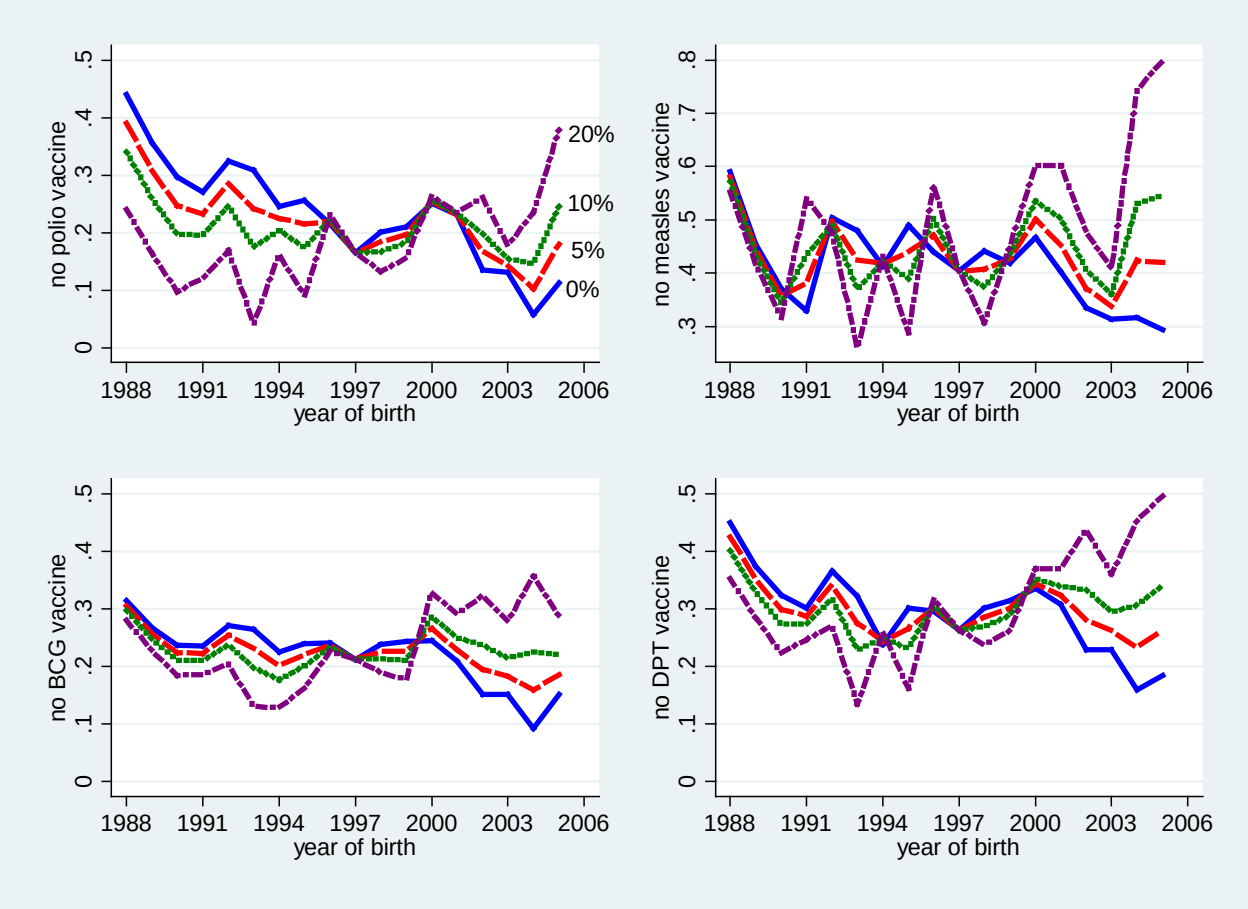

Figure 8: Predicted changes in “no vaccination,” by HIV prevalence

Table 1. Demographic and Health Survey Datasets

	Burkina Faso	**Cameroon**	**Cote d'Ivoire**	**Ethiopia**	**Ghana**
Survey year	1992-93	1991	1994		1993-94
[Birth years]	[1988-93]	[1988-91]	[1991-94]		[1990-94]
(obs)	(5828)	(2319)	(3998)		(2204)
Survey year	1998-99	1998	1998-99	2000	1998-99
[Birth years]	[1994-99]	[1995-98]	[1993-99]	[1995-00]	[1993-99]
(obs)	(5950)	(2317)	(1992)	(10873)	(3298)
Survey year	2003	2004	2005	2005	2003
[Birth years]	[1998-03]	[1999-04]	[2000-05]	[2000-05]	[1998-03]
(obs)	(10645)	(8113)	(3633)	(9861)	(3844)
# of regions	13	3	9	11	10
	Guinea	**Kenya**	**Malawi**	**Mali**	**Niger**
Survey year		1988-89			
[Birth years]		[1988-89]			
(obs)		(1769)			
Survey year		1993	1992	1995-96	1992
[Birth years]		[1988-93]	[1988-92]	[1992-96]	[1988-92]
(obs)		(6115)	(4326)	(6030)	(6141)
Survey year	1999	1998	2000	2001	1998
[Birth years]	[1994-99]	[1995-98]	[1995-00]	[1996-01]	[1995-98]
(obs)	(5825)	(3531)	(11926)	(13091)	(4798)
Survey year	2005	2003	2004-05	2006	2006
[Birth years]	[2000-05]	[1998-03]	[1999-05]	[2001-05]	[2001-05]
(obs)	(6363)	(5495)	(10912)	(12285)	(8638)
# of regions	5	7	3	9	6
	Senegal	**Tanzania**	**Zambia**	**Zimbabwe**	
Survey year	1992-93	1996	1992	1994	
[Birth years]	[1988-93]	[1991-96]	[1988-92]	[1991-94]	
(obs)	(5642)	(6169)	(5438)	(2436)	
Survey year	1997	1999	1996-97	1999	
[Birth years]	[1992-97]	[1994-99]	[1991-96]	[1994-99]	
(obs)	(7372)	(2406)	(7246)	(3640)	
Survey year	2005	2004-05	2001-02	2005-06	
[Birth years]	[2000-05]	[1999-05]	[1996-02]	[2000-05]	
(obs)	(10944)	(6923)	(6862)	(5220)	
# of regions	4	20	9	10	

Table 2. Antenatal care

		If antenatal care:				
	Any antenatal care	Urine test	Blood pressure	Blood test	Weight taken	Observations (antenatal care)
Burkina Faso	0.649	0.789	0.955	0.360	0.982	18754
Cameroon	0.816	0.839	0.940	0.824	0.960	9737
Cote d'Ivoire	0.869	n.a.	n.a.	n.a.	n.a.	9341
Ethiopia	0.276	0.239	0.657	0.255	0.696	13720
Ghana	0.900	0.847	0.949	0.871	0.930	8062
Guinea	0.774	0.600	0.873	0.428	0.883	9785
Kenya	0.944	0.503	0.836	0.579	0.919	12971
Malawi	0.948	0.220	0.805	0.397	0.956	19309
Mali	0.583	0.548	0.866	0.403	0.932	20629
Niger	0.386	0.391	0.881	0.371	0.962	16202
Senegal	0.859	0.827	0.977	0.567	0.952	19620
Tanzania	0.974	0.413	0.656	0.541	0.944	12071
Zambia	0.953	0.248	0.866	0.444	0.935	16773
Zimbabwe	0.944	0.754	0.934	0.727	0.957	8831

Notes. Means are presented by country over all DHS waves. Means are weighted using sample weights. Observations are the number responding to the question of whether they had had any antenatal care.

Table 3. Birth deliveries

	Trained professional	Delivery at a clinic	Public clinic	Private clinic	Trained professional, if clinic delivery	Observations (trained professional)
Burkina Faso	0.545	0.381	0.373	0.008	0.988	22408
Cameroon	0.617	0.590	0.426	0.164	0.997	12699
Cote d'Ivoire	0.490	0.510	0.498	0.012	0.991	5990
Ethiopia	0.110	0.051	0.047	0.004	0.992	20690
Ghana	0.649	0.442	0.340	0.102	0.992	5483
Guinea	0.388	0.302	0.289	0.012	0.975	12076
Kenya	0.502	0.426	0.323	0.120	0.993	16845
Malawi	0.578	0.610	0.411	0.199	0.916	27088
Mali	0.438	0.407	0.392	0.014	0.987	31273
Niger	0.359	0.169	0.165	0.004	0.991	19465
Senegal	0.494	0.542	0.503	0.039	0.867	23872
Tanzania	0.537	0.471	0.402	0.069	0.963	15432
Zambia	0.471	0.467	0.365	0.102	0.992	19497
Zimbabwe	0.816	0.704	0.573	0.131	0.997	11267

Notes. Means are presented by country over all DHS waves. Means are weighted using sample weights. Observations are the number responding to the question of whether a trained professional attended the birth.

Table 4. Children's immunizations

	Indicator: Child was **not** immunized against:					
	Polio at birth	Polio	Measles	BCG	DPT	Observations (DPT)
Burkina Faso	0.497	0.249	0.462	0.252	0.297	20252
Cameroon	0.408	0.189	0.475	0.220	0.274	11707
Cote d'Ivoire	0.908	0.278	0.536	0.271	0.363	5392
Ethiopia	0.876	0.295	0.708	0.517	0.556	18546
Ghana	0.561	0.162	0.371	0.168	0.180	8753
Guinea	0.475	0.285	0.512	0.254	0.316	10635
Kenya	0.397	0.117	0.338	0.098	0.117	14413
Malawi	0.589	0.116	0.307	0.121	0.115	24536
Mali	0.550	0.271	0.466	0.295	0.323	26877
Niger	0.751	0.473	0.664	0.523	0.567	18046
Senegal	0.543	0.191	0.396	0.163	0.201	15714
Tanzania	0.548	0.093	0.307	0.085	0.297	13929
Zambia	0.881	0.118	0.306	0.095	0.132	17568
Zimbabwe	n.a.	0.242	0.398	0.179	0.250	10480

Notes. Means are presented by country over all DHS waves, with the exception of the measure of "no polio vaccine at birth." Because only 2 DHS waves conducted earlier than 1992/1993 collected information on this vaccine, means are computed over children born from 1993 onward. Means are weighted using sample weights. Observations are the number responding to the question of whether the child had received a DPT vaccine.

Table 5. Antenatal care and HIV prevalence

		If had antenatal care:			
	Had antenatal care	Urine test	Blood test	Blood pressure	Weight taken
Mean of dependent variable	[0.755]	[0.528]	[0.506]	[0.858]	[0.932]
HIV prevalence in year of birth	2.601 (0.021)	–1.477 (0.034)	0.384 (0.034)	–0.293 (0.024)	0.241 (0.017)
Indicators for year of birth	yes	yes	yes	yes	yes
Country/region fixed effects	no	no	no	no	no
Mother and child characteristics	no	no	no	no	no
HIV prevalence in year of birth	–1.734 (0.074)	–2.220 (0.254)	–1.214 (0.273)	–2.058 (0.203)	–1.403 (0.148)
Indicators for year of birth	yes	yes	yes	yes	yes
Country/region fixed effects	yes	yes	yes	yes	yes
Mother and child characteristics	yes	yes	yes	yes	yes
Observations	177785	68867	68830	68880	68923
Range of birth years	1988-2005	1995-2005	1995-2005	1995-2005	1995-2005

Notes: Ordinary Least Squares estimates. The mean of the dependent variable, calculated using sample weights, is in square brackets. Standard errors are in parentheses. Mother and child characteristics include the mother's education in years, the mother's age in years, the child's age in months, an indicator for the child's sex, and an indicator of whether the family lived in an urban area.

Table 6. Care at delivery and HIV prevalence

	Delivered in a public or private clinic	If delivered in a clinic, clinic was public	Had a trained birth attendant	If delivered in a clinic, had a trained birth attendant
Mean of dependent variable	[0.419]	[0.843]	[0.475]	[0.961]
HIV prevalence in year of birth	2.214 (0.023)	–1.561 (0.023)	1.794 (0.024)	0.083 (0.013)
Indicators for year of birth	yes	yes	yes	yes
Country/region fixed effects	no	no	no	no
Mother and child characteristics	no	no	no	no
HIV prevalence in year of birth	–0.768 (0.085)	–0.509 (0.094)	–1.353 (0.087)	–0.303 (0.052)
Indicators for year of birth	yes	yes	yes	yes
Country/region fixed effects	yes	yes	yes	yes
Mother and child characteristics	yes	yes	yes	yes
Observations	221421	98360	216901	95095
Range of birth years	1988-2005	1988-2005	1988-2005	1988-2005

Notes: Ordinary Least Squares estimates. The mean of the dependent variable, calculated using sample weights, is in square brackets. Standard errors are in parentheses. Mother and child characteristics include the mother's education in years, the mother's age in years, the child's age in months, an indicator for the child's sex, and an indicator of whether the family lived in an urban area.

Table 7. Child immunizations and HIV prevalence

	no polio vaccine at birth	no polio vaccine	no measles vaccine	no BCG vaccine	no DPT vaccine
Mean of dependent variable	[0.602]	[0.222]	[0.448]	[0.242]	[0.291]
HIV prevalence in year of birth	0.081 (0.030)	–0.960 (0.019)	–1.270 (0.023)	–1.488 (0.020)	–1.498 (0.021)
Indicators for year of birth	yes	yes	yes	yes	yes
Country/region fixed effects	no	no	no	no	no
Mother and child characteristics	no	no	no	no	no
HIV prevalence in year of birth	7.018 (0.224)	2.708 (0.077)	2.767 (0.087)	2.021 (0.077)	2.657 (0.082)
Indicators for year of birth	yes	yes	yes	yes	yes
Country/region fixed effects	yes	yes	yes	yes	yes
Mother and child characteristics	yes	yes	yes	yes	yes
Observations	157395	212266	211582	212361	212260
Range of birth years	1993-2005	1988-2005	1988-2005	1988-2005	1988-2005

Notes: Ordinary Least Squares estimates. The mean of the dependent variable, calculated using sample weights, is in square brackets. Standard errors are in parentheses. Mother and child characteristics include the mother's education in years, the mother's age in years, the child's age in months, an indicator for the child's sex, and an indicator of whether the family lived in an urban area.

Table 8. Tests for models with HIV prevalence/birth year interactions

dependent variable:	Test: birth year effects jointly insignificant F (p-value)	Test: birth year/HIV prevalence interactions jointly insignificant F (p-value)	Test: birth year/HIV interactions follow linear trend F (p-value)
Had antenatal care (AC)	154.52 (0.000)	44.04 (0.000)	5.34 (0.000)
If AC: urine test	8.20 (0.000)	12.03 (0.000)	3.43 (0.000)
If AC: blood pressure	5.99 (0.000)	12.39 (0.000)	3.04 (0.001)
If AC: blood test	8.20 (0.000)	4.45 (0.000)	2.47 (0.008)
If AC: weight taken	7.24 (0.000)	10.48 (0.000)	2.65 (0.005)
Delivered in public or private clinic	35.20 (0.000)	9.04 (0.000)	3.47 (0.000)
If delivered in a clinic: clinic was public	4.93 (0.000)	4.57 (0.000)	2.82 (0.000)
Had trained birth attendant	14.98 (0.000)	18.46 (0.000)	1.39 (0.137)
If delivered in a clinic: had trained birth attendant	19.90 (0.000)	9.21 (0.000)	7.16 (0.000)
No polio vaccine at birth	143.13 (0.000)	98.50 (0.000)	15.79 (0.000)
No polio vaccine at birth	136.43 (0.000)	92.15 (0.000)	15.30 (0.000)
No polio vaccine	300.19 (0.000)	105.45 (0.000)	27.61 (0.000)
No measles vaccine	180.45 (0.000)	173.20 (0.000)	122.49 (0.000)
No BCG vaccine	124.08 (0.000)	77.09 (0.000)	33.26 (0.000)
No DPT vaccine	152.61 (0.000)	103.20 (0.000)	41.84 (0.000)

Note: Each row shows test statistics from a regression of the dependent variable on a set of mother and child controls, regions/country controls, birth year indicators, and interactions between the birth year indicators and the HIV prevalence in the country/region from the most recent DHS survey (equation 3 in text). The results of these regressions are graphed in Figures 4-8.

Table 9. Problems accessing medical care

	Burkina Faso	Cameroon	Ethiopia	Ghana	Guinea	Malawi
	2003	2004	2005	2003	2005	2004-05
A big problem with access to medical care is:						
not knowing where to go	0.188	0.198		0.113	0.201	0.156
distance	0.464	0.387	0.677	0.328	0.551	0.600
money	0.630	0.657	0.756	0.548	0.733	0.616
transportation	0.404	0.371	0.716	0.332	0.512	0.549
Observations	12476	10638	14063	5689	7933	11686
	Mali	Niger	Senegal	Tanzania	Zambia	Zimbabwe
	2006	2006	2005	2004-05	2001-02	2005-06
A big problem with access to medical care is:						
not knowing where to go	0.210	0.169	0.104	0.063	0.070	
distance	0.384	0.512	0.362	0.376	0.455	0.414
money	0.526	0.650	0.534	0.399	0.664	0.578
transportation	0.363	0.507	0.354	0.372	0.474	0.422
Observations	14552	9203	14585	10319	7652	8894

Notes. Means are weighted using sample weights. Blank cells indicate the relevant question was not asked in the survey.