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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 14 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 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 shouldering the heaviest burdens have seen the largest erosion in non-HIV-related health services for pregnant women and children. Using semiparametric 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.

Keywords AIDS · Health services · DHS · Sub-Saharan Africa

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

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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 (Colvin 2005; Easterly 2008; Impact of HIV on delivery of health care in sub-Saharan Africa: A tale of secrecy and inertia [Editorial] 1995; Jones et al. 2003).

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 article, we examine whether the AIDS crisis has compromised non-AIDS-related health services in 14 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 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 shouldering the heaviest burdens have seen the largest erosion in non-HIV-related health services for pregnant women and children. Using semiparametric 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. Since the mid-1990s, women interviewed in DHS surveys have been asked whether routine procedures, such as blood pressure measurement and urine tests, were conducted during antenatal care. The likelihood that women report these procedures has declined in high HIV regions relative to low HIV regions.

We begin in the second section of this article by introducing the DHS data that we use to examine the impact of HIV on health care delivery. We discuss our estimation strategy in the third section. We present evidence on the associations between HIV and health services in the fourth section, and then we explore explanations for our findings in the fifth section. 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 that we observe between HIV and health care delivery. The sixth section discusses ways in which future health service delivery may be affected by the arrival of antiretroviral therapy (ART).

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 14 countries in sub-Saharan Africa.[1] We have data from nine African countries where HIV prevalence rates are relatively low—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 1991–1992 survey from Tanzania because the geocoding 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, and within the past five years for others. (Table 6 in Online Resource 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 Table 6 (see Online Resource 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.

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, seven and eight countries are represented. In all years beyond that, information is available from at least nine 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 (for example, three in Cameroon and in Malawi, 10 in Zimbabwe, and 20 in Tanzania), and in total, we analyze data from 119 regions. The HIV prevalence rates that we use in our

[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 2005/2006 Tanzanian AIS. See http://www.measuredhs.com/aboutsurveys for a description of the DHS and AIS. In this article, we do not distinguish between AIS and DHS, but refer to both as "DHS."

[2] 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.

[3] No information on miscarriages is provided.

[4] We exclude 133 cases where information on mother's education is missing and 3,509 cases where information on the household's location (region) within a country is missing.

Table 1 Demographic and Health Survey data sets

	Burkina Faso	Cameroon	Cote d'Ivoire	Ethiopia	Ghana
Survey Year	1992–1993	1991	1994		1993–1994
[Birth Years]	[1988–1993]	[1988–1991]	[1991–1994]		[1990–1994]
(Observations)	(5,828)	(2,319)	(3,998)		(2,204)
Survey Year	1998–1999	1998	1998–1999	2000	1998–1999
[Birth Years]	[1994–1999]	[1995–1998]	[1993–1999]	[1995–2000]	[1993–1999]
(Observations)	(5,950)	(2,317)	(1,992)	(10,873)	(3,298)
Survey Year	2003	2004	2005	2005	2003
[Birth Years]	[1998–2003]	[1999–2004]	[2000–2005]	[2000–2005]	[1998–2003]
(Observations)	(10,645)	(8,113)	(3,633)	(9,861)	(3,844)
Number of Regions	13	3	9	11	10
	Guinea	Kenya	Malawi	Mali	Niger
Survey Year		1988–89			
[Birth Years]		[1988–89]			
(Observations)		(1769)			
Survey Year		1993	1992	1995–1996	1992
[Birth Years]		[1988–1993]	[1988–1992]	[1992–1996]	[1988–1992]
(Observations)		(6,115)	(4,326)	(6,030)	(6,141)
Survey Year	1999	1998	2000	2001	1998
[Birth Years]	[1994–1999]	[1995–1998]	[1995–2000]	[1996–2001]	[1995–1998]
(Observations)	(5,825)	(3,531)	(11,926)	(13,091)	(4,798)
Survey Year	2005	2003	2004–2005	2006	2006
[Birth Years]	[2000–2005]	[1998–2003]	[1999–2005]	[2001–2005]	[2001–2005]
(Observations)	(6,363)	(5,495)	(10,912)	(12,285)	(8,638)
Number of Regions	5	7	3	9	6
	Senegal	Tanzania	Zambia	Zimbabwe	
Survey Year	1992–1993	1996	1992	1994	
[Birth Years]	[1988–1993]	[1991–1996]	[1988–1992]	[1991–1994]	
(Observations)	(5,642)	(6,169)	(5,438)	(2,436)	
Survey Year	1997	1999	1996–1997	1999	
[Birth Years]	[1992–1997]	[1994–1999]	[1991–1996]	[1994–1999]	
(Observations)	(7,372)	(2,406)	(7,246)	(3,640)	
Survey Year	2005	2004–2005	2001-2002	2005–2006	
[Birth Years]	[2000–2005]	[1999–2005]	[1996–2002]	[2000–2005]	
(Observations)	(10,944)	(6,923)	(6,862)	(5,220)	
Number of Regions	4	20	9	10	

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 Fig. 1, where weighted averages of HIV prevalence

[5] The rates are calculated using data on HIV testing for men and women ages 15–49. These are weighted using sample weights given in the DHS HIV data set for each country.

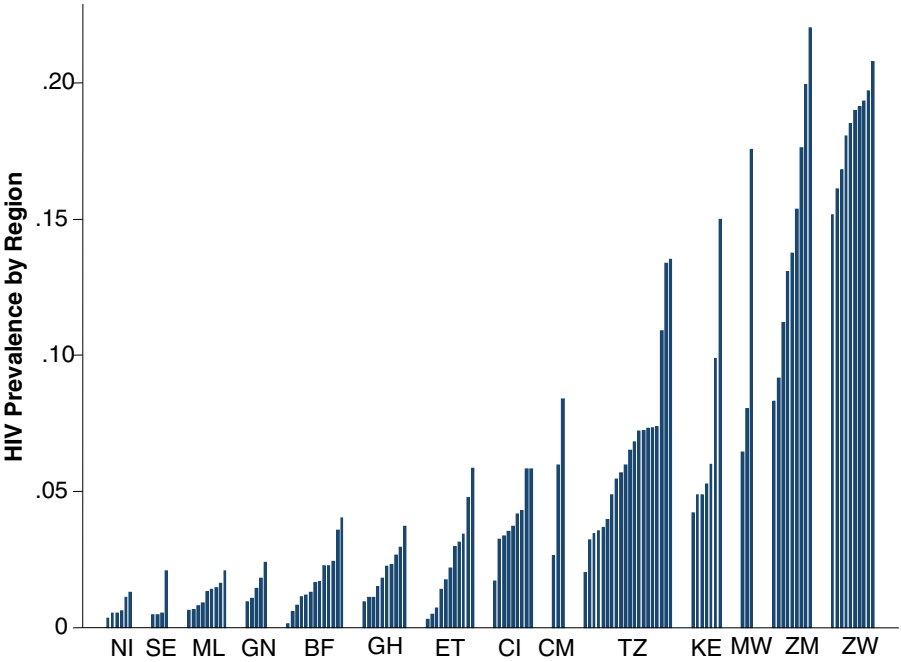

Fig. 1 Regional HIV prevalence rates by country for Niger (NI), Senegal (SE), Mali (ML), Guinea (GN), Burkina Faso (BF), Ghana (GH), Ethiopia (ET), Cote d'Ivoire (CI), Cameroon (CM), Tanzania (TZ), Kenya (KE), Malawi (MW), Zambia (ZM), and Zimbabwe (ZW)

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%. 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% or higher). In the third section, 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.

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 1% level. In addition, the sample-weighted average for the

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 1% level.

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 antenatal procedures 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 the third section, 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% of births were attended by a trained professional—true for 56% of births in high-prevalence countries. In lower-prevalence countries, approximately one-third of all births occurred in public clinics, and 3% occurred in private clinics. In higher-prevalence countries, a significantly larger fraction of births occurred in clinics, with 40% reported for public clinics and 13% reported in private clinics. Differences across countries in conditions reported at birth are large: 82% of women in Zimbabwe reported the presence of a trained professional at birth, true of only 11% 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% of children born in Tanzania during the period are reported to be immunized against polio, for example, which is true of only 59% of children in Niger.

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

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 earlier, 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 twenty-first century is different in regions with high HIV prevalence rates when compared with regions with low prevalence rates. As we show later, 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

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

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

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

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, Eq. (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: (1) that HIV prevalence increased linearly from 1980 to the current time period; and (2) that HIV prevalence has a

[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. 1986:956). The countries we study reported their first cases of AIDS in the early- to mid-1980s. Later, we discuss how our results change if we use a later date—1985 rather than 1980—to impute regional HIV prevalence.

[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.

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 (2010) showed country-level estimates from UNAIDS (Joint United Nations Programme on HIV/AIDS) 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-1990s. However, increases in HIV prevalence did not taper off in Mali, Mozambique, and Namibia.[8] These patterns suggest that the assumptions underlying Eq. (2) should be loosened. We do so by estimating models of the following form:

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

where all variables are defined as earlier, only the actual prevalence measured 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 Eqs. (2) and (3). It is straightforward to see that Eq. (3) is a less restrictive version of Eq. (2). First, substitute Eq. (1) into Eq. (2) to obtain

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

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

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

In Eq. (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

[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 because of small sample sizes combined with low HIV rates.

effects γ_t^*) that varies with HIV prevalence. The only difference between Eqs. (4) and (3) is that in Eq. (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 Eq. (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

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

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 1993–2005 period. All other estimates cover the 1988–2005 period.

Results

Table 3 presents estimates of Eq. (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 ordinary least squares (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 Eq. (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

[9] Estimates using probit models yield similar results. For almost all outcomes, Hausman tests reject the equality of coefficients between random effect and fixed effect specifications. At a p value of .05, this is true for antenatal care (chi-square test statistic = 328.44); blood pressure taken during antenatal care (9.76); blood tested during antenatal care (11.46); weight taken during antenatal care (7.12); clinic delivery (25.73); public clinic, conditional on clinic delivery (17.02); trained birth attendant at delivery (39.78); BCG vaccine (10.70); and DPT vaccine (11.12). At a p value of .10, we reject equality of random- and fixed-effect coefficients additionally for two outcomes: urine tests during antenatal care (chi-square = 3.58, p value = .0668) and polio vaccine (chi-square = 4.83, p value = .0894). Hausman tests fail to reject equality of the random-effect and fixed-effect coefficients for the measles vaccine (chi-square = 2.04, p value = .3602). Given these results, we present the country-region fixed effect results for our parametric estimation of Eq. (2) throughout the analysis. However, random-effect coefficients and fixed-effect coefficients are very similar for all outcomes. These results are available upon request.

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	–2.220	–1.214	–2.058	–1.403
	(0.074)	(0.254)	(0.273)	(0.203)	(0.148)
	[0.331]	[0.677]	[0.522]	[0.638]	[0.228]
Country/Region Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	177,785	68,867	68,830	68,880	68,923
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.

high HIV prevalence are significantly more likely to report prenatal care. Relative to living in a region with 5% prevalence, women living in a region with 10% 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 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.

[10] For the majority of our health service measures, results are robust to the inclusion of country-by-year fixed effects. This is true for reporting any antenatal care, and conditional on care reporting having had a urine test and blood pressure taken. It is true also for reporting a clinic delivery and the presence of a trained attendant at birth. In addition, our results continue to hold for reporting polio at birth and for children receiving polio, measles, BCG and DPT vaccines. When country-by-year fixed effects are included, HIV prevalence becomes insignificant in analyzing weight taken during antenatal care. For reports of having blood taken during antenatal care and reports that a public clinic was used, conditional upon a clinic delivery, the sign on HIV prevalence flips (from negative to positive). We prefer the specifications that do not include country-by-year fixed effects because they remove a lot of the signal in the data and may obscure the impact of HIV.

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 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 that 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).[11]

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 positively and significantly associated with immunizations in OLS regressions. However, within regions over time, children in regions with currently high HIV prevalence are significantly less

[11] Results in Table 4 are significant for the presence of a trained birth attendant, whether one relies on fixed-effect standard errors or those that are also clustered at the country/region. However, results for delivering at a clinic, or conditionally a public clinic, are not significant when fixed-effect standard errors are additionally clustered on the country/region.

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
Mean of Dependent Variable	0.419	0.843	0.475
HIV Prevalence in Year of Birth	1.013 (0.023)	–1.156 (0.025)	0.541 (0.024)
Country/Region Fixed Effects	No	No	No
HIV Prevalence in Year of Birth	–0.768	–0.509	–1.353
	(0.085)	(0.094)	(0.087)
	[0.531]	[0.320]	[0.283]
Country/Region Fixed Effects	Yes	Yes	Yes
Observations	221,421	98,360	216,901
Range of Birth Years	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.

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%, those born in the same region in 2005 (prevalence of 20%) would be 30 percentage points less likely to be immunized

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	0.511	0.802	0.860	0.968
	(0.030)	(0.021)	(0.024)	(0.021)	(0.023)
Country/Region Fixed Effects	No	No	No	No	No
HIV Prevalence in Year of Birth	–7.018	–2.708	–2.767	–2.021	–2.657
	(0.224)	(0.077)	(0.087)	(0.077)	(0.082)
	[0.571]	[0.535]	[0.523]	[0.393]	[0.623]
Country/Region Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	157,395	212,266	211,582	212,361	212,260
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.

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 earlier but assume 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 Eq. (3), reproduced here for convenience:

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

Our estimates are shown graphically. Specifically, after estimating Eq. (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%). 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, 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. 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. This upward trend is less pronounced at higher prevalence rates. At a 10% prevalence, the increase in antenatal care over the period from 1988 to 2005 was approximately 10 percentage points; and at 20% prevalence, antenatal care was relatively constant from

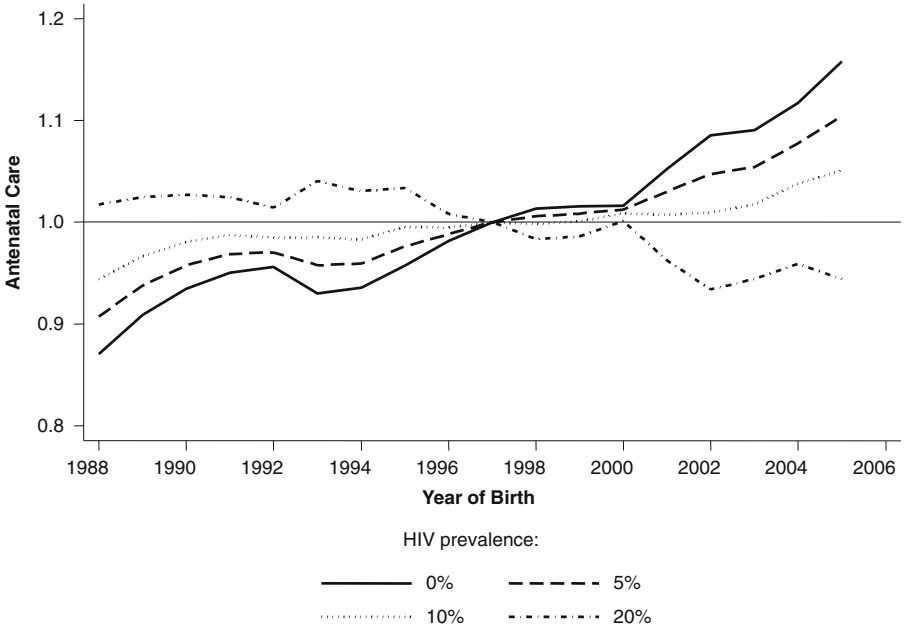

Fig. 2 Trends in antenatal care by HIV prevalence

1988 to 1995, and then declined by approximately 5 percentage points between 1995 and 2004. Test statistics from the regression underlying Fig. 2 are shown in the first row of Table 7 in Online Resource 1. 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 7 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 Eq. (4) are valid. This hypothesis is rejected. This is not surprising, given that the changes in antenatal care at different prevalence rates shown in Fig. 2 do not begin to diverge until the mid-1990s. 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 nonlinear. Second, it could be that the adverse effects of HIV on antenatal care have increased since the mid-1990s. 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 Fig. 3. Consistent with the results in Table 3, differences in all 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%, and such reports are approximately 30 percentage points less likely in regions where HIV prevalence is now 20%. The linearity restrictions are also rejected for these measures of care.

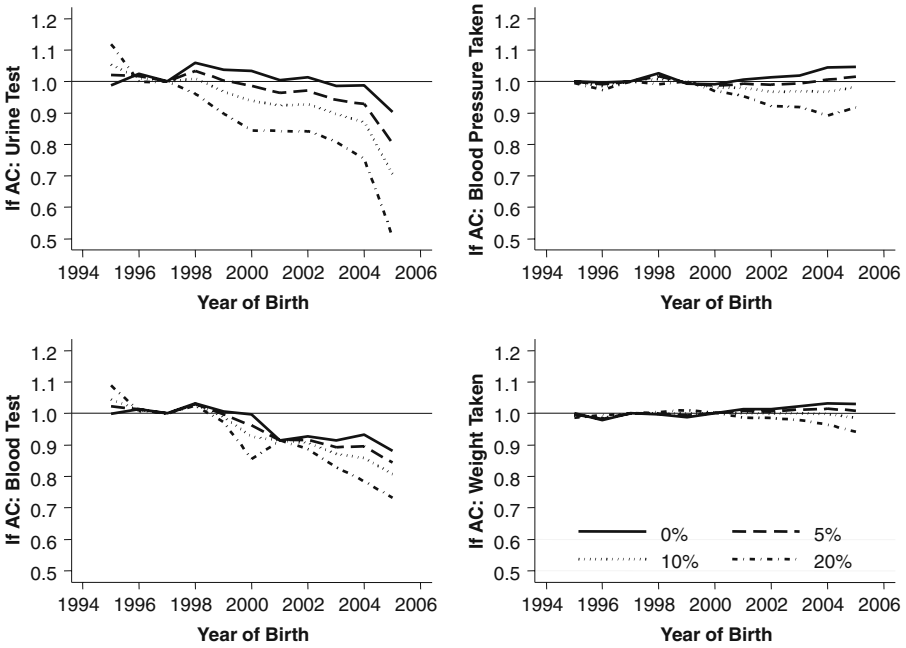

Fig. 3 Trends in antenatal procedures by HIV prevalence

Results for delivery care, in Fig. 4, indicate that the largest differences across higher- and lower-HIV-prevalence regions occur for the presence of a trained birth attendant. At 20% prevalence, the presence of a trained birth attendant declined 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, and whether clinic deliveries occurred in a public clinic.

Results for children's vaccines are presented in Fig. 5 and Fig. 6. (The latter is available in Online Resource 1.) 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% 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 (Fig. 6). The figures for the other vaccines are noisier, but show the same general pattern.

Overall, the estimates of the less restrictive models, using Eq. (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 shows greater year-to-year fluctuations,

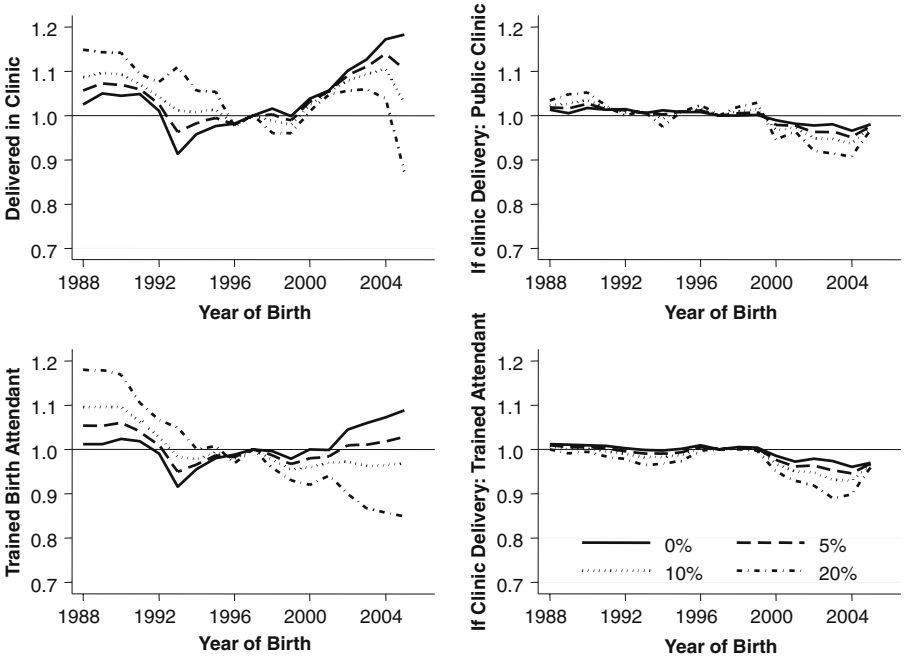

Fig. 4 Trends in birth delivery care by HIV prevalence

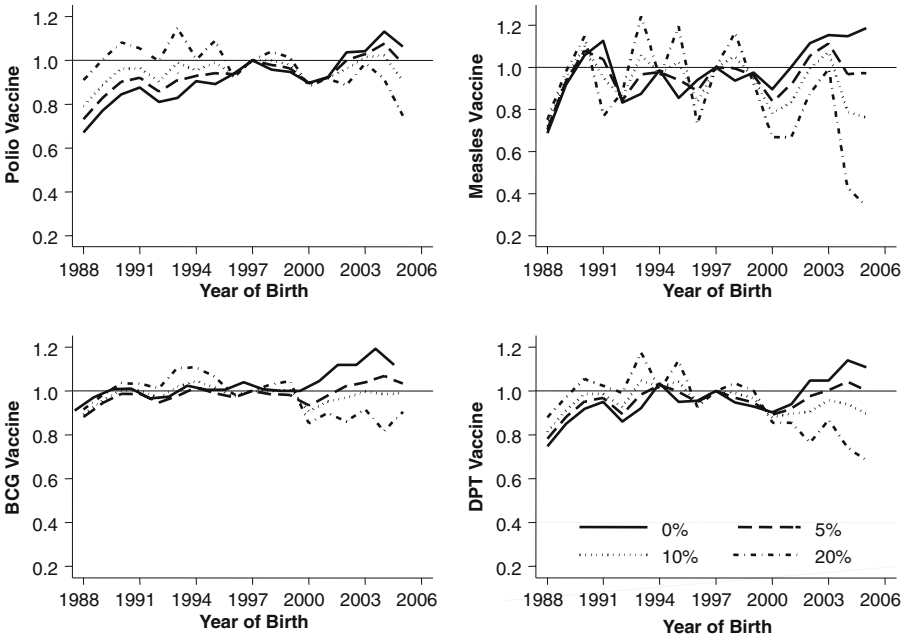

Fig. 5 Trends in childhood vaccinations by HIV prevalence

but also 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 in an editorial appearing in the *Lancet* ("Impact of HIV on delivery of health care in sub-Saharan Africa" 1995).

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 that 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 (noncompeting) 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 earlier, the areas with high current HIV prevalence had, on average, better health care statistics (e.g., higher rates of prenatal care) in the late 1980s and early 1990s 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.[12] 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

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.[13] Only a small fraction of young children are maternal orphans. One percent of all children under the age of 5 have mothers who are deceased. The fraction of children who are maternal orphans increases with age: only 0.3% of children younger than 1 year of age are maternal orphans, whereas 2.0% of 4-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 5 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% 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 reestimated 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 excluded, the coefficient on HIV prevalence is −1.03, with a standard error

[12] 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 that 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.

[13] Information on the vital status of the mother is unknown or missing for 341 of 138,486 children younger than 5 in the sampled households in these surveys.

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.[14] 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 (ART) 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 to 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 8 of our online appendix. Between 6.3% and 21.0% of women report not knowing where to go for medical care; 32.8% to 60.0% report that distance is a problem; 39.9% to 75.6% say that money is an issue; and 33.2% to 71.6% say that 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. 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

[14] 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 five 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 three years, we included only orphans under the age of 3.

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 because, as we discuss earlier, we do not find an association between wealth and HIV prevalence. Nonetheless, we examine 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 are 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 12 countries in our sample for which information on maternal HIV status can be matched to the health information.[15] We estimate regressions as in Eq. (2) for antenatal care, birth deliveries, and children's immunizations, which include 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 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.

[15] Zambia and Tanzania are excluded.

Quality of Health Services

Our parametric and semiparametric 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 receive 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 an increased need by HIV patients for care.

Grépin (2009) examined 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 found 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 indicated that foreign aid for AIDS grew little until the year 2000 and then escalated rapidly as funds for ART became available through the President's Emergency Plan for AIDS Relief (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 to 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-1990s, 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.

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 been deteriorating 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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