

**The impact of the AIDS pandemic on health services in Africa:
Evidence from Demographic and Health Surveys**

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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 the largest in regions that have developed the highest rates of HIV. 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 non-HIV related health services for pregnant women and children. Using semi-parametric techniques, we can date the beginning of the divergence in the use of antenatal care and in children's immunizations between high and low HIV regions to the mid-1990s.

1. Introduction

The AIDS crisis presents critical challenges to the health care systems of many countries in sub-Saharan Africa. On the supply side, the pandemic may compromise the ability of health systems to deliver care, as health professionals fall ill, or choose to leave for less-risky work elsewhere. The increase in morbidity that accompanies HIV may also change the nature of care offered by clinics and hospitals, reinforced by health budgets that may have 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).

AIDS may also affect 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).

In this paper, we examine whether the AIDS crisis has compromised 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 the largest in regions that have the highest rates of HIV prevalence. Regions of countries that have light HIV 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 non-HIV related health services for pregnant women and children. Using semi-parametric techniques, we can date the beginning of the divergence in the use of antenatal care and in children's immunizations between high and low HIV regions to the mid-1990s. For tests women report were conducted during antenatal care, data are only available beginning in the mid-1990s, and we observe divergence in outcomes throughout the time period under study for these results.

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. This section also contains a discussion of whether sample selection issues could bias our results, and whether it is reasonable to ascribe a causal interpretation to the associations we observe between HIV and health care delivery. Section 6 discusses ways in which future health service delivery may be affected by the arrival of antiretroviral therapy (ART).

2. Demographic and Health Survey Data

Demographic and Health Surveys (DHS) 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. We analyze data from 41 DHS surveys conducted between 1988 and 2006 in fourteen countries in sub-Saharan Africa.¹ We have data from nine African countries where HIV prevalence rates are relatively low –

¹ In two cases, the data are not drawn from the standard DHS, but from AIDS Indicator Surveys (AIS). All data for Cote d'Ivoire in 2005 are drawn from an AIS. The data used to construct regional HIV prevalence for Tanzania were drawn from the 2005/05 Tanzanian AIS. See <http://www.measuredhs.com/aboutsurveys/> for a description of the DHS and AIS. Below, we do not distinguish between AIS and DHS, but refer to both as "DHS".

Burkina Faso, Cameroon, Cote d'Ivoire, Ethiopia, Ghana, Guinea, Mali, Niger and Senegal – and five countries in East and Southern Africa where rates are higher – Kenya, Malawi, Tanzania, Zambia, and Zimbabwe.² 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.

The structure and content of the DHS has varied little over time and across countries. 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 the information collected for each survey.

Our analysis samples are organized at the "birth level." Information on prenatal and delivery care is available even if the child subsequently died.³ However, because information on each birth is obtained from mothers, our samples are necessarily restricted to mothers who did not die between the time of the birth and the survey. In addition, with a few exceptions noted in Appendix Table 1, vaccination information is available only for children who are living at the time of the survey. In our discussion section, we consider how the exclusion of births to mothers who have died, and (for our analysis of vaccinations) children who have died may influence our results.

²All results presented here are robust to the exclusion of Zimbabwe, which may have seen more upheaval and displacement of persons than other countries examined.

³ No information on miscarriages is provided.

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.⁴ 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. Each country is divided into regions that can be consistently identified across survey years. 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. 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.⁵ Differences in prevalence between countries, and between regions within countries, can be seen in Figure 1, where weighted averages of HIV prevalence are presented by region for all 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). In Section 3, we discuss the methods we use to examine whether health services for pregnant women and children deteriorated most quickly in regions that have the highest HIV burdens.

⁴ We exclude 133 cases where information on mother's education is missing and 3509 cases where information on the household's location (region) within a country is missing.

⁵ The rates are calculated using HIV testing data for men and women ages 15-49. These are weighted using sample weights given in the DHS HIV dataset for each country.

Non-AIDS related health care

To evaluate the potential impact of HIV and AIDS on health care delivery, we chose a standard set of health care measures asked in all countries regarding antenatal care, birth deliveries and children's immunizations. Table 2 presents sample-weighted averages for each outcome separately for lower prevalence countries (Niger, Senegal, Mali, Guinea, Burkina Faso, Ghana, Ethiopia, Cote d'Ivoire and Cameroon) and for higher prevalence countries (Tanzania, Kenya, Malawi, Zambia, and Zimbabwe) taken over all DHS waves in which these questions were asked. Unless otherwise noted, questions appear in surveys from 1988 to 2005. Asterisks (***) denote the differences in means between the lower and higher prevalence countries that are significant at the one-percent level. In addition, the sample-weighted average for the country with the lowest mean over this period, and that with the highest mean over this period, are presented in columns 3 and 4, to give a sense of the amount of variation we observe in our data.

The first row presents results 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 her urine and blood was tested, and whether measurements for blood pressure and weight were taken. Women in the higher prevalence countries are significantly more likely to report antenatal care but, conditional on reporting antenatal care, are significantly less likely to report having had urine tests, or having their blood pressure taken. Blood tests were equally likely to be reported during antenatal care in higher and lower prevalence countries, while having weight taken is more likely in higher prevalence countries. Overall, women in low-prevalence countries are significantly less likely to have tests performed when pregnant, because they are 30 percentage points less likely to report having had antenatal care on average.

We do not know whether declines in these services, which we document in Section 3, have translated into 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 HIV from being prevented.

Outcome measures for birth deliveries are presented in the next panel of Table 2. In low-prevalence countries, 42 percent of births were attended by a trained professional – true for 56 percent of births in high-prevalence countries. In lower prevalence countries, approximately a third of all births occurred in public clinics, and 3 percent in private clinics. In higher prevalence countries, a significantly larger fraction of births occur in clinics, with 40 percent reported for public clinics, and 13 percent in private clinics. Differences across countries in conditions reported at birth are large: 82 percent of women in Zimbabwe reported the presence of a trained professional at birth, true of only 11 percent of women in Ethiopia.

The rates of childhood immunization against polio, measles, BCG, and DPT are reported in the bottom panel of Table 2. 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. We code variables equal to ‘1’ if the child is reported – either by the mother or on the health card – to be vaccinated, and equal to ‘0’ if the mother reports that there was no vaccine, and there is no evidence of the vaccine recorded on the child’s health card. For all vaccines, children in higher prevalence countries are significantly more likely to have been vaccinated during this period. Large differences between countries in vaccination rates can also be seen in the bottom panel of Table 2: 91 percent of children born in Tanzania during the period are

reported to be immunized against polio, for example, which is true of only 59 percent of children in Niger.

In summary, women in countries where HIV rates are now higher were significantly more likely, coming into this period, to report antenatal care, trained birth deliveries, and children's immunizations. Our focus will be on changes within regions of countries over time from 1988 to 2005.

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.⁶ 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 regional HIV prevalence in the most recent survey. This permits us to examine whether the evolution of health 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,

⁶ 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.

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 Table 2, there are pronounced differences in the levels of the measures we examine between higher and lower prevalence countries. 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 at the time of the birth, 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.⁷

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. Although we know nothing about the second of these assumptions, there is evidence that the first—of a linear increase in HIV prevalence—is incorrect for some of the countries in our sample. For example, Oster (2009) shows country-level estimates from UNAIDS of HIV prevalence for 12 African countries, as well as estimates she constructed using mortality data. Both series show that in some countries, including Burkina Faso, Cameroon, Kenya, Malawi, Tanzania, Uganda, Zambia and Zimbabwe, increases in HIV prevalence tapered off or ceased in the mid- to late-1990's. However, increases in HIV prevalence did not taper off in Mali, Mozambique, and Namibia.⁸ These patterns suggest that the assumptions underlying (2) should be loosened. We do so 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:

⁷ Results reported in Tables 3, 4 and 5 are robust to additionally allowing unobservables to be clustered at the region level. For the fixed effect estimates, these are reported in square brackets beneath the standard errors in parentheses.

⁸ For the final country, Ethiopia, UNAIDS data show increases in HIV prevalence that taper off around 1996, whereas Oster's estimates are imprecise, showing large year-to-year variation, possibly due to small sample sizes combined with low HIV rates.

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

Writing

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

and

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

this can be expressed as:

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

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 received a polio vaccine at birth is available in 1988 only in Niger. By birth year 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 3 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). Means of the dependent variables, calculated using sample weights, are presented in the first row. The second row presents estimates from equation (2) where, in addition to estimated HIV prevalence, we include birth year indicators, and mother and child characteristics. The following row presents estimates from regressions that also include country-region fixed effects.⁹ Women in regions with high HIV prevalence are significantly more likely to report prenatal care. Relative to living in a region with 5 percent prevalence, women living in a region with 10 percent HIV prevalence are 9 percentage points more likely to report antenatal care (1.708×0.05). 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

⁹ Estimates using probit models yield similar results.

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 there on antenatal care than in regions with low levels of HIV prevalence.¹⁰

Increases in HIV prevalence are also associated with declines in the types of procedures conducted during antenatal care. Conditional on reporting antenatal care, women in 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 regions currently shouldering a high HIV burden. For example, consider one region of Zimbabwe—Matabeleland South—where, if the HIV burden increased linearly, we would expect that HIV prevalence increased by 8 percentage points between 1995 and 2005 (from 0.12 to 0.20). A woman would be 16 percentage points less likely on average to report that her blood pressure was taken during prenatal care if she was pregnant in 2005, relative to a woman who was pregnant in 1995 (-2.058×0.08).

Antenatal care is itself negatively associated with HIV prevalence, controlling for country-region fixed effects, so that these effects are magnified when we estimate models that do not condition on the receipt of antenatal care. For example, as shown in Table 3, 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 4 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

¹⁰ Results on reporting any antenatal care are also robust to the inclusion of country-by-year fixed effects.

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, we find delivery at a clinic is significantly more likely in regions with high HIV prevalence. However, over time within a region (presented in the second row of regression results), we find clinic delivery is significantly less likely to be reported as estimated HIV prevalence increases. Without fixed effects, conditional on being a clinic birth, delivery is significantly less likely to be at a public clinic in regions where HIV prevalence is higher. This coefficient, while still negative and significant, falls by half in absolute value when country-region fixed effects are included. Table 4 also shows 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 an 8 percentage point increase in the rate of HIV prevalence witnessed an 11 percentage point drop in the probability of a trained attendant at the birth (-1.353×0.08). 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 5 turns to children's health care outcomes, and presents estimates of the association between HIV prevalence and children reported to have had a polio vaccine soon after birth (column 1), or to have ever received polio, measles, BCG and DPT vaccines (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 immunizations. However, within regions over time, children in regions with currently high HIV prevalence are significantly less likely to be vaccinated against any of these diseases. Relative to children born in the region of Matabeleland South in

Zimbabwe in 1990, when our linear estimate suggests an HIV prevalence rate of 8 percent, those born in the same region in 2005 (prevalence of 20 percent) would be 30 percentage points less likely to be immunized against polio, measles and DPT, and 24 percentage points less likely to have received a BCG vaccine (-2.02×0.12).

In summary, in regions that are bearing the heaviest HIV burdens, we find that the quality of antenatal care, the probability of a trained attendant at births, and child immunizations have all been eroded.

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. 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 our antenatal care regression declines in absolute value from -1.73 (as shown in Table 3) to -1.42 . The coefficient on prevalence in the regression for “polio vaccine at birth” falls from -7.02 (as shown in Table 5) 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. In our graphs, we normalize 1997 to be 1.0, so that the graphs tell us *relative to 1997* what we would predict for each birth year, for each outcome, at different prevalence rates.

As shown in Table 2, average values of the health care outcomes differ widely between countries with high and low prevalence. Our interest here is to highlight 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 2 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. We find this upward trend is less pronounced at higher prevalence rates. At a 10 percent prevalence, the increase in antenatal care over the period from 1988 to 2005 is approximately 10 percentage points, and at 20 percent prevalence, antenatal care was relatively constant from 1988 to 1995, and then declined by approximately 5 percentage points between 1995 and 2004. Test statistics from the regression underlying Figure 2 are shown in the first row of Table 6. These indicate that the hypothesis that the birth year effects γ_t^* are jointly insignificant (that is, that all

year effects are insignificantly different from 1997) can be rejected, as can the hypothesis that the birth year/HIV prevalence interactions β_t^* are jointly insignificant.

The last column in Table 6 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 2 do not begin to diverge until the mid-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 3. Consistent with the results in Table 3, 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. Relative to reports of having blood tested during antenatal care in 1997, such reports are approximately 20 percentage points less likely in 2005 in regions where HIV prevalence is now 10 percent, and such reports are approximately 30 percentage points less likely in regions where HIV prevalence is now 20 percent. The linearity restrictions are also rejected for these measures of care.

Results for delivery care, in Figure 4, 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 1997, and by another 15 percentage points from 1997 to 2005. At zero prevalence, the presence of a trained birth attendant was approximately 10 percentage points higher in 2005 relative to 1997. Consistent with the results in Table 4, 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 5 and 6. In high HIV regions, mothers were increasingly less likely to report that their child had 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 (Figure 6). 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 3 to 5: 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 the use of antenatal care, this divergence began in the mid-1990s. Figure 5, although noisy, suggests improvement in children's immunizations until 1993 or 1994 in both high and low prevalence regions. After that time, regions with the lowest HIV prevalence rates continued to make progress, while those where HIV rates are highest began to lose ground. 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

The results presented in the last section indicate that the quality of maternal and child health care has deteriorated in regions with high recent HIV prevalence relative to regions with low recent HIV prevalence. These associations are large. Provided they reflect causal effects running from HIV to health care quality, they suggest that the AIDS epidemic has generated considerable collateral damage to non-HIV related health care.

As we noted in our introduction, the interpretation of these results requires some care. Although we think it is unlikely, it is possible that the associations we document do not reflect causal relationships. In addition, it could be that sample selection issues have produced biases in our estimates. Furthermore, provided our results reflect causal effects of HIV on health care, they do not identify which of the several (non-competing) explanations for this effect is at play. One explanation is that AIDS adversely affected access to care. Another is that AIDS may 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 could have had a large effect on the quality of care available. We discuss these issues in turn.

Causal interpretations

Although there are several compelling reasons why the AIDS epidemic could have disrupted non-HIV health care, it is possible that the association between current HIV prevalence and declines in health care quality is driven by other mechanisms. One scenario is that deterioration in the health care system raised the prevalence of HIV, rather than the reverse. This might be the case if the deterioration in health care systems led to fewer resources devoted to AIDS

prevention, such as AIDS education or condom distribution. Although this possibility is difficult to rule out, we think it is unlikely to be a major factor driving our results. As noted above, the areas with high current HIV prevalence had, on average, better health care statistics (e.g. higher rates of prenatal care, etc.) in the late 1980's and early 1990's than areas with low prevalence. If good health care systems protect regions against the spread of HIV, then we should have observed a more rapid spread in HIV in areas with weak health systems at the beginning of the epidemic.

Another possibility is that economic downturns produced both increases in HIV prevalence and declines in health care quality. If this were so, one would expect to see declines in wealth in regions with high HIV prevalence.¹¹ 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 constructed a measure of household assets equal to the sum of indicators for the ownership of a radio, television, refrigerator, bicycle, motorcycle and car. 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 (0.885) rather than negative, indicating that areas in which HIV rose fastest experienced larger increases in wealth than other areas. However, a test that the coefficient equals zero cannot be rejected at the 10% level.

Selection issues

¹¹ A finding that wealth and HIV prevalence are negatively associated would not provide conclusive evidence on this issue, since it could be either that wealth declines caused increases in HIV, or increases in HIV caused wealth declines. However, a finding of an *absence* of a negative association between wealth and HIV would provide evidence against the hypothesis that the association between HIV prevalence and health care quality was driven by wealth declines that worsened both.

Our analyses exclude births to women who died between the time of the birth and the date of the survey. We have no way to measure maternal death in cases in which the child also dies.

However, 23 of the 41 surveys we use collect information on the vital status of the parents of all children living in each household, and information on the numbers of maternal orphans provide some information on the extent of maternal death.¹² Only a small fraction of young children are maternal orphans. For all children under the age of 5, one percent of children have mothers who are deceased. The fraction of children who are maternal orphans increases with age: only 0.3 percent of children younger than one year of age are maternal orphans, whereas 2.0 percent of four-year-old children are maternal orphans. As expected, children living in high HIV regions are more likely to be maternal orphans. Using a sample of all children younger than five years of age, we regressed an indicator of whether a child is a maternal orphan on a set of age indicators, survey year indicators, country-region fixed effects, an indicator of the child's gender, and a measure of HIV prevalence in the child's year of birth. A 10 percentage point increase in HIV prevalence is associated with a 0.6 percentage point increase in the probability of being a maternal orphan.

Although rates of maternal orphanhood of 1 percent are high by international standards, they are too low to produce large biases in our estimates. To demonstrate this, we added maternal orphans into our samples, and re-estimated models of the form shown in Table 3, assuming that the mothers of maternal orphans either did or did not receive antenatal care. Specifically, we used the sample of 23 surveys for which data on maternal orphans are available, and regressed antenatal care on HIV prevalence in the child's year of birth, an indicator for the child's sex, a set of birth year indicators, and country-region fixed effects. When maternal orphans are

¹² Information on the vital status of the mother is unknown or missing for 341 out of 138,486 children younger than five in the sampled households in these surveys.

excluded, the coefficient on HIV prevalence is -1.03 , with a standard error of 0.075 . When maternal orphans are included and it is assumed their mothers received antenatal care, the coefficient is -1.01 , and when they are included and it is assumed that their mothers did not receive antenatal care, the coefficient is -1.14 .¹³ Results for other outcomes are also insensitive to assumptions about the health care of mothers who died.

Access to care

One explanation for our results is that AIDS-related illnesses 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 was “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

¹³ We restricted the ages of orphans to be in the same range of the ages of non-orphans in the same survey wave. For example, in survey waves in which mothers reported on antenatal care for children born in the past 5 years, we included only orphans under the age of 5; in survey waves in which mothers reported on antenatal care for children born in the past 3 years, we included only orphans under the age of 3.

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 7. Between 6.3 and 21.0 percent of women report not knowing where to go for medical care; 32.8 to 60.0 percent report that distance is a problem; 39.9 to 75.6 percent say money is an issue; and 33.2 to 71.6 percent say transportation is a problem. However, there is no evidence that high HIV countries have worse access to care.

The evidence is quite different when we compare high- and low-HIV prevalence regions within countries. We ran regressions of each of the access measures on a set of country fixed effects and the regional HIV prevalence measure, with standard errors clustered at the level of the country/region. We find that, within countries, women in high-HIV regions reported *fewer* problems with access to care. The coefficients on HIV prevalence imply that a 5-percentage point increase in HIV prevalence is associated with a 3.3 percentage point decline in the probability that “not knowing where to go for care” is reported to be a big problem; a 6.8 percentage point decline in the probability that “distance to care” is a problem; a 3.7 percentage point decline in the probability that lack of money for care is a problem; and a 6.4 percentage point decline in the probability that transportation is a problem with access to care. For all access measures except “lack of money,” the coefficient on HIV prevalence is statistically different from zero at the 1% level or better. These associations need not be causal, but may simply indicate that HIV is more prevalent in more developed regions of countries, with denser health infrastructure and transportation networks. In addition, because we have data on only one year per country, these results do not say anything about whether access to care has declined faster, or

improved more slowly, in high-HIV regions. However, they do indicate that, within countries, access to health care is not generally worse in higher-HIV regions.

Demand for health services

One possible explanation for our results is that HIV reduced demand for health care services.

One route could be through wealth. 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.

This explanation seems unlikely since, as we discussed above, we do not find an association between wealth and HIV prevalence. Nonetheless, we examined whether controlling for household wealth weakens the association between HIV prevalence and prenatal care, delivery services, and vaccination. In all cases, the addition of asset information has only small effects on the coefficient on HIV prevalence.

Another “demand side” explanation for our results might be that HIV positive mothers being less likely to seek antenatal and other medical care, either because they are ill or because clinics do not welcome them. We explore this using the last round of DHS data for each of the twelve countries in our sample for which information on maternal HIV status can be matched to the health information.¹⁴ 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

¹⁴ Zambia and Tanzania are excluded.

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 and weight measurements taken. They are 3.4 percentage points more likely to report a clinic delivery, and 2.9 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 an increased need by HIV patients for care.

Grépin (2009) examines whether the influx of foreign aid earmarked to HIV and 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 and 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 antenatal care and immunizations 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 care for 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, TB, DPT) and the quality of care their mothers receive during pregnancy and delivery.

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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.

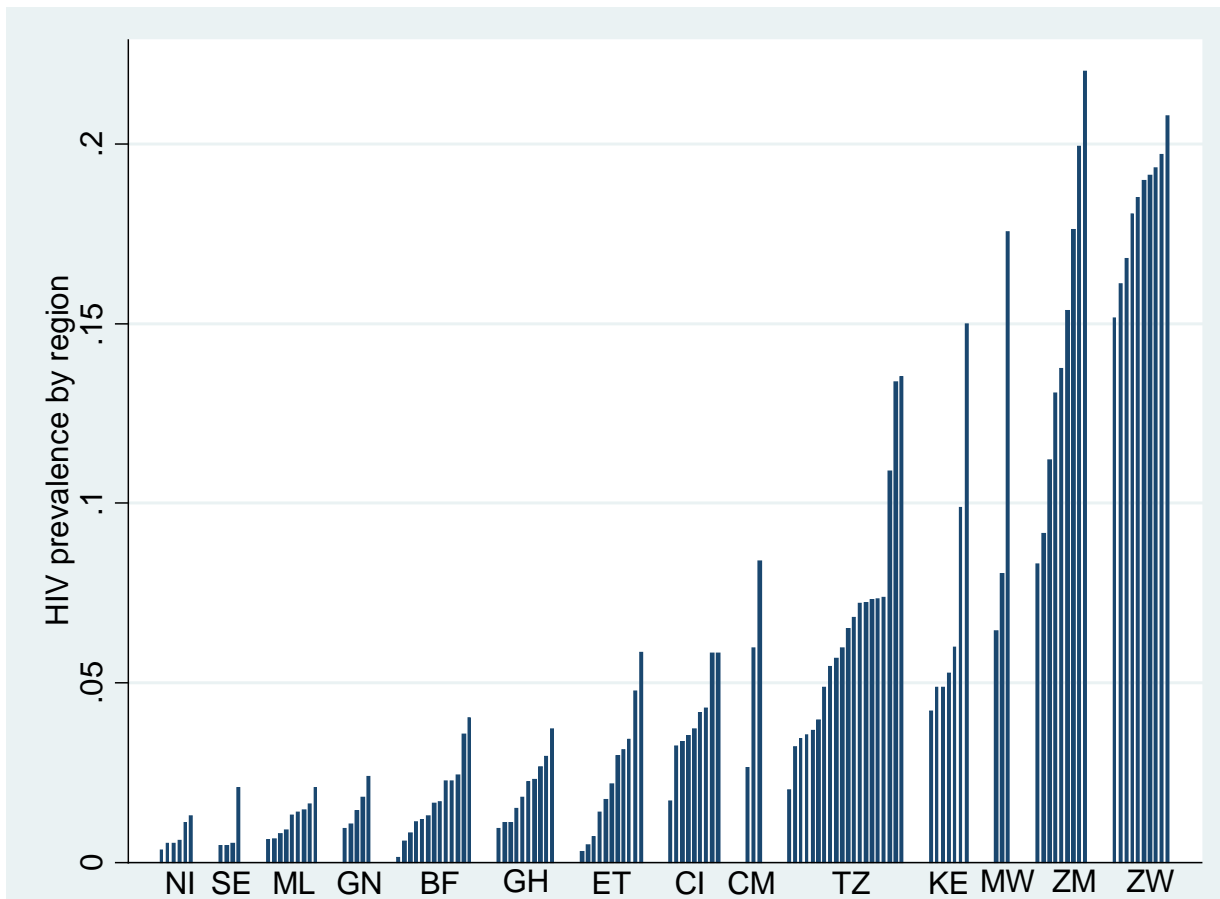


Figure 1. Regional HIV prevalence rates by country for Niger (NI); Senegal (SE); Mali (ML); Guinea (GN); Burkina Faso (BF); Ghana (GH); Ethiopia (ET); Cote d'Ivoire (CI); Cameroon (CM); Tanzania (TZ); Kenya (KE); Malawi (MW); Zambia (ZM) and Zimbabwe (ZW).

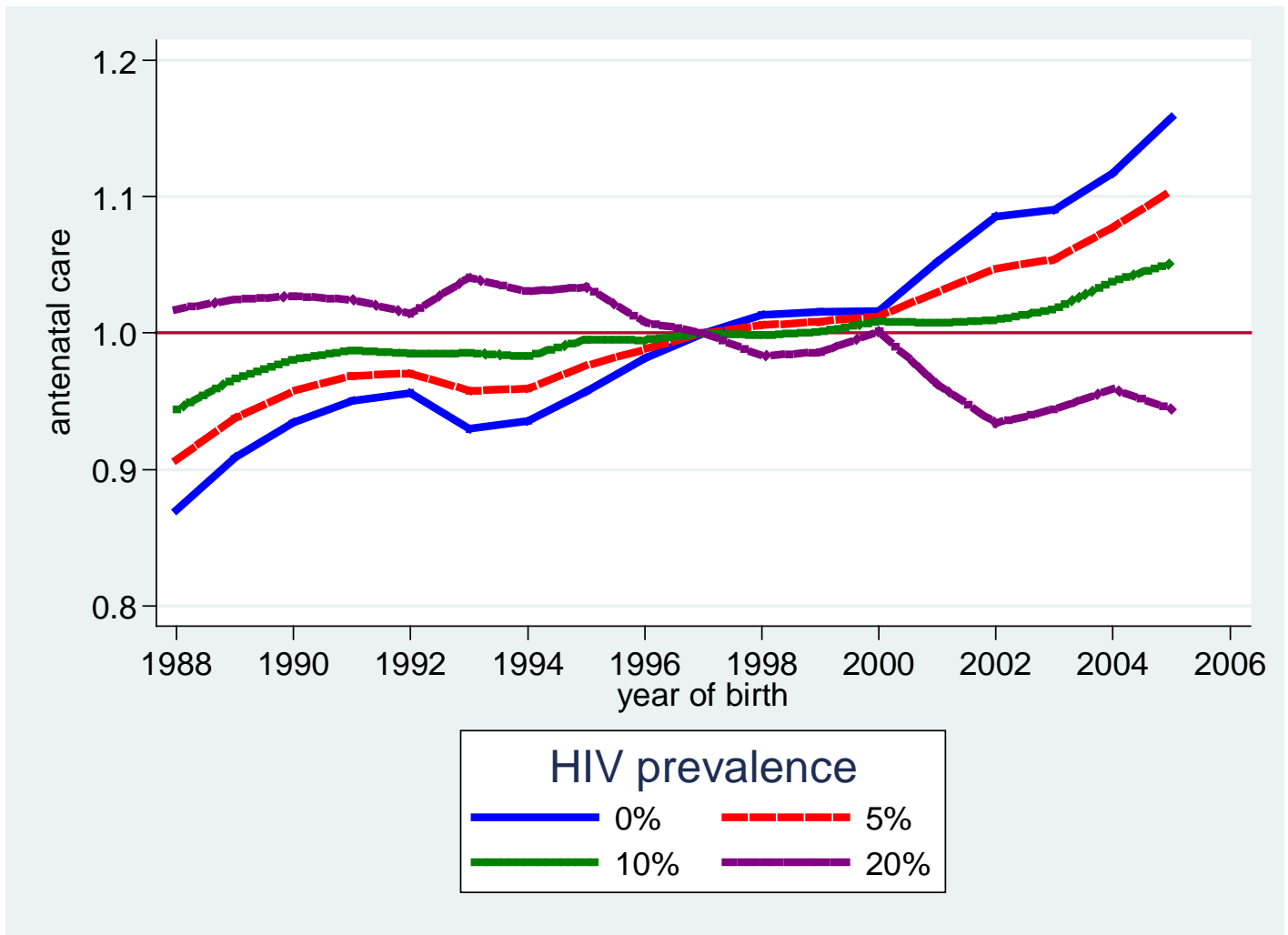


Figure 2: Trends in antenatal care by HIV prevalence

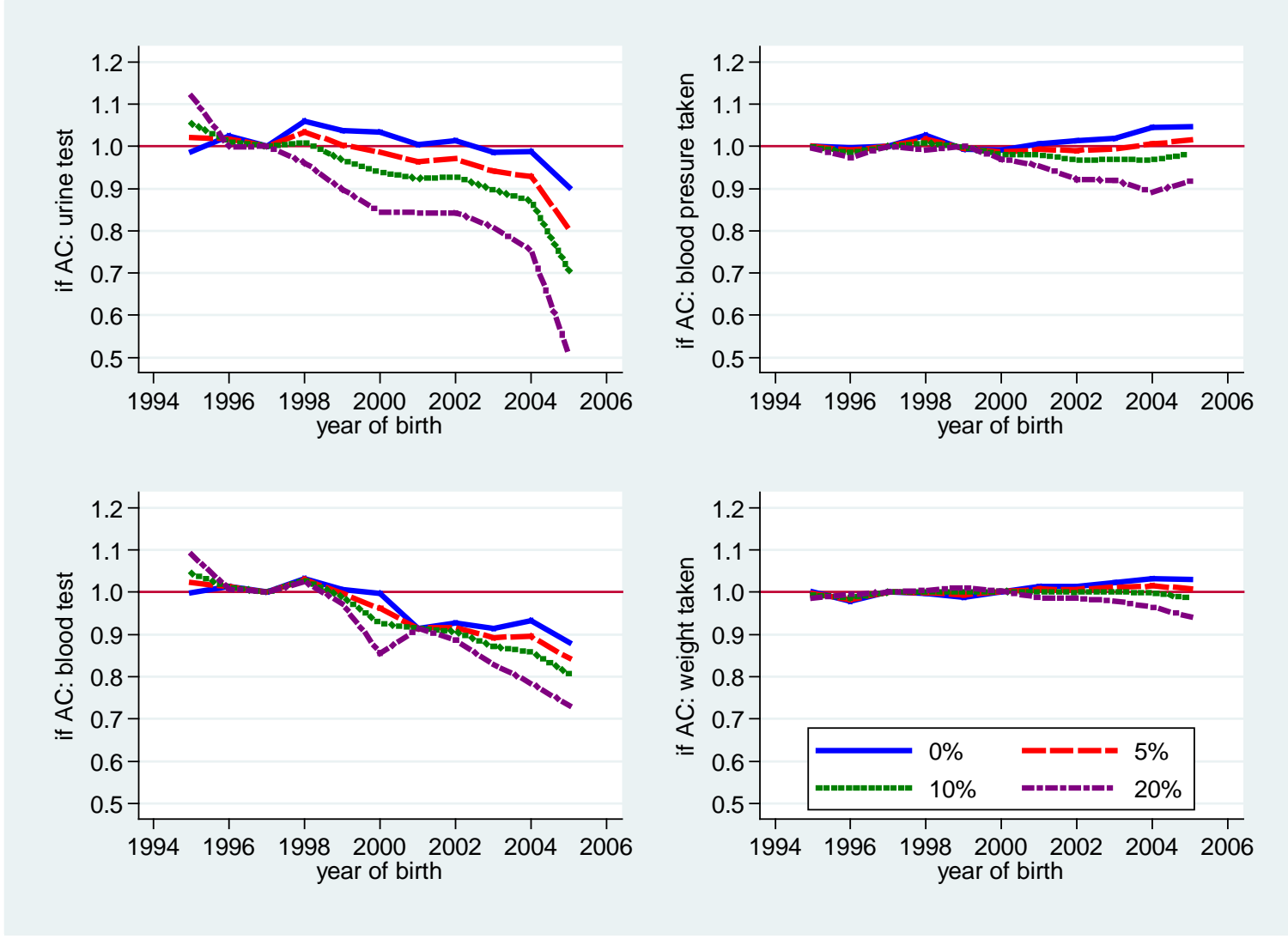


Figure 3: Trends in antenatal procedures by HIV prevalence

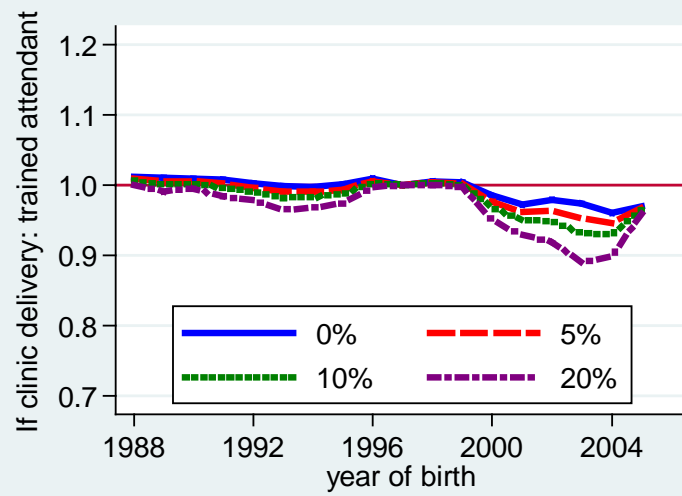
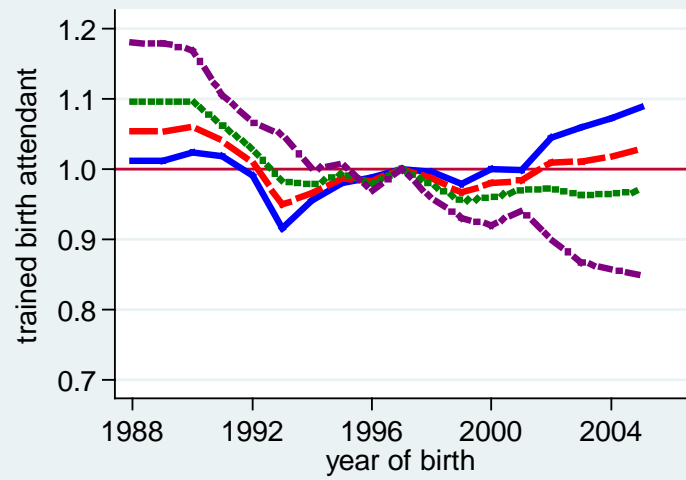
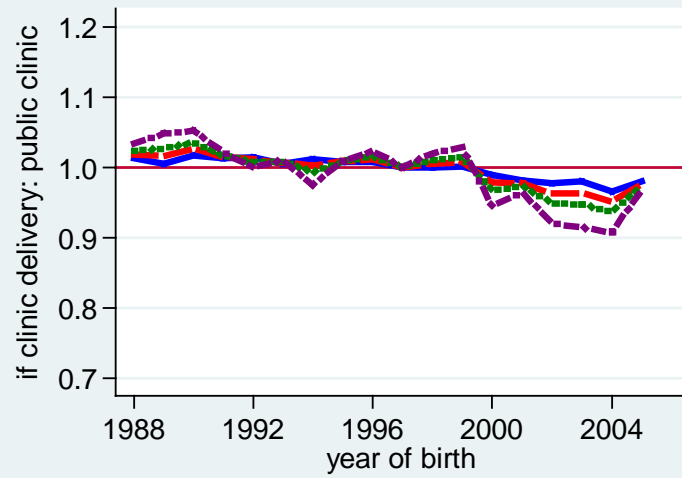
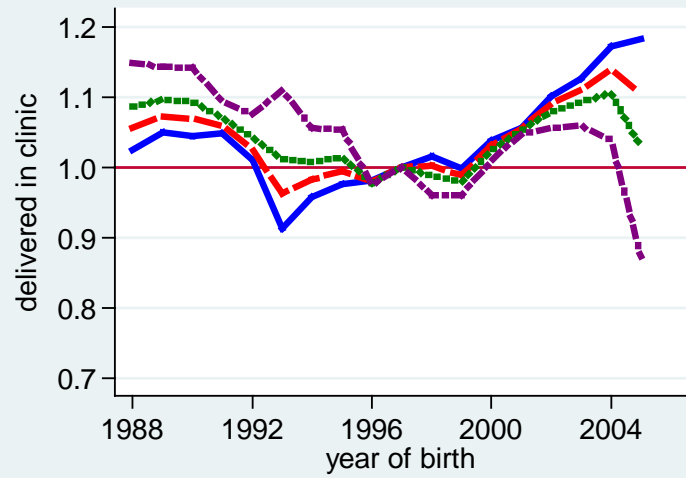


Figure 4: Trends in birth delivery care by HIV prevalence

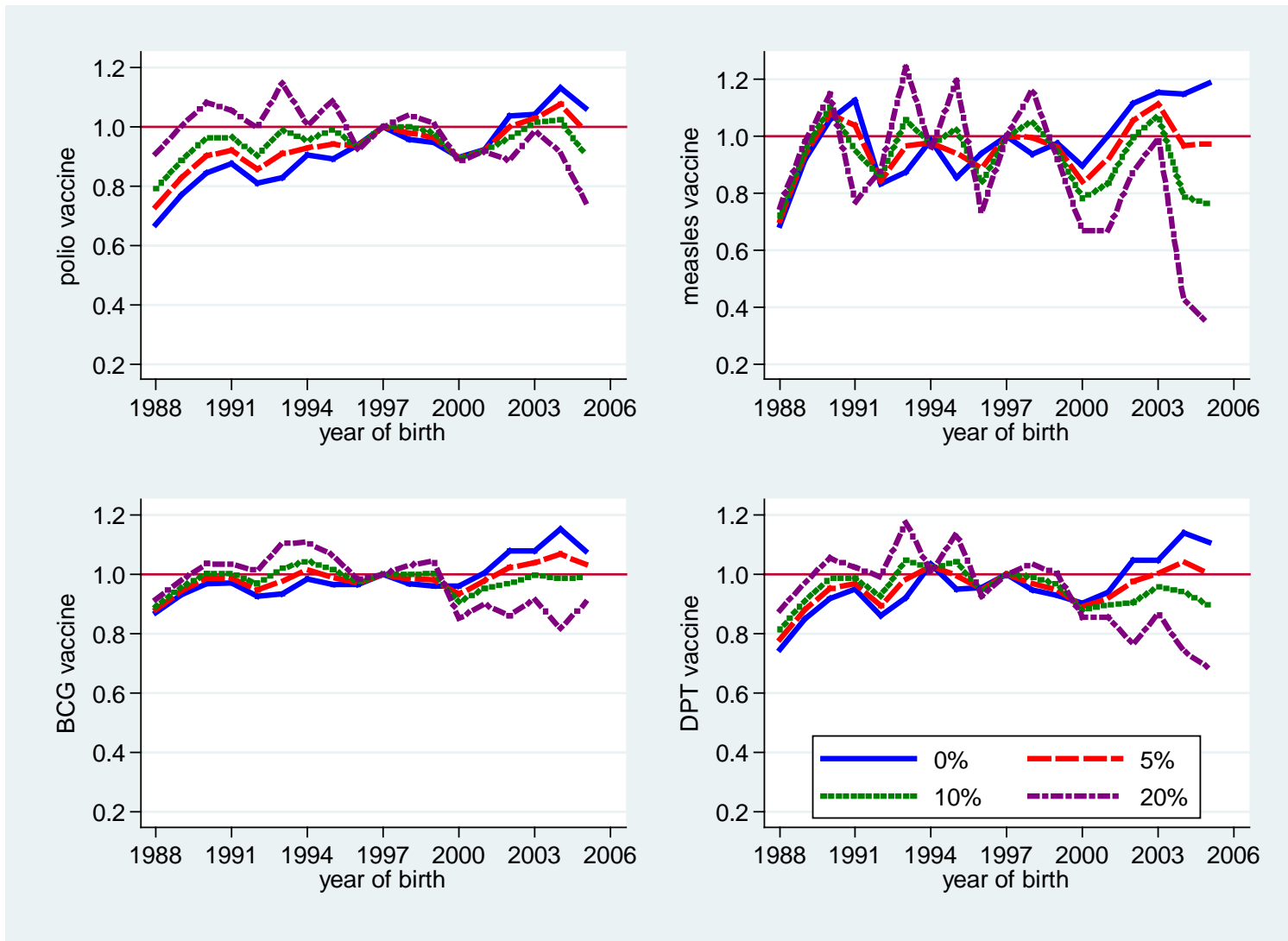


Figure 5: Trends in childhood vaccinations by HIV prevalence

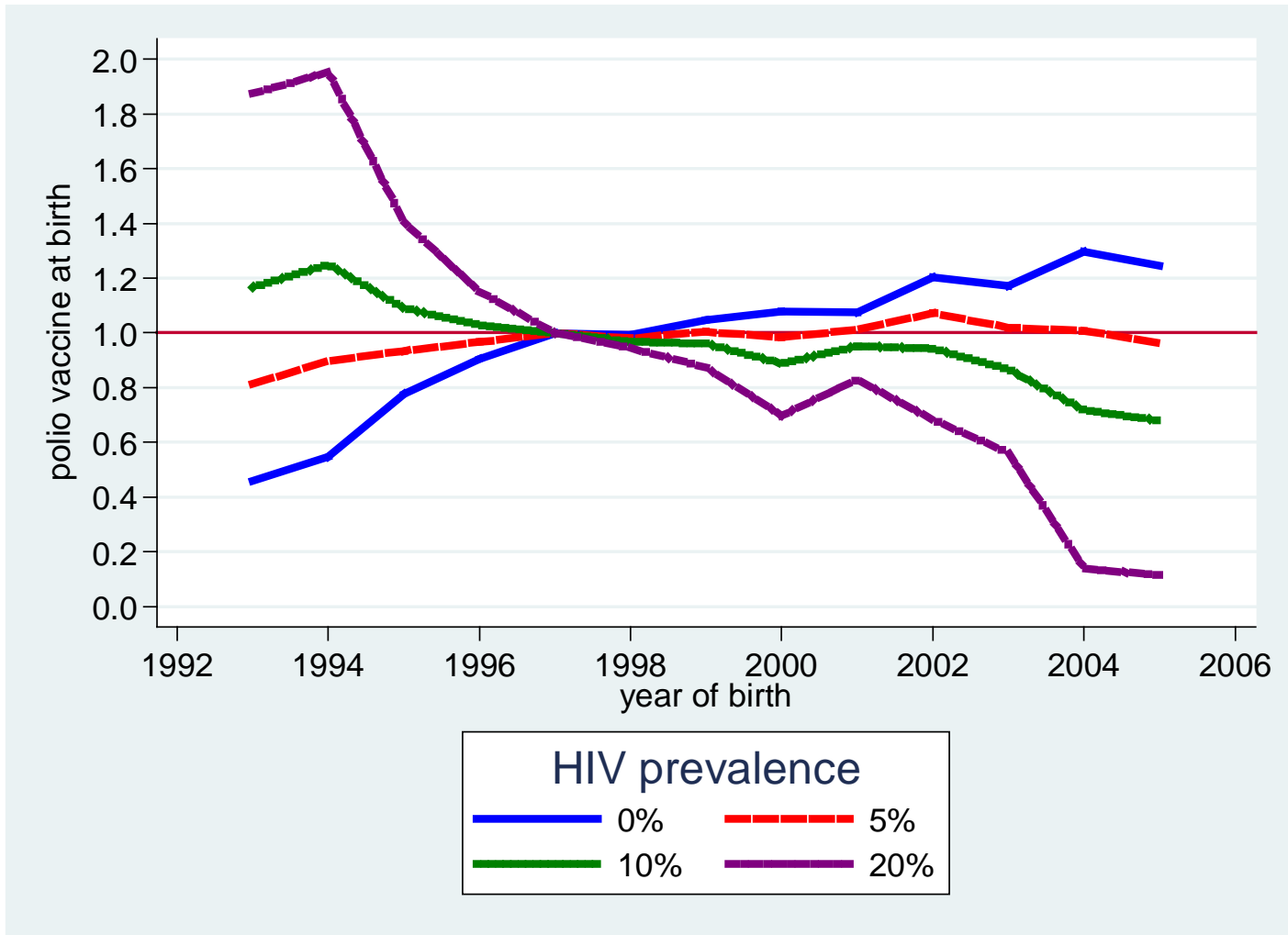


Figure 6: Trends in polio vaccinations shortly after birth by HIV prevalence

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. Prenatal and Early Life Health Care Reported

	Means (1988-2005)			
	Lower Prevalence Countries	Higher Prevalence Countries	Highest mean level reported care (Country)	Lowest mean level reported care (Country)
ANTENATAL CARE:				
Any antenatal care	0.645	0.953***	0.974 (TZ)	0.276 (ET)
Conditional on antenatal care:				
Urine test (1994 +)	0.652	0.378***	0.847 (GH)	0.219 (MW)
Blood pressure taken (1994+)	0.893	0.815***	0.977 (SN)	0.657 (TZ)
Blood test (1994+)	0.509	0.503	0.870 (GH)	0.255 (ET)
Weight taken (1994+)	0.918	0.948***	0.983 (BF)	0.697 (ET)
Unconditional on antenatal care:				
Urine test (1994 +)	0.313	0.350***	0.738 (GH)	0.067 (ET)
Blood pressure taken (1994+)	0.428	0.743***	0.868 (ZW)	0.180 (NI)
Blood test (1994+)	0.245	0.461***	0.759 (GH)	0.071 (ET)
Weight taken (1994+)	0.440	0.862***	0.894 (MW)	0.194 (ET)
BIRTH DELIVERY:				
Trained professional present	0.423	0.562***	0.816 (ZW)	0.110 (ET)
Delivery at a clinic	0.356	0.532***	0.704 (ZW)	0.051 (ET)
Delivery at a public clinic	0.326	0.403***	0.573 (ZW)	0.047 (ET)
Delivery at a private clinic	0.030	0.131***	0.199 (MW)	0.004 (NI)
CHILD IMMUNIZATIONS:				
Polio at birth (1993 +)	0.388	0.423***	0.607 (KE)	0.104 (ZM)
Polio	0.722	0.872***	0.913 (TZ)	0.587 (NI)
Measles	0.478	0.676***	0.701 (TZ)	0.324 (ET)
BCG	0.680	0.889***	0.921 (TZ)	0.502 (ET)
DPT	0.638	0.829***	0.890 (MW)	0.466 (ET)

Notes. Lower prevalence countries include Niger (NI), Senegal (SE), Mali (ML), Guinea (GN), Burkina Faso (BF), Ghana (GH), Ethiopia (ET), Cote d'Ivoire (CI) and Cameroon (CM). Higher prevalence countries include Tanzania (TZ), Kenya (KE), Malawi (MW), Zambia (ZM) and Zimbabwe (ZW). Asterisks (***) in column 2 denote that the difference in means between the lower and higher prevalence countries is significant at the one-percent level.

Table 3. 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	1.708 (0.023)	-1.760 (0.035)	-0.130 (0.035)	-0.381 (0.026)	0.186 (0.018)
Country/region fixed effects	no	no	no	no	no
HIV prevalence in year of birth	-1.734 (0.074) [0.331]	-2.220 (0.254) [0.677]	-1.214 (0.273) [0.522]	-2.058 (0.203) [0.638]	-1.403 (0.148) [0.228]
Country/region fixed effects	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 variables, calculated using sample weights, are presented in the first row. Standard errors are in parentheses, and standard errors that allow for clustering at the region level are presented in square brackets. All regressions control for year of birth fixed effects and mother and child characteristics, including the mother's education in years, the mother's age at the birth 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 4. 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	1.013 (0.023)	-1.156 (0.025)	0.541 (0.024)	0.023 (0.014)
Country/region fixed effects	no	no	no	No
HIV prevalence in year of birth	-0.768 (0.085) [0.531]	-0.509 (0.094) [0.320]	-1.353 (0.087) [0.283]	-0.303 (0.052) [0.437]
Country/region fixed effects	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 variables, calculated using sample weights, are presented in the first row. Standard errors are in parentheses, and standard errors that allow for clustering at the region level are presented in square brackets. All regressions control for year of birth fixed effects and mother and child characteristics, including the mother's education in years, the mother's age at the birth 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 5. Child immunizations and HIV prevalence

	polio vaccine at birth	polio vaccine	measles vaccine	BCG vaccine	DPT vaccine
Mean of dependent variable	0.398	0.778	0.552	0.758	0.709
HIV prevalence in year of birth	-0.868 (0.030)	0.511 (0.021)	0.802 (0.024)	0.860 (0.021)	0.968 (0.023)
Country/region fixed effects	No	no	no	no	no
HIV prevalence in year of birth	-7.018 (0.224) [0.571]	-2.708 (0.077) [0.535]	-2.767 (0.087) [0.523]	-2.021 (0.077) [0.393]	-2.657 (0.082) [0.623]
Country/region fixed effects	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 variables, calculated using sample weights, are presented in the first row. Standard errors are in parentheses, and standard errors that allow for clustering at the region level are presented in square brackets. All regressions control for year of birth fixed effects and mother and child characteristics, including the mother's education in years, the mother's age at the birth 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. Tests for models with HIV prevalence/birth year interactions

dependent variable:	Test: birth year effects jointly insignificant		Test: birth year/HIV prevalence interactions jointly insignificant		Test: birth year/HIV interactions follow linear trend	
	F	(p-value)	F	(p-value)	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)
Polio vaccine at birth	143.13	(0.000)	98.50	(0.000)	15.79	(0.000)
Polio vaccine	300.19	(0.000)	105.45	(0.000)	27.61	(0.000)
Measles vaccine	180.45	(0.000)	173.20	(0.000)	122.49	(0.000)
BCG vaccine	124.08	(0.000)	77.09	(0.000)	33.26	(0.000)
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 2-6.

Table 7. Problems accessing medical care

Country, year	observations	A big problem with access to medical care is...			
		not knowing where to go	distance	money	transportation
Burkina Faso, 2003	12,477	0.188	0.464	0.630	0.404
Cameroon, 2004	10,645	0.198	0.387	0.657	0.371
Ethiopia, 2005	14,067		0.677	0.756	0.716
Ghana, 2003	5,689	0.113	0.328	0.548	0.332
Guinea, 2005	7,944	0.201	0.551	0.733	0.512
Malawi, 2004	11,687	0.156	0.600	0.616	0.549
Mali, 2006	14,557	0.210	0.384	0.526	0.363
Niger, 2006	9,209	0.169	0.512	0.650	0.507
Senegal, 2005	14,590	0.104	0.362	0.534	0.354
Tanzania, 2004	10,325	0.063	0.376	0.399	0.372
Zambia, 2006	7,654	0.070	0.455	0.664	0.474
Zimbabwe, 2006	8,896		0.414	0.578	0.422

Note: Means are weighted using sample weights. Blank cells indicate the relevant question was not asked in the survey. None of these questions were asked in the most recent survey from Cote d'Ivoire and Kenya.