AIDS and African Development

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Mead Over

Because AIDS affects primarily the most productive age group and is fatal and widespread, it will have a larger impact on African development than other more common diseases. Infection rates are higher in urban than in rural areas, and studies suggest that they are highest among urban high-income, skilled men and their partners. Macroeconomic models show that the greater the infection rate among educated workers and the greater the propensity to finance medical care out of savings, the more detrimental is the impact of AIDS on the growth of per capita income. Regardless of the macroeconomic effect, most households and businesses directly affected by AIDS will be economically worse off, at least in the short run. It is not clear, however, what effect AIDS will have on poverty in Sub-Saharan Africa or on income inequality. Governments need to assess the potential economic impact of AIDS, implement cost-effective programs to mitigate the impact, and target prevention programs to the economic sectors most sensitive to HIV infection.

The World Health Organization (WHO) estimates that by mid-1993 more than 8 million African adults were infected with the human immunodeficiency virus (HIV), the virus that causes AIDS, and an estimated 1.2 million adults had died of AIDS (WHO/GPA 1993).[1] Africa accounts for more than 60 percent of the 13 million cumulative cases of adult HIV infection worldwide. Other, more prevalent diseases in Sub-Saharan Africa claim more lives than AIDS and also have a negative impact on economic development—for example, there are probably 110 million cases of malaria in Sub-Saharan Africa each year (World Bank, forthcoming). Why, then, should policymakers be particularly concerned about the economic impact of AIDS?

Four characteristics of AIDS and its epidemiology give it an economic impact greater than that of more prevalent diseases.[2] First, with current medical technology, AIDS is always fatal. There is no cure and no vaccine. In contrast, fewer

The World Bank Research Observer, vol. 9, no. 2 (July 1994), pp. 203–40

than 20 percent of malaria episodes in infants and fewer than 1 percent in adults end in death (Ghana Health Assessment Project Team 1981).

Second, AIDS in Africa is affecting primarily prime-aged adults in their economically most productive years, who acquire HIV mainly through heterosexual intercourse, and young children, who acquire it from their mothers at birth. The skills and experience lost through adult deaths from AIDS represent a huge setback to efforts to raise the productivity of the work force. And because adults are often responsible for the care of both young and elderly dependents, increased adult deaths will leave large numbers of surviving family members with lower incomes, poorer health, and reduced prospects. AIDS is also a growing cause of child mortality, which threatens to erase past improvements in child health.

Third, in many African countries, HIV and AIDS are already widespread and their economic and social effects are already being felt. Before the AIDS epidemic, adults in their economically most productive years were dying at a rate of about five to six per thousand persons a year, or eight times the rate in industrial countries. In many African countries, particularly in urban areas, the baseline adult mortality rate has doubled or tripled, and AIDS is now the major cause of adult deaths. And those who have died of AIDS represent only a fraction of those who are infected. The high prevalence (percentage of people infected) of HIV in Africa and the long incubation period for AIDS imply that disability and death from HIV and AIDS will hold back African development well into the next century, even if prevention efforts are successful. The need is thus urgent to invest in programs to prevent and slow the spread of HIV and to mitigate the economic and social impact of AIDS.[3]

Fourth, unlike other major causes of premature death in Africa, AIDS has not spared the elite. The degree to which AIDS will affect economic growth will depend largely on the severity with which it strikes educated Africans.

Although the channels through which AIDS will affect economic growth are clear, the likely severity of that impact is still not well documented—because of a dearth of studies measuring current impacts and uncertainties about the future spread of the disease. This article provides an overview of the likely impact of the AIDS epidemic on African economic development. The first half explores the aggregate economic effect of AIDS—its demographic impact and its effect on growth in per capita income. Though there are numerous predictive models employing a wide range of assumptions, there is little empirical information to inform the choice of assumptions. In particular, the aggregate economic impact of AIDS will depend on the behavioral responses of economic agents to demographic shocks. The second half of the article reviews what is known about the coping behavior of households, firms, and government in such areas as medical care, labor and productivity, and education. This understanding is important for improving aggregate models and for exploring the distributional implications of AIDS.

The Aggregate Effect on the Economy

The size of the AIDS epidemic, now and in the future, and its potential effects on the growth rate of the population and the health of the labor force are the starting point for any discussion of the economic impact of AIDS. Four steps are involved in such projections:

- Estimating the current rate of HIV infection in the adult population as a whole and within economically important categories
- Projecting the path of HIV infection in each of these population groups
- Computing the demographic consequences of the path of HIV infection
- Estimating the economic consequences of these demographic changes.

Estimating the current rate of HIV infection with the data at hand is difficult. Projecting infection rates is even more difficult, requiring detailed knowledge about the sexual behavior of different epidemiological and demographic groups in the country. Modeling these behaviors is important because of what it can tell us about the cost-effective targeting of interventions to these different groups (Over and Piot 1993; Bos and Bulatao 1992; Anderson and others 1991).

This approach implies a unidirectional causal link from HIV infection to economic consequences. It does not allow for rational economic agents to respond to the perceived growing threat of AIDS—and to the price changes it sends rippling through markets—by changing their behavior and thereby changing the HIV incidence rate (percentage rate of new infections among uninfected people). Some authors have taken the first step toward developing such a model by simulating the impact on the future epidemic of specific changes in behavior (Bulatao 1991; Way and Stanecki 1991; Armstrong and Bos 1992). A few authors are beginning to model human sexual behavior (Philippson and Posner 1993; Kremer 1994). No one, however, has yet produced a model that allows feedback in both directions.

An approach that allows behavioral responses to affect the future spread of HIV would be theoretically satisfying, but the long period between a change in sexual behavior and the demographic consequences of that behavior—as well as the subsequent lag between the demographic changes and their economic consequences—suggests that the gains in understanding from such an approach would be apparent only in projections covering many decades. For medium-term projections, a model that treats the epidemiology and demographic consequences of AIDS as unaffected by the economic projections is likely to be sufficiently accurate.

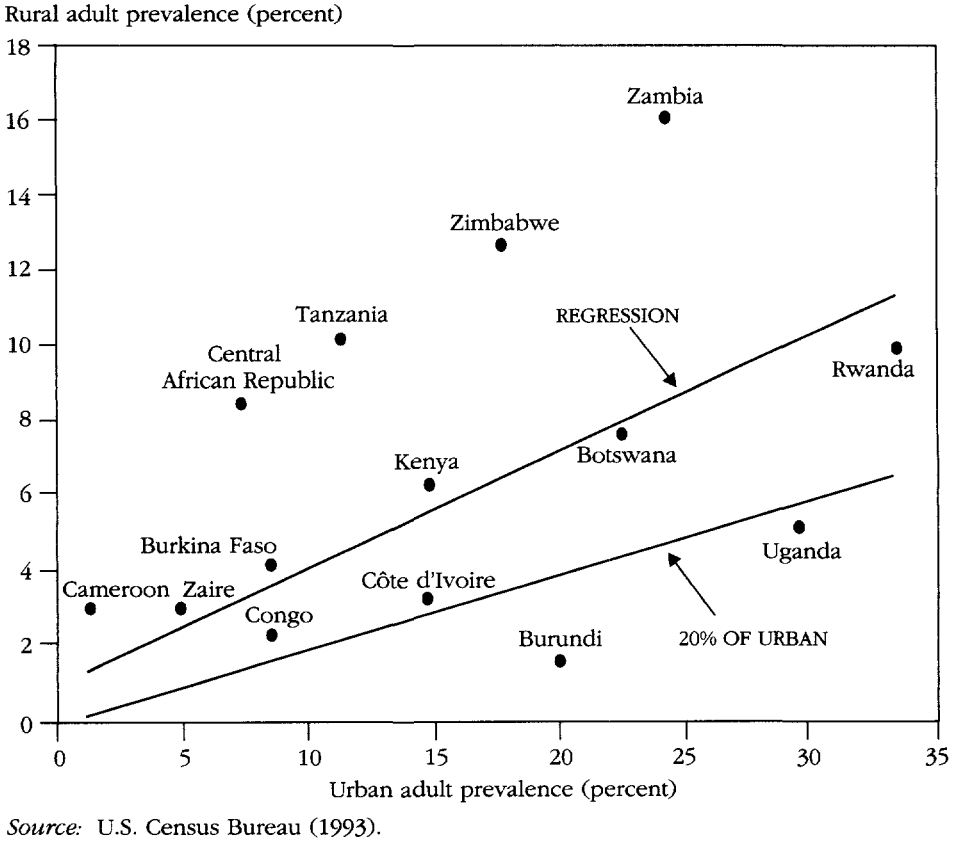
HIV Prevalence in the General Population

If we had good data on seroprevalence (the percentage of people found to be HIV-positive through blood tests) in the adult population as a whole in each African country by time of infection, we could predict when these people

would come down with AIDS. But systematic national seroprevalence surveys have been conducted only in Rwanda (1986), Uganda (1988), and Côte d'Ivoire (1989), and for none of these countries do we have a series of annual surveys. Rather, the available data consist of information on conveniently sampled subgroups of the population, such as pregnant women and blood donors. We can plot estimates of the percentage of "low-risk" adults infected with HIV in 1993 in rural and urban areas of the fourteen African countries with the highest infection rates, using the U.S. Census Bureau data set on HIV seroprevalence rates (figure 1).[4] For rates in the population at large, we can then extrapolate from these data.

Urban or rural residency is the economically relevant variable most often collected in studies of HIV prevalence. For many African countries, data on rural and urban levels of infection can be used to estimate the national infection rate. One approach is to calculate a weighted average of the urban and rural low-risk prevalence rates, using the urban and rural proportions of the adult

Figure 1. *Rural and Urban Rates of HIV Infection Among Low-Risk Adults in Fourteen African Countries, circa 1993*

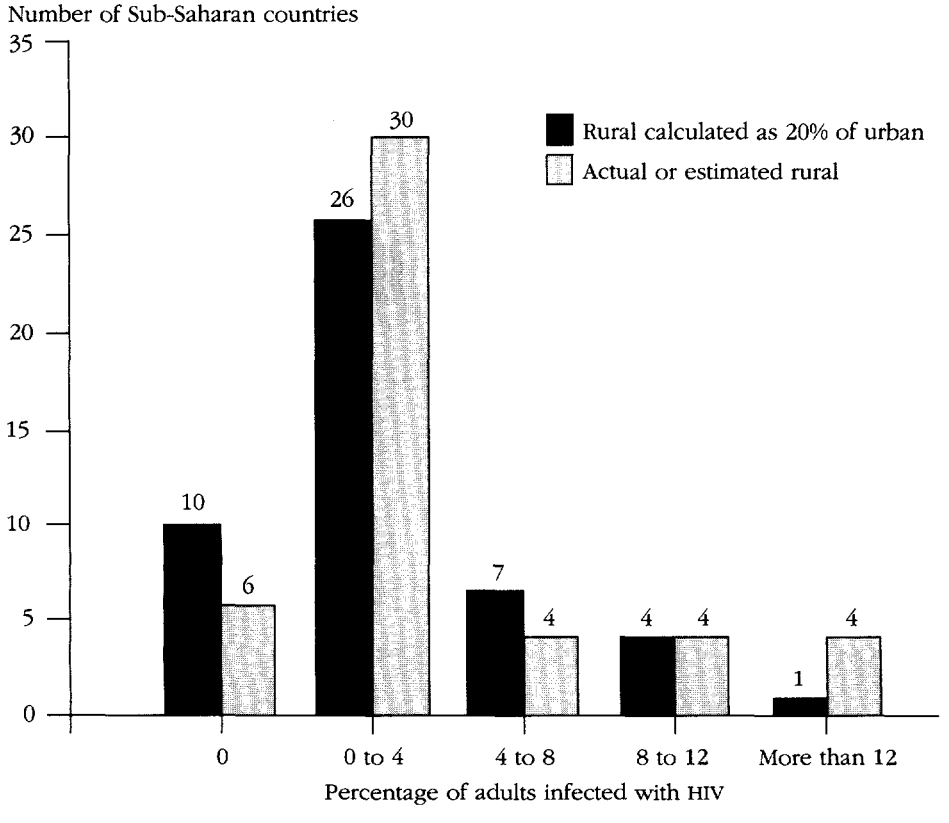


Source: U.S. Census Bureau (1993).

population as the weights. Applying this approach to the forty-seven Sub-Saharan African countries in the U.S. Bureau of the Census data set on seroprevalence rates yields estimates of 3.4 million urban and from 1.9 to 4.3 million rural HIV-infected adults in mid-1993.[5] Assuming that about one million HIV-infected persons have died since the beginning of the epidemic, the larger total of 7.7 million infected adults is consistent with the 8 million *cumulative* infections predicted for mid-1993 by WHO on the basis of its confidential data—suggesting that WHO's data may not differ much from the Census Bureau data base.

Two frequency distributions of the national adult seroprevalence rate for the forty-seven Sub-Saharan countries for which data are available are presented in figure 2. One assumes conservatively that rural prevalence rates are one-fifth of urban rates; the other uses the rural prevalence rates in the data set or estimates them from a regression of the prevalence rates in figure 1. Weighting each country's estimated prevalence rate by its population yields seropreva-

Figure 2. *Frequency Distribution of National Adult Infection Rates for HIV-1, 1993*



Source: Authors' calculations based on U.S. Bureau of Census data; see text.

lence rates for the adult population of Africa of 2.5 for the conservative case and 3.6 percent for the other case.

The Current Rate of HIV Infection by Economic Group

A full understanding of the economic impact of AIDS requires information not only on its average prevalence but also on whether prevalence differs for different economic groups. It is often stated that HIV is a disease of poverty.[6] The most frequently cited evidence to support this assertion is the greater estimated number of HIV-infected adults in rural areas of Sub-Saharan Africa than in urban areas, where almost all adults with at least a secondary school education reside. But much less certainty can be attached to rural than to urban infection rates. Estimates of the number of rural adults infected with HIV bracket the more accurately estimated urban number. For the purpose of understanding the epidemic's economic impact, however, the number of infected people is less important than the percentage infected in each economic group. And even the larger estimate of the number of rural adult infections—some 27 percent larger than the urban number—corresponds to a rural infection *rate* only half the urban rate.

By its disproportionate effect on the urban population, HIV presents a sharp contrast to other causes of death. A comparison of adult mortality in seven Sub-Saharan countries in the 1970s and 1980s (before AIDS could have significantly affected the patterns) found higher urban life expectancies at age fifteen—by as many as six years–in every case (Timaeus 1993, table 6–3).

Beyond the simple but compelling correlation between HIV infection and urban residence, the evidence on the correlation of HIV infection with socioeconomic status is incomplete. For the purpose of predicting the economic impact of current infection patterns, it would be sufficient to have a multivariate analysis of infection rates by education level, while holding constant age, gender, and ethnic group. But most epidemiological studies either omit socioeconomic indicators altogether or apply only bivariate analysis. The bivariate analyses beg the question because any measured correlation between HIV infection and education might be due to the fact that, for example, older individuals are more likely to be both HIV infected and educated. Those that do apply multivariate analysis include among the explanatory variables such "risk factors" as marital status, number of sex partners, history of sexually transmitted diseases, occupation, and amount of travel. The inclusion of the "risk factors" is unhelpful, because they are outcomes of the same set of decisions that could lead to HIV infection. Their inclusion in the analysis serves only to mask the relationship between infection and the true independent variables.[7]

Suppose that changing sexual partners is positively related to socioeconomic status for men and negatively related to status for unattached women because of differences in social roles. If this were the case, one would predict, after controlling for other determinants of casual sexual activity such as age and

ethnicity, that men with higher status who are unaware of the risk of HIV infection would have a higher rate of HIV infection than similar men of lower status. Furthermore, the spouses of these men would share their risk—resulting in higher infection rates for women whose husbands have higher status. Unattached women, particularly prostitutes, would have lower infection rates at higher status.

A few studies seem to confirm this hypothesized relation between socioeconomic status and sexual behavior or HIV infection. Preliminary results from multicountry surveys sponsored by WHO during the late 1980s show a monotonically increasing relationship between male schooling and the number of casual or commercial partners over the past twelve months for the Central African Republic, Côte d'Ivoire, Kenya, and Togo (Cleland and others 1992; Caraël and others 1990), although no multivariate analysis of the data has yet been published. In urban Rwanda in 1987 the rate of HIV infection in women attending prenatal clinics was not correlated with their own socioeconomic status, but rose with the education and income of their husband or partner (Allen and others 1991). Infection rates also differed by partner's occupation, ranging from 9 percent for women whose husbands or partners were farmers to 30 percent for women whose husbands were in the private sector or government (table 1). Applying a multivariate analysis to the data, the Rwandan study found that the odds of HIV infection were 1.96 times higher among women with high-income partners (more than 10,000 Rwandan francs a month) than for women with lower-income partners.[8] Education, occupation, and age had no statistically significant effect. However, these results are biased because they include as covariates many behaviors that are themselves determined by socioeconomic status—such as number of partners and presence of other sexually transmitted diseases. Thus, the results should be interpreted as the effect of income, holding constant other behaviors also determined by income.

An ongoing study of a population sample from the Rakai District of Uganda finds a strong, statistically significant, and positive association between education and HIV infection for both women and men, based on a bivariate analysis. Men and women with secondary educations have infection rates (20 and 41 percent) more than twice as high as men and women with no education (8 and 14 percent; Serwadda and others 1992). Multivariate analysis of the data is confounded by the inclusion of risk factors as though they were independent variables. Studies of workers in a textile factory and a large bank in Kinshasa, Zaire, in 1987 found that the risk of HIV infection rose with socioeconomic status (Ryder and others 1990). Since the studies controlled for area of residence (urban), gender (almost all workers were men), and travel pattern (employers of the same enterprise are more likely to share travel patterns than subjects chosen in a random survey or in other kinds of convenience surveys), the absence of multiple regression analysis is less restrictive in their interpretation. Seroprevalence rates were higher among male employees of the bank (5.8 percent) than among male employees of the textile factory (2.8 percent).

Table 1. *Percentage of Women Who Are HIV-Positive, by Socioeconomic Status of Their Male Partners, Kigali, Rwanda, 1987*

Socioeconomic status of partner	*Percentage of HIV-positive women*
Education	
0–4 years	18
5–7 years	32
8 years or more	34
Monthly income (Rwandan francs)	
None	22
1–9,999	25
10,000 or more	35
Occupation	
Farmer	9
Military	22
Private sector	32
Civil service	38

Note: Total number of respondents, 1,350.
Source: Allen and others (1991).

Seroprevalence rates varied from 2.8 percent for manual workers to 4.5 percent for foremen and 5.3 percent for executives in the textile factory (Ndilu and others 1988) and from 4.2 percent of manual laborers to 6.8 percent of high-income employees in the bank (Ryder and others 1990). A study of adults in Monze District, Zambia, that controlled for age, gender, and urban or rural residence also found that skilled workers and traders were more likely to be infected (Buvé and Foster 1993).

Data on the infection rate of unattached women come largely from studies of prostitutes. The few studies that have collected information on the socioeconomic status of their subjects uniformly find that prostitutes that charge more for their services have fewer sexual contacts and, presumably as a result, lower infection rates (Kreiss and others 1986; Denis and others 1987, cited in Padian 1988).

Some observers predict that the gap in seroprevalence between rich and poor, urban and rural, will eventually narrow. There is evidence, for example, that many urbanites return to their village of origin when they come down with AIDS, lowering urban prevalence and raising rural prevalence even in the absence of any behavioral change (Buvé and Foster 1993). But if the most important cause of differences in prevalence in urban and rural areas and by income is the higher frequency of unprotected sex with new partners among urban high-income males and low-income single females, and if this behavior

continues, epidemiological models predict that the gap in prevalence will continue (Over and Piot 1993). The gap will also continue if both groups change their behavior by the same amount (for example, by increasing the frequency of condom use). Only if groups that currently engage in riskier behavior systematically lower their risk while low-risk groups do not, will the gap narrow. Such an outcome is a possible result of greater responsiveness by better-educated men and by prostitutes to the fear of HIV infection, but it is by no means assured. The study of sexual behavior as it affects the rate of new HIV infection (the incidence rate) will require fully developed structural models that characterize the simultaneous determination of epidemiological risk factors, sexual behavior, and infection. There is a need for new data and an even greater need for new analyses of existing data that include socioeconomic as well as epidemiological variables.

Projecting Infection Rates

Given the estimates of current HIV infection rates in Sub-Saharan countries derived above, the next task is to project infection rates. Because the median incubation period of HIV infection is as long as ten years, current patterns of infection can be used to predict mortality patterns five to ten years in the future. However, over longer periods, differences in the structure and parameters of alternative models used to project the progression of infection rates in an African country lead to divergent outcomes. (The models have been discussed in several surveys and so are not described here; United Nations/WHO 1991; Stoto 1993; Stover 1993a; Chin and Sato 1994.)

At an upper extreme of a range of assumptions about sexual behavior, Anderson and his coauthors have shown that national rates of adult HIV infection could rise to as high as 40 percent over fifty years (Anderson 1988; Anderson and others 1991). Other analysts, using more modest assumptions about sexual behavior, have projected ceilings of 10 to 20 percent (Bulatao 1991; Bongaarts 1990). Data from WHO-supported national surveys of sexual behavior in the late 1980s suggest that even the lower rates of change in sexual partners assumed by Bulatao exceed those observed in Africa (Cleland and others 1992). The release of recently collected WHO data on behavior should lead to substantial new understanding of the possible future trajectories of infection rates in African countries. In the meantime, it is important to perform sensitivity analysis on estimates of impact with respect to the national seroprevalence rate and its distribution by socioeconomic class.

Demographic Consequences of HIV Infection

Compared with projecting infection rates, projecting the demographic consequences of infection is straightforward, requiring only assumptions about the

effect of HIV infection on mortality and fertility. Given these assumptions, demographic models routinely compute predictions about the demographic variables that influence a country's economic growth: the size and health of the labor force and its age distribution. If infection data were available by socioeconomic group or sector of employment, it would be useful to extend the models to predict the size and health of these subsets of the labor force.

IMPACT ON MORTALITY AND FERTILITY. The demographic impact of an HIV epidemic depends on how it affects mortality and fertility. Stover (1993a, b) notes that all epidemiologic and demographic models agree that the higher death rates due to AIDS would eventually reduce population growth to zero if the HIV infection rate among adults rose high enough. He also derives a relationship between the prevalence rate and the proportion of the work force that is sick in any given year (Stover 1993b). Both relations are approximately linear over the range of interest, and both share a critical dependence on the length of the "incubation period" of HIV infection—the time from HIV infection to AIDS. The importance of the incubation period is sufficient to warrant a review of what is known about its length.

The impact of HIV on mortality depends on the distribution of the lag between infection and AIDS and between AIDS and death. The time profile of HIV incubation is relatively well known for homosexual and bisexual men in industrial countries (Moss and Bachetti 1989; Rutherford and others 1990). A longitudinal medical study of a cohort of homosexual and bisexual men in San Francisco, launched in the 1970s before the advent of the AIDS epidemic, has drawn blood from participants every six months. Researchers were able to test for HIV and to determine within a six-month interval when each participant became infected. In this ongoing study, the median time from infection to development of AIDS is ten to eleven years, with an almost constant hazard rate of converting from infection to AIDS of about 9 percent a year.

No one knows whether this distribution of incubation time is applicable to epidemics among other population groups and in developing countries (Ryder and Mgerwa 1994). Indirect methods suggest that the time from HIV infection to AIDS is shorter in Sub-Saharan Africa. Among 101 HIV-positive but asymptomatic hospital employees in Kinshasa, 31 percent developed AIDS-related illness or AIDS over a period of two years, much higher than the 18 to 22 percent that would have been predicted on the basis of the San Francisco data (Ryder and Mgerwa 1994, p. 271). Researchers working in Kagera Region, Tanzania, measured the HIV prevalence rate in 1989 and the incidence rate between 1989 and 1991. Applying the model of a stable epidemic, which they admit may not be applicable in Kagera, the researchers tentatively estimate the average duration of a case of HIV infection as the ratio of prevalence to incidence. For the portion of Kagera Region where prevalence and incidence were highest, and therefore most accurately estimated, the prevalence rate was 14 percent and the incidence rate 1.8 percent, implying an average duration of infection of seven

years (Killewo and others 1993). Stover (1993a, b) suggests that the mean incubation period might be as low as five years or as high as ten years in Sub-Saharan Africa. Indeed, it could vary from country to country.

The other important variable affecting the demographic consequences of HIV infection is the fertility rate. An elementary conclusion of the demographic modeling is that HIV infection will not sufficiently shorten the lives of a large enough number of women to reduce national birth rates unless infection lowers age-specific fertility rates.[9] By the time most HIV-infected women die, they have already given birth to several children (Stover 1993a, b). Behavioral responses to the AIDS epidemic can affect individual fertility, however. For example, HIV-positive couples may decide to avoid pregnancy rather than risk giving birth to children who will be infected with HIV or who may soon be orphaned. Other behaviors related to reducing the spread of HIV—such as delayed marriage, less sexual activity, and greater use of condoms—may also reduce fertility (Caldwell and others 1993). Conversely, uninfected parents might respond to the higher mortality rate of children who will be infected with HIV as adults by having more children, to guarantee a certain number of surviving offspring for their security in old age.

There is no good evidence about which of these effects might dominate. It is inherently difficult to deduce how fertility is responding to the epidemic. Comparing fertility rates of HIV-infected and uninfected women fundamentally confounds the effect of HIV infection with differences in the characteristics of these women that led to their different HIV status and that also affect their fertility. For instance, prostitutes may be more likely to be infected than other women and, because of infertility caused by other sexually transmitted diseases, to have fewer children regardless of their HIV status. Even among prostitutes who are pregnant, the probability of having another child is likely to be less than that of other women, and prostitutes are more likely to be HIV-infected than are average pregnant women. Thus, without holding constant these confounding characteristics, one cannot deduce the effect of HIV infection on fertility by comparing the fertility behavior of women subsequent to their having a child and being informed of their HIV status.

Two studies in Zaire have nevertheless attempted to gauge the impact of HIV infection and counseling on fertility. A study followed 553 women for thirty-six months after delivery at Mama Yemo Hospital in Kinshasa, Zaire, and found that HIV-positive women had lower annual pregnancy rates than HIV-negative women (245 per 1,000 compared with 316 per 1,000) and that fertility was lowest among symptomatic HIV-positive women (Ryder and others 1991). A second study at the same hospital examined the impact of an HIV-counseling and testing program on 364 postpartum women and found, after a twelve-month follow-up, that 6 percent of HIV-positive and 8 percent of HIV-negative women had become pregnant (Heyward and others 1993). For the reasons just mentioned, these studies are difficult to interpret, but they suggest

that HIV-positive women are *unresponsive* to counseling and testing programs designed to prevent births.

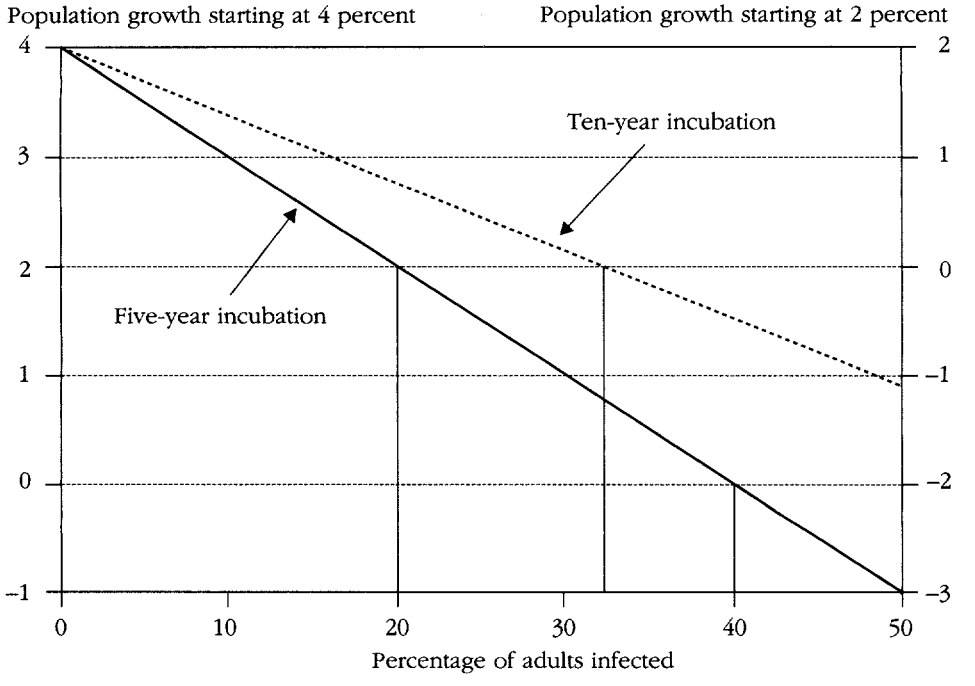
Because of the lack of evidence and the possibility that fertility could be affected in either direction, most demographers have assumed that fertility will slowly decline through the coming decades just as it was projected to do in the absence of the AIDS epidemic. None of the demographic models takes into account the possible effect of AIDS-related behavioral changes on fertility.

PROJECTING DEMOGRAPHIC EFFECTS. The uncertainty about the incubation period in Africa translates into some uncertainty about the effect of a sustained prevalence of HIV infection on the growth, health, and age distribution of the labor force. Assuming that fertility rates follow the path they would have taken without HIV infection and that the incubation period is ten years, Stover (1993a, b) calculates that it would take a sustained prevalence rate of 48 percent of the adult population to halt population growth in an African country that would otherwise be growing at a rapid 3 percent a year. If the incubation period is only five years, a 30-percent seroprevalence rate is sufficient to bring population growth to zero. Furthermore, the relationship between these values is a linear function of the prevalence rate as depicted in figure 3 (Stover 1994, personal communication).

Consider the cases of a 2 and a 4 percent annual base growth rate of the population (figure 3). For the country that was growing at 4 percent before the onset of the AIDS epidemic, an incubation period of five years means that the population growth rate would fall to zero if the national seroprevalence rate rose to 40 percent (the intersection of the solid curve and a zero rate of population growth on the left axis of figure 3). If the incubation period is ten years (the dashed curve), the population would stop growing only if the adult prevalence rate exceeded 50 percent. Such extreme prevalence rates have been observed in high-risk groups in urban areas but are unlikely to prevail across an entire country. With an underlying population growth rate of 2 percent a year (right axis), however, the sustained national seroprevalence rate among adults that would reduce population growth to zero drops to 32 percent for an incubation period of ten years and to 20 percent for an incubation period of five years.

Two lessons can be drawn from this exercise. First, zero or negative population growth is not a likely outcome for an entire country in Africa, although it could occur in areas where infection rates are extremely high if there were no offsetting in-migration. Second, the impact of a change in the sustained prevalence rate on population growth can be estimated, regardless of current levels of prevalence or population growth, if the incubation period is also known. Every ten-percentage-point increase in the prevalence rate will, according to figure 3, reduce population growth by between 0.6 and 1 percentage point a year, depending on the incubation period.

Figure 3. *Impact of a Sustained HIV Infection Rate on the Population Growth Rate*



Note: Assumes fertility rate is unchanged by the HIV epidemic.
Source: Authors' derivation based on Stover (1993a, b, c).

Impact on Growth of per Capita Income

Despite different approaches and assumptions, the various demographic-epidemiologic models agree that the AIDS epidemic will lead to a steep rise in mortality rates among economically active adults and among young children. Life expectancy will decline. Assuming that the slow decline in fertility is not affected by the epidemic and that seroprevalence rates stay below 30 percent among adults, population growth rates will be slowed but will stabilize at positive levels nationally.

In addition to slowing the growth of the population, and therefore of the labor force, the AIDS epidemic has a second direct and immediate effect on national output: it makes people sick. With a survival rate of about one year for Africans who contract AIDS, Stover (1993b) shows that in a steady-state epidemic, the portion of the HIV-infected adult population that will be sick with AIDS is determined largely by the incubation period. An incubation period of

five years means that 14 percent of the HIV-infected population would be sick in any year; the rate falls to 9 percent with an incubation period of ten years. Every ten-percentage-point increase in the prevalence of HIV infection increases the share of the adult labor force that is sick during the year by 0.9 to 1.4 percentage points. At these slower population growth rates, up to 4.2 percent of the adult work force will be suffering from AIDS.

Higher mortality caused by AIDS is a tragedy to those who die and to their families. But if the epidemic slows the growth of the gross domestic product (GDP) by less than it slows the growth of the population and the labor force, the negative economic effects of AIDS will be partially offset by increased growth in per capita income. Under what conditions will a high death rate from AIDS result in higher average welfare among those who survive?

If national output is produced by two factors of production, workers and capital, then the growth rate of output is simply a weighted average of the growth rates of these two productive factors. In a world of constant returns to scale, the weights are the output elasticities of the two factors and they sum to one. In this simple world, the impact of an HIV epidemic with a sustained national prevalence of, for example, 10 percent is the weighted average of its effects on the growth of capital and healthy labor.

When HIV prevalence is rising, the growth of effective labor will temporarily fall even lower as the share of workers who are sick rises and their efficiency falls. But as soon as the prevalence rate levels off, the rate of sickness will also level off, and the only effect of the epidemic on the growth of effective labor will be through its effect on the number of workers. From figure 3, every ten-percentage-point increase in the epidemic will slow the growth of the work force by 0.6 to 1.0 percentage points a year.

How likely is it that a sustained HIV prevalence rate of 10 percent will slow the growth of capital by as much as 0.6 to 1.0 percentage points a year and thereby slow the rate of per capita income growth?[10] The HIV epidemic will slow capital accumulation primarily by inducing a partial reallocation of private and public resources from savings and investment to medical treatment of AIDS patients, social support payments for orphans, and, increasingly, programs to prevent the spread of HIV (see the following section on coping with AIDS). Following Cuddington (1992) and Over (1992), the savings consumed by AIDS treatment during the year are determined as follows,

$$(1)\quad \begin{array}{c}\textit{National savings diverted by AIDS treatment}\end{array} = \begin{array}{c}\textit{Number of workers}\end{array} \times \begin{array}{c}\textit{Proportion of workers HIV+}\end{array} \times \begin{array}{c}\textit{Proportion of HIV+ workers with AIDS}\end{array} \times \begin{array}{c}\textit{Annual treatment cost of AIDS}\end{array} \times \begin{array}{c}\textit{Proportion of treatment cost from savings}\end{array}$$

The magnitude of this diversion of savings thus depends partly on epidemiological factors—the HIV prevalence rate and the proportion of HIV-positive workers who are sick—and partly on two economic factors—the annual cost of treating an AIDS sufferer and the way that cost is financed. Annual medical

costs and the way they are financed differ both within and among developing countries (Over 1992; Over and others 1988). Cost and financing can also be influenced by public policy, as countries and individuals decide whether to buy expensive antivirals that achieve only limited additional healthy life. (Over and Piot 1993 provide estimates of the cost-effectiveness of alternative ways of treating AIDS in a developing country.)

One of the most obvious effects of the AIDS epidemic will be increased private and public expenditure on medical care. There is virtually no representative empirical evidence on how households finance AIDS medical costs or on other effects of the epidemic on savings behavior. Households may finance part or all of medical costs out of savings. According to anecdotal evidence, some households have sold land or productive assets to finance medical care (Ankrah and others 1992; Anarfi 1992, cited in Caldwell and others 1993). We do not know to what extent this behavior differs from that associated with hospitalization of adults for other causes. Many households presumably finance medical care from transfers from other households (Anarfi 1992 cited in Caldwell and others 1993), but these transfers must also be financed. Households with little or no savings may reallocate their existing medical budget from other household members to the person with AIDS (McGrath and others 1993) or reduce the consumption of other household members.

But even if medical costs are financed from savings, anticipatory behavior by households may result in *increased* savings that offset spending on medical care. For example, at least one anthropological study has documented attempts by infected adults to build a house or otherwise provide for family members who will survive them (Ankrah and others 1993). The prospect of contracting HIV may induce unaffected individuals to save more against the day when they may need to spend more on medical care if they become infected or to support themselves in the event that their children die prematurely of AIDS.

The next section of the paper reviews evidence on the magnitude of AIDS treatment costs and suggests the empirical regularity that these costs average from two to four times per capita income. Substituting the ratio of average medical treatment costs for AIDS to per capita income into equation 1 and dividing by total national capital stock gives an expression for the percentage reduction in capital stock each year due to AIDS treatment costs:

$$(2)\quad \begin{array}{l}\textit{Annual percentage reduction in capital due to AIDS treatment}\end{array} = \frac{\textit{Proportion of HIV+ workers} \times \textit{Proportion of HIV+ workers with AIDS} \times \frac{\textit{Average medical costs for AIDS treatment}}{\textit{GDP per capita}} \times \textit{Proportion of treatment cost from savings}}{\textit{Capital-output ratio}} \times 100$$

Note that the denominator in equation 2 is the capital-output ratio, which also commonly ranges between two and four. If the ratio of average medical

treatment costs for AIDS to per capita income and the capital-output ratio cancel out in the typical country, the impact of HIV prevalence on capital stock will be determined by the product of the three remaining proportions in the numerator. An HIV prevalence rate of 10 percent of the population, some 10 percent of them sick with AIDS in a given year, and a reallocation from savings of about half of AIDS treatment costs would result in a reduction in the growth rate of capital of 0.5 percentage point a year ($0.1 \times 0.1 \times 0.5 \times 100$).

The impact on the rate of growth of capital is of the same order of magnitude as the reduction in the growth rate of labor that such an epidemic would produce. That means that the direction and size of the epidemic's impact on per capita income will be determined by the exact values of the parameters in the two equations above, which will differ from country to country. Sensitivity analysis of the two equations with respect to two epidemiological parameters (the prevalence rate and incubation period of the epidemic) and three economic ones (the capital-output ratio, the ratio of AIDS treatment cost to per capita income, and the proportion of AIDS treatment costs financed from savings) reveals that the direction of the epidemic's impact on per capita income is determined by the economic parameters, while the size of the impact is determined by the epidemiologic ones. If more than half of treatment costs are financed from savings and the ratio of the cost of treating an AIDS case to per capita income is more than twice the capital-output ratio, the epidemic will reduce the growth rate of per capita income. The magnitude of that reduction will range from 0.1 percentage point a year if the national prevalence rate is 10 percent and the incubation period is ten years to 0.8 percentage point a year when the prevalence rate is 30 percent and the incubation period only five years.[11]

Studies have simulated the macroeconomic impact of AIDS under alternative assumptions about the share of treatment costs financed from savings, the productivity of workers with AIDS, and the impact of AIDS on population growth (Cuddington 1993; Cuddington and Hancock 1992; Over 1992; Kambou, Devarajan, and Over 1992). Under the assumptions that population growth slows by 0.7 percentage points, that treatment costs are financed entirely from savings, and that a worker with AIDS is half as productive as a healthy worker, Cuddington (1993) predicts that GDP growth in Tanzania would slow by 0.8 percentage points and that growth in per capita GDP would slow by 0.1 percentage points. For Malawi, under similar assumptions on treatment costs and productivity but assuming a larger slowdown in population growth of 1.2 percentage points, Cuddington and Hancock (1992) predict that AIDS would reduce GDP growth by 1.5 percentage points and per capita income by 0.3 points. (To get the growth rate of GDP per capita to increase, the authors had to assume that AIDS treatment costs had no effect on national saving and that people with AIDS were as productive as healthy members of the work force until death. Both of these assumptions are clearly implausible.)

These models ignore existing labor market rigidities, such as a high minimum wage or restrictions on firing workers, that would be expected to slow

an economy's adaptation to the epidemic. They predict a smaller impact from AIDS than would be the case were these rigidities also considered. These simulations also assume that the work force is homogeneous in terms of education and productivity.

Over (1992) adds realism to the models by incorporating two sectors (a high-productivity urban sector and a low-productivity rural sector) and three types of labor (the uneducated, those with primary schooling, and those with more than primary schooling). He applied the model to thirty Sub-Saharan countries for which complete data were available, under alternative assumptions about the share of AIDS treatment costs financed from savings and the relation between the socioeconomic status of the work force and the incidence of HIV/AIDS.[12] The model does not consider the lower productivity of workers with AIDS.

Results for the ten countries with the highest levels of HIV infection show that the negative impact of AIDS on average growth in per capita income increases with the share of AIDS treatment costs financed from savings and with the skill of infected workers. For example, if each group of workers has twice the risk of contracting HIV of the skill group below it and if AIDS treatment costs are financed entirely from savings, growth in per capita income will be 0.41 percentage points lower each year. The AIDS epidemic increases growth in per capita income only if the less-skilled have a rate of infection twice that of the next higher-skill group (gradient of 0.5) and if treatment costs are not financed out of savings. Neither assumption seems plausible.

These models cannot hope to capture the complexity of all the adjustments that will occur as individuals, households, and firms cope with AIDS. However, they are useful in demonstrating how certain characteristics of the AIDS epidemic are likely to affect the growth in per capita income. Under the most plausible assumptions, AIDS reduces the rate of growth in per capita income below what it would be in the absence of AIDS, despite slower population growth. Though the magnitude of the reductions seems small, for many countries in Sub-Saharan Africa even a small drop means that already negative per capita growth rates will fall even more. That will happen if, as some of these models assume, AIDS is killing a higher percentage of the most skilled workers and if increased medical costs are financed out of savings. When slower population growth is the result of a higher mortality rate among more productive adults, the potential economic benefits of the slower population growth will probably not be realized.

We turn next to an exploration of how African populations cope with AIDS, looking at that behavior in more detail than is possible in aggregate models. The models described above were based on assumptions about the determinants of the economic impact of a given number and distribution of AIDS cases—the share of medical care financed from savings, the impact of AIDS on the productivity of individual workers and the work force, the substitutability of capital and labor in African production processes—rather than on empirical

investigation of coping behavior. The next section examines what is known about responses to the AIDS epidemic, both to improve estimates of macroeconomic impacts and to explore the distributional implications of illness and deaths caused by AIDS. The focus is on the coping behavior of private (households and firms) and public agents, which will affect rates of capital formation (through expenditure decisions) and the productivity of labor.

Coping with the Epidemic

Learning how households cope with AIDS is important because households are the fundamental economic decisionmaking unit in African economies, accounting for most agricultural production, informal self-employment, and consumption decisions. Illness and death from HIV and AIDS will affect resource allocation, production, consumption, savings, investment, and, above all, the well-being of patients and their surviving family members. When someone is stricken with AIDS, healthy members of the household begin to reallocate their time, reevaluate their production decisions, and alter their consumption and investment to improve the outcomes within this new constraint. In the absence of large-scale social welfare programs in Sub-Saharan countries, most households rely on their own endowments and assistance from the extended family and neighbors to cope with the effects of AIDS.

Policymakers in countries hard hit by the AIDS epidemic also face tough decisions about allocating scarce public resources for treating the disease in an environment where many households already live in poverty. Several important research questions remain to be answered before the economic impact on households and the public sector can be properly assessed and the appropriate policy response determined: How quickly and effectively can households recover from the impact of AIDS through traditional sources of support? How have disability and deaths from AIDS affected the living standards of households that send assistance to other households? How is AIDS likely to alter the distribution of income? How important will AIDS become relative to other causes of poverty in Sub-Saharan Africa, and is AIDS-induced poverty any more amenable to reduction than poverty from other causes?

Health Care Costs

Estimating health care costs for AIDS is important for several reasons. Total expenditures (public and private) are needed to estimate the overall decline in national savings likely to accompany the AIDS epidemic; these estimates can then be fed into the models on aggregate economic growth discussed above. They are important for ministry of health planning and budgeting because, to the extent that publicly provided health care services are highly subsidized or free, most of the additional spending associated with meeting increased de-

mand for health care will come out of the public budget. And they are critical for evaluating alternative treatment strategies and identifying treatments that provide the greatest benefits, given a country's overall constraints.

Estimating the costs of treating AIDS sufferers is not easy, especially in the African context. Information on household spending on treatment often comes from survivors, who may not be aware of all costs. Estimating the effects of the AIDS epidemic on public expenditure requires information on the likely demand effect and the cost per unit of demand. Neither is known. For example, although there are rough estimates of the number of people infected in Sub-Saharan Africa, little is known about how many of them are seeking medical treatment for opportunistic illnesses associated with AIDS or for terminal care. Many of these opportunistic infections were already widely prevalent in Africa before the onset of the AIDS epidemic, making the connection with AIDS more difficult to identify. The selection of treatment also complicates estimation. Ideal treatments based on Western protocols are unlikely to be suitable or affordable in Africa, but what will take their place is not clear. And as the epidemic spreads, the amount spent per person treated is likely to drop as resources are stretched to their limits. That means that current levels of public spending on patients and their survivors are probably not realistic estimates of what costs will be when the number of AIDS cases rises to five or more times current levels.

Most evidence on how much households spend on medical care for AIDS patients comes from their survivors. These figures underestimate spending because survivors are not usually aware of all AIDS-related expenditures and because they may not have recognized the connection between some illnesses and AIDS. Davachi and others (1988) estimated that a single twenty-five-day episode of inpatient treatment for a pediatric AIDS case at Mama Yemo Hospital in Kinshasa, Zaire, costs households $90, three times the average monthly income. A subsequent study in the same hospital found that HIV-positive patients had spent $109 on medical treatment prior to admission—twice the amount spent by HIV-negative patients (Hassig and others 1990). In Kagera Region, Tanzania, 88 percent of a sample of adults who died of AIDS in 1990–91 were reported by surviving household members to have received medical care before death, compared with 77 percent of adults who died of other causes, and to have spent an average of $65 for drugs and medical care, compared with $47 for adults dying of other causes (Mujinja and Over, 1993). A study of fewer than forty symptomatic AIDS patients in Ghana found median monthly spending on treatment of $25 (Anarfi 1992, cited in Caldwell and others 1993).

The impact of AIDS on the demand for medical care cannot be measured simply by the number of terminally ill AIDS patients admitted or treated at health facilities. Far more common will be increased consultations for opportunistic infections already prevalent in the population, such as tuberculosis, pneumonia, and malaria. Which cases have an AIDS-related cause will not usually be known. For example, about 30 percent of adult admissions and 43 per-

cent of the adult bed days in a 250-bed hospital in southern Zambia in 1991 were for HIV-related illnesses (Buvé and others 1992). The large share of bed days was due mainly to the long hospital stays of HIV-positive patients with tuberculosis (44.5 days); HIV-positive patients without tuberculosis spent about the same amount of time in hospital as HIV-negative patients (10.5–11 days). In July 1992, almost one-third of 1,489 admissions to Bukoba Regional Hospital in northwestern Tanzania tested HIV-positive; 57.4 percent of patients admitted for tuberculosis treatment and about one-third of malaria patients were found to be infected with HIV (Kwesigabo and others 1993). It is not easy to distinguish malaria patients who are HIV-infected but not yet immune-compromised from patients who represent additional cases of malaria caused by AIDS-related failure of the immune system. This makes it all the more difficult to predict the impact of the epidemic on private medical expenditures or on the demand for publicly provided medical care.

In considering treatment costs, the hypothetical costs of ideal treatment should be distinguished from the costs of treatment actually provided (Hanson 1992; Over and others 1988). The costs of "ideal" treatment for AIDS and related illnesses will vary according to the level of the health system providing the treatment and the availability of resources. Pallangyo and Laing (1990) estimate that lifetime drug and nursing costs for a typical HIV-positive adult in Tanzania would amount to $290, assuming inpatient or outpatient care for seventeen episodes of opportunistic illness and full availability of the drugs recommended in current treatment protocols (table 2). If only 60 percent of the drugs on the treatment protocol are available, costs drop by 10 percent (World Bank 1992). Total spending by the Tanzanian health sector for treating AIDS

Table 2. *Estimates of Total Direct Treatment Costs per AIDS Case*
(U.S. dollars)

Country and year	*Low*	*Mean*	*High*
Kenya (1992)		938	
Rwanda (1988–90)		358	
South Africa (1991)	1,850		11,800
Tanzania (1991)		adults, 290	
		children, 195	
Tanzania (1987–88)	104		631
Zaire (1987–88)	132		1,585
Zimbabwe (1991)	64	614	2,574

Note: Low and high costs are presented because private expenditure and access to the most expensive public care often depend partly on what patients are willing and able to spend.

Sources: For Kenya: Family Health International/AIDSTECH (1993, table 7, p. 26); for Rwanda: Shepard and Bail (1991); for South Africa: Broomberg and others (1993); for Tanzania: Pallangyo and Laing (1990); for Tanzania and Zaire: Over and others (1988); for Zimbabwe: Whiteside (1991, cited in Whiteside and FitzSimmons 1992).

patients under these assumptions would constitute 40 to 50 percent of recurrent costs in the 1991 health budget (World Bank 1992, p. 65).

Some countries are exploring alternative models of care, such as home-based care, which would reduce the burden on costly inpatient facilities. A program launched in Kabale District, Uganda, in 1991 provides basic medical care, counseling, and homemaking services for households with AIDS patients. After two years the program, which was offered by all health care agencies in the area, had reached an estimated 15 percent of AIDS sufferers at an average cost per home visit of $0.40 and an average cost per AIDS case of $53 (Masheija and others 1993). What shares were paid by the public sector and what by households or other private agencies is not known. Nor is it clear whether the capital costs necessary to run the program were included. A home-based care program in Monze, Zambia, was estimated to cost $11 (at the 1992 exchange rate of $1.51 per Zambian pound) per visit if vehicle depreciation is included or half that amount if not (Foster 1993a). The lifetime cost per patient for home-based care (five visits) came to $54 ($26 excluding depreciation), or the equivalent of eighteen days in a hospital. Although home-based care may not provide the same services as outpatient or inpatient hospital service, Foster (1993a) notes that home-based care is usually offered in addition to some hospitalization, not as a complete substitute. Home-based care is likely to cost more per patient in rural than in urban areas, because of the greater distances. The time cost of home-based care to households already burdened by the loss of a productive adult is not included in these estimates. Even if the cost to the public health system is less, home-based care may merely shift the costs of treatment back to the household.

This concern points to an urgent need to measure carefully the costs and benefits of alternative models of health care from the perspective of both families and the health system. But no study has yet measured actual public or total expenditures (private and public) on AIDS treatment in an African country. Deriving them for the public sector requires information on the number of patients, the percentage who seek care in each type of public or private facility, how often they seek it, and the resources spent for treatment. Because this information is generally not available, most studies have attempted to calculate an actual treatment cost *per patient* in the public sector, without asserting how many patients might be involved. These costs need to be considered in the context of average public expenditures on health care in Sub-Saharan countries today, which range from $1 to $30 per person, with an average in most countries of $5 or less per person (World Bank, forthcoming).

Lifetime treatment costs of hospitalized AIDS patients in Rwanda were estimated at $358 in 1988–90, 91 percent of it for inpatient care (Shepard and Bail 1991).[13] The daily costs of hospitalization at Mama Yemo Hospital in Kinshasa, Zaire, in 1988 were estimated at $5.36 for HIV-positive patients and $4.65 for HIV-negative patients (Hassig and others 1990). In Kenya the daily cost of providing inpatient care—drugs, tests, radiology, and overhead—ranges

from $33 in a private hospital to $11 in government hospitals and $4 in mission hospitals (Family Health International/AIDSTECH 1993, table 6, p. 23). These estimates seem to assume that the daily costs of AIDS treatment are similar to those for other illnesses requiring hospitalization; the amount was not calculated on the basis of AIDS-specific opportunistic infections.

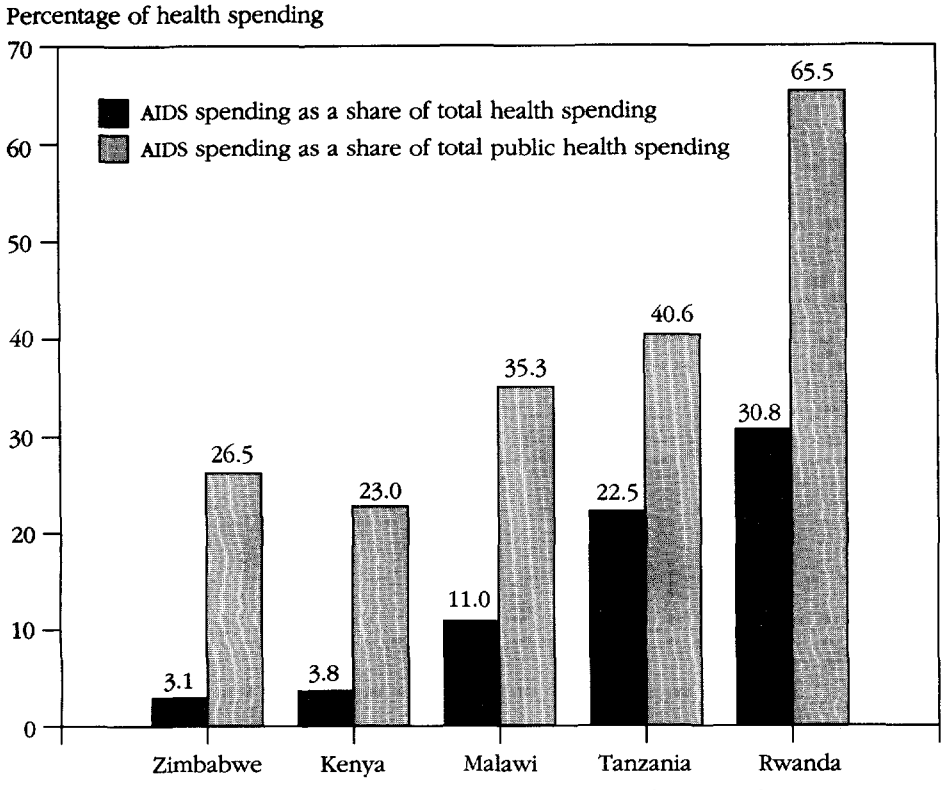
Other studies have estimated total (public and private) actual costs *per case*. Private expenditures for treatment depend in part on how much patients are willing and able to spend, so these studies often give low and high estimates of total expenditure per case (Over and others 1988). For example, assuming that every symptomatic HIV-positive adult seeks some modern sector treatment, if only at a local dispensary or health post, the estimated total treatment cost per case of HIV in 1987–88 was between $132 and $1,585 in Zaire and between $104 and $631 in Tanzania, where private sector options are fewer and incomes lower (table 2) (Over and others 1988).

Costs per case suggest that if every AIDS patient received modern treatment, overall expenditure would be enormous. Multiplying public and private costs per AIDS case by the number of estimated cases for five countries in Sub-Saharan Africa in the 1990s yields results ranging from the equivalent of 23 percent of public health spending for Kenya to 66.5 percent for Rwanda (figure 4). Of course, the direct costs of treating AIDS in the public sector will likely never reach these levels. Not all AIDS patients will seek care, and as the numbers of AIDS patients rise, lower-cost treatment options will be selected. The challenge for the health sector is to define policies that will guide the allocation of available resources in order to offer limited palliative care for AIDS patients while still providing effective health care to other patients, most of whom can be cured.

AIDS will have other effects on the health care system as well. As people come down with AIDS and the demand for scarce medical care rises, patients with more treatable conditions may not receive the care they need. A random sample of more than 200 admissions to Mama Yemo Hospital in Kinshasa, Zaire, in 1988 revealed that half were HIV-positive (Hassig and others 1990). Since the hospital was operating at full capacity before the AIDS epidemic, this means that a substantial number of people with other treatable illnesses were being crowded out by AIDS patients. The study points to an unexpectedly high mortality rate among non-AIDS patients as evidence that only the most desperately ill patients without AIDS are being admitted. In Kenya, an estimated 40 percent of hospital beds are thought to be occupied by HIV-positive patients (Family Health International/AIDSTECH 1993, p. 29).

Governments are also trying to prevent the spread of HIV, and the success of these efforts will influence the future impact of AIDS on the economy. Mann and others (1992) estimate that spending on AIDS prevention by national AIDS programs in Sub-Saharan Africa in 1991 amounted to only 7 cents per capita. Total prevention costs for the region were estimated at $36.9 million. As reported by country program managers, prevention spending ranges from less than one cent per capita in Nigeria to 66 cents in Congo (table 3). Though

Figure 4. *Potential AIDS Treatment Costs as a Share of Total and Public Health Expenditures, 1990*



Note: Derived from a regression of AIDS treatment costs as a function of GNP per capita.
Source: Ainsworth and Over (1994, Figure 4, p. 568).

these amounts seem low, they need to be viewed in the context of average public health spending in Sub-Saharan Africa of $5 per person per year. A study of donor-financed AIDS prevention and control programs in the late 1980s in sixteen Sub-Saharan countries estimated an average first-year program budget per HIV-positive person of $20 (Over and Piot 1993, tables 20–22). The range of programmed spending was wide—from $2 per HIV-positive person in Uganda to $31,370 in Ethiopia—though the range of actual annual expenditure was smaller (table 3). Assuming that the potential annual benefits of an AIDS prevention program are roughly proportional to the number of new cases that might be averted that year—in turn, roughly proportional to the number of infectious adults currently in the population—the logic for spending 100 times more per HIV-positive adult in one country than another is not apparent. Decisions about how much spending is "enough" in a given country should depend on the stage of the epidemic and on the cost-effectiveness of the chosen interventions.

Table 3. *Annual Expenditure on Prevention by National AIDS Programs, Selected African Countries, 1991*
(U.S. dollars)

Country	*Total program resources mobilized (millions)*	*Amount per capita*	*Amount per HIV positive person*
Cameroon	2.5	0.21	58.53
Congo	1.5	0.66	32.16
Côte d'Ivoire	2.2	0.19	5.46
Ethiopia	2.8	0.06	19.92
Nigeria	0.1	0.00	0.41
Rwanda	0.8	0.12	3.08
Senegal	0.9	0.13	185.62
Tanzania	1.0	0.04	1.72
Uganda	1.2	0.06	2.00
Zambia	5.5	0.65	10.66
Weighted average		0.07	6.52

Note: Includes total resources mobilized from domestic and international sources, minus expenditure on patient care and research. Average is weighted by national population.

Source: Cameron and Shepard (1992, table 11.2, pp. 480–81). Number of HIV positive persons are authors' estimates for 1993, as presented in figures 1 and 2.

Labor and Productivity

The burden of caring for AIDS sufferers, whether in the home or in the hospital, usually falls on women, who would otherwise be engaged in farming or other productive work (Lado 1992, cited in Foster 1993b; Ankrah and others 1992). Over the longer run, as it becomes apparent that the AIDS patient will die, the household may change its mix of productive activities. After a household member dies, the household loses entirely the person's time and skills and may also lose access to land, housing, and other assets inherited by others.

One field study of 129 households—20 of them affected by AIDS directly or indirectly—described the process by which AIDS affects a typical rural Ugandan household over time, providing insights into household coping strategies (Barnett and Blaikie 1992). The authors trace the process through which the death of an adult leads to reduced remittances, farm inputs, and family labor; lower agricultural production; shifts from cash crops to subsistence crops; reduced schooling; and higher levels of child malnutrition. The sample was too small to detect a quantifiable impact of AIDS on agricultural production—still the most important economic activity in many African countries—as distinct from the continuous coping of all farm households to changes in the environment.

No study has documented farmers' supply response to AIDS in terms of output or labor inputs. Most evidence is anecdotal. Gillespie (1989) postulated that the sensitivity of agricultural zones to the loss of labor from AIDS depends

on five factors: the seasonality of the demand for labor, the degree of labor specialization by gender and age, the interdependence of labor inputs, economies of scale in labor, and the substitutability of labor-saving technologies. He also predicted that affected families would shift from labor-intensive crops, such as legumes, to tubers, such as potatoes, sweet potatoes, and cassava. For example, if faced with a rising rate of loss of productive adults, farmers in Zambia might well switch from maize production, which requires some 550 hours of labor per hectare annually, two-thirds of it during December and January, to cassava, which requires only 448 hours per hectare, spread out more evenly over the year (Marter 1978, cited in Foster 1993b). If households shift production from export to subsistence crops, export revenues will also suffer. But such switches from more to less labor-intensive crops and from cash to subsistence crops, though often predicted, have yet to be documented. Nor has it been shown that crop switches in response to death of a household member from AIDS are any more or less significant than those in response to drought, a change in prices, or other factors.

Productivity in nonagricultural activities is likely to suffer as well. Workers who fall ill due to AIDS will be less productive on the job and will be absent more often. Absenteeism is also likely to increase among healthy workers, as they take time off to attend funerals and care for those who are ill. Observers in South Africa, Zambia, and Zimbabwe have speculated that absenteeism and fatigue on the job due to AIDS may be more costly than AIDS deaths (PANOS Institute 1992, p. 75). Job turnover and training and recruitment costs will rise as well. For example, among approximately 1,700 employees of Barclay's Bank in Zambia, the mortality rate rose steadily from 0.4 percent per year in 1987 to 2.2 percent in 1992, with adults younger than forty-six accounting for 86 percent of the deaths during this six-year period (Keembe 1993). The mortality rate among 6,000 employees of twenty-one companies in Lusaka and copperbelt towns in Zambia rose eightfold, from 0.24 to 2.1 percent a year during 1987–93 (Baggaley and others 1993). About half of the twenty-one firms reported that AIDS had affected their productivity, and 19 percent reported that it had affected their recruitment.

AIDS-related deaths will also reduce a firm's stock of skilled labor. Certain types of scarce, highly skilled local labor may have to be replaced by expatriates, raising the costs of production. In 1986, for example, Kenya produced only 174 engineering graduates and Zimbabwe only 52 (PANOS Institute 1992, p.71). Industries that rely on skilled workers will be particularly vulnerable. Only 6 percent of Zambia's labor force is employed in the mining sector—which accounted for 85 percent of the value of Zambia's exports in 1988 (Foster 1993b)—but one-third of these workers are highly skilled. In Kenya, about 10 percent of the mining labor force can be classified as highly skilled, and infection rates are estimated to be 12 percent (Family Health International/AIDSTECH 1993, annex A-8, and table 4).[14] The impact on firms of the deaths of skilled workers and managers will depend on how difficult and costly it is

for firms to replace workers at various grades, a subject about which little is known.

Larger outlays for health, unemployment, funeral, and death benefits will raise the costs of production or reduce the productivity of labor. The annual hospital bill for the Uganda Railway Corporation has risen to $77,300, and the costs per hospitalized patient have risen dramatically from $69 in 1988 to $300 in 1992 (PANOS Institute 1993, p. 76). Firms will cope with the reduced productivity and loss of trained staff through their production and investment decisions. They may choose less labor-intensive technology, substituting capital for labor. They may recruit and train more workers than needed for a specific job, in anticipation of some losses to AIDS. Although initially all these effects may be seen as costs to firms, ultimately workers are likely to bear the brunt of them, through lower wages and less liberal absentee policies.

Survivors: Caring for Orphans

In hard-hit countries, the AIDS epidemic will create large numbers of survivors—widows, widowers, elderly parents, and orphaned children.[15] Women in Sub-Saharan Africa are particularly vulnerable to HIV infection and to the economic impact of AIDS. HIV is more easily transmitted from men to women than from women to men. A woman's lower economic status, lower education level, and dependency on her husband may give her little influence in determining whether a condom is used during intercourse and little bargaining power over her husband's extramarital affairs. Throughout Africa, women's status is related to their childbearing capacity. Thus, perversely, practicing safe sex or abstinence may limit a woman's exposure to AIDS at the cost of lowering her status. Customary inheritance practices often leave nothing to the wife, and where inheritance laws exist, they are often difficult to enforce. Among the Tonga of Zambia, as in many other groups, the husband's relatives customarily claim all of the household's possessions upon his death (Foster 1993b). The widow can be left without shelter or the means to earn a living. Suspicion that widows are infected by HIV may limit their prospects for remarriage locally, prompting their migration to areas where they are unknown.

Because of the way HIV spreads through families, many children who lose one parent to AIDS will eventually lose the other. And because child fostering is common in many African societies even for children whose parents are alive, both orphaned and other children in the household will be affected by the AIDS epidemic. For example, in Côte d'Ivoire in the mid-1980s, one child in five under age fifteen whose parents were alive was living away from them (Ainsworth 1992). Preliminary results of a study in Kagera Region, Tanzania, show that about one child in five with two living parents lives with only one of them and that about 12 percent live with other relatives (Ainsworth and others 1993). The number rises to one in three or four for children who have lost one parent and are living with someone other than the remaining parent. This practice

means that both orphans and other resident children will be affected by the loss of adults. Further, since the AIDS epidemic tends to cluster in communities, survivors will also tend to be clustered, straining traditional mechanisms communities have for coping with adult death. New groups and communities will be thrown into poverty.

International attention has focused on the plight of AIDS orphans. WHO (1992) predicts that by the year 2000, more than 10 million HIV-negative children worldwide under age ten will have lost their mothers to AIDS—some 90 percent of them in Sub-Saharan Africa.[16] UNICEF predicts that 3 to 5 million maternal orphans will be created by the AIDS epidemic in ten Central and East African countries by 1999, amounting to 6 to 11 percent of children under the age of fifteen (Preble 1990; UNICEF 1990, 1991). The accuracy of both of these predictions rests on their assumptions about AIDS mortality among women, the number of children left behind, and the mortality and age structure of the surviving children. Neither study predicts the number of children who will be orphaned by the death of their fathers or provides separate estimates for those who will lose both parents.

Sample surveys have attempted to estimate the numbers of orphans in areas hard-hit by the epidemic.[17] In Masaka District, Uganda, a survey of 5,022 children under fifteen years old found that 10 percent had lost one or both parents (Kamali and others 1992). Fifteen percent of the surviving parents of orphans were infected with HIV, compared with 5 percent of the parents of nonorphaned children. Within one year of initial interviews, twenty-six children had lost one or both parents; in twenty-four cases the remaining parent was HIV-positive. A survey of 1,781 children from 586 randomly selected households in Manicaland, Zimbabwe, found that 6.9 percent of children under fifteen had lost one or both parents (G. Foster and others 1992).

In interpreting these findings, it is important to keep in mind that many if not most orphans in Sub-Saharan Africa have lost their parents to causes other than AIDS. High baseline levels of adult mortality in African countries result in many orphaned children even without AIDS, and families and communities have established coping mechanisms for absorbing them. Actual counts and estimates based on census data for four East African countries show that roughly 2 percent of children under age fifteen were motherless and 3.5 to 7 percent had lost their father (table 4). In three of the countries—Kenya, Malawi, and Uganda—the censuses predate the onset of the AIDS epidemic. Using Malawi's figure for two-parent orphans of 0.5 percent of all children under fifteen, it can be estimated that 5 to 8.5 percent of all children under the age of fifteen were orphans (having lost one or both parents) before the onset of the AIDS epidemic. Intercensal population growth rates can be compared with the number of children enumerated in hard-hit districts to estimate the additional orphaning caused by AIDS. Ainsworth and Over (1994, p. 575) estimate this figure for Uganda and Kagera Region of Tanzania.

Table 4. *Actual and Estimated Numbers of Orphans under Age Fifteen in Selected East African Countries*

		Maternal orphans		*Paternal orphans*		*Two-parent orphans*		*Total orphans*[a]	
Country	*Year*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Kenya	1969	100,837	1.91	374,563	7.08	26,465	0.50	448,935	8.49
Malawi	1977	49,355	2.03	85,096	3.51	12,421	0.51	122,030	5.03
Tanzania	1988	200,985	1.96	401,970	3.91	57,637	0.53	545,318	5.31
Kagera Region	1988	18,125	2.92	36,250	5.85	7,771	1.25	46,604	7.5
Uganda	1969	106,203	2.44	203,869	4.68	21,779	0.50	288,293	6.62
Masaka and Rakai	1969	6,717	2.31	12,467	4.28	1,457	0.50	17,727	6.09

Note: Shaded areas are estimates. For Kenya, Tanzania, and Uganda, it was assumed that, absent AIDS, 0.5 percent of children under fifteen are two-parent orphans. For Tanzania, it was further assumed that the proportion of paternal to maternal orphans was two to one and that AIDS caused higher rates of orphanhood only in three districts in the hard-hit Kagera Region (Ainsworth and Rwegarulira 1992).

a. Number of maternal and paternal orphans minus two-parent orphans.

Source: Ainsworth and Over (1994, table 5, p. 574), based on census data.

Though there are many orphans in Sub-Saharan Africa, there are few orphanages. In 1990 in the hard-hit Kagera Region of Tanzania, orphanages were operating at only 57 percent of capacity, and nationwide only 1,083 children were residing in children's homes, most of them run by the private sector (Ainsworth and Rwegarulira 1992). Largely because extended families are willing to absorb orphaned children, there has been no rush to build orphanages in response to the AIDS epidemic. The annual cost of the publicly financed children's home in Dar es Salaam was estimated at $649 to $928 per child per year—several times per capita income (Ainsworth and Rwegarulira 1992). Private sector orphanages may spend several times this amount. (Koda and Over 1993 estimated the annual cost of one privately operated orphanage in northwest Tanzania at $3,370 per child, compared to $165 to subsidize care in a foster home.) These efforts are clearly not replicable on a large scale.

However, children living in households affected by AIDS—whether orphans or not—may be disadvantaged in many respects, and donors and government agencies are already preparing assistance programs specifically for them. But we have yet to see any published analysis of expenditures by public agencies in Africa concerned with child welfare or of the effect of the AIDS epidemic on the level of expenditure or its uses. Few studies have examined the cost-effectiveness of programs for orphans as a poverty-reduction strategy. No study has assessed the efficacy of using orphanhood in targeting assistance to the neediest children. There are many needy children in countries hard-hit by AIDS—including children orphaned from other causes and children in impoverished families. The AIDS epidemic will add to the numbers of children in distress, although it is not known by how much. Policymakers need to identify the most vulnerable children, whether orphaned or not.

Education

The education sector will experience both demand and supply shocks as a result of the AIDS epidemic.[18] The demand for schooling may be lower than it would have been in the absence of AIDS for two reasons. First, the cohort entering school may be smaller than it would otherwise have been. The worst-case scenario in a World Bank study (1992b) of the AIDS epidemic in Tanzania finds that by 2020 the epidemic will have reduced the cohort of primary-school-aged children by 22 percent and that of secondary-school-aged children by 14 percent over enrollments in the absence of AIDS.

Second, adult deaths from AIDS may result in lower investments in children's schooling, reducing future productivity and the household's stock of human capital. When an adult falls ill or dies, children may be removed from school because they are needed at home or because the family has fewer resources to pay for schooling (Katabaro 1993). Preliminary results from the Kagera study suggest that children who have lost a father or both parents are less likely to enroll in school than are other children (Ainsworth and Koda 1993). All children, whether orphans or not, in households that have experienced the recent death of a female adult have markedly lower enrollment rates and, once enrolled, spend fewer hours in school. AIDS is thus likely to lower school enrollments as children substitute for the loss of female labor. In countries like Uganda, where households finance perhaps 70 percent of the costs of primary schooling, the death of adults will probably substantially reduce the household's ability to pay school fees—more so than in Tanzania, where fees are lower. In the longer run, as AIDS lowers life expectancies, the impact on the demand for education will depend on whether households perceive their own children as being able to avoid the higher risk of mortality in the surrounding population or of being equally exposed to it. If households feel that their children are less vulnerable, demand for education will remain unchanged or may even increase, to the extent that households believe that AIDS will result in a shortage of skilled labor. If households believe that their children share the new higher mortality risk, shorter anticipated lifetimes would reduce the demand for education.

Policymakers need information on whether policies targeted to individual needy children will be as effective as systemic reforms to improve the quality of schooling. Particularly in countries where enrollment rates were in decline even before the AIDS epidemic, it will be important to identify the causes of the decline and to determine whether interventions directed to a specific group of children are likely to be cost-effective. Tanzanian census data for 1988, for example, show that children who have lost their mother are less likely to enroll in school than are children whose mother is alive (Ainsworth and Rwegarulira 1992). But the gap between wealthier and poorer districts within a region is sometimes even larger. Studies are needed comparing the impact of adult deaths on school enrollment with that of other factors, such as low incomes.

In the short run, there may be pressure to exempt children from hard-hit families from paying school fees. Schooling is already underfunded throughout Africa, and the revenues from school fees can often make a big difference at the margin in the quality of education. In Uganda, the major expense is not the official school fees, but the fees paid by parent associations to top off the salaries of underpaid teachers. Exempting orphans would place a larger financial burden on other children's families, many of them poor.

On the supply side, AIDS will affect the number of teachers needed in the work force, their turnover and training costs, and the efficiency of the schooling system (Shaeffer 1993). There are also important externalities to changing the behavior of teachers, who can influence children to change their behavior in ways that reduce their chances of HIV infection. Thus, policies that help prevent the spread of HIV infection to teachers and that prolong the effectiveness of HIV-infected teachers are high priorities. It is important to note as well that poor working conditions and inadequate remuneration have already created large-scale teacher attrition in many countries (Mburugu 1993). AIDS will contribute to these problems, but preventing AIDS will be only one of the solutions.

Conclusion

Because AIDS affects primarily the most productive age group and is fatal and widespread, it will have a larger impact on African development than other, more common diseases. Further, the long incubation period between infection with HIV and development of full-blown AIDS makes it certain that, absent a cure, AIDS will affect African development prospects for the foreseeable future.

Models of the impact of HIV/AIDS on population growth generally assume that only mortality is affected by the epidemic, although behavioral responses to the epidemic could also result in fertility changes. Depending on the incubation period and the underlying population growth rate in the absence of AIDS, these models generally predict that population growth will remain positive as long as the nationwide HIV infection rate among adults remains less than 30 percent. There are areas within countries where rates that high prevail, but to date no African country has experienced such a high level of infection nationally.

The impact of AIDS on growth of per capita income will depend on its effects on the growth rate of healthy labor and capital and on the socioeconomic distribution of HIV infection. Since the overwhelming share of the population in most countries is rural, the majority of those infected are poor and unskilled. However, infection rates are higher in urban areas, where most of the educated live. Furthermore, a handful of studies in Sub-Saharan Africa suggest that prevalence in urban areas is higher among higher-income, higher-skilled men and their partners. Macroeconomic models show that the higher the infection

rate among the more educated workers and the higher the propensity of medical care to be financed out of savings, the more detrimental the disease will be to growth of per capita income.

While the literature on macroeconomic impact has explored the sensitivity of results to alternative assumptions on epidemiological parameters and the responses of economic agents, little empirical information is available to guide the choice of the most likely scenario in a given country. Studies are needed that document the coping behavior of economic agents—households, firms, and the public sector—to inform the macroeconomic models and to elucidate the distributional implications of AIDS. Regardless of the macroeconomic effect, most households and businesses directly affected by deaths from AIDS will be economically worse off, at least in the short run. It is not clear, however, to what extent AIDS will affect poverty in Sub-Saharan Africa or whether, by disproportionately impoverishing the more educated, it will actually reduce the inequality of income distribution in some areas.

Sub-Saharan Africa has the lowest levels of per capita income of any developing region, and economic performance faltered in the late 1980s, exposing many underlying economic problems. These countries face a large number of development problems in every sector, of which AIDS is but one. The potential macroeconomic impact of AIDS may be significant, particularly when economic indicators are already so low, and skilled labor is already scarce. Understanding how much AIDS will affect African development and choosing appropriate policies to reduce poverty and promote economic growth depend on accurate measures of the coping processes of economic agents. Governments need to assess more accurately the potential economic impact of AIDS, identify and implement programs to mitigate that impact, and target cost-effective prevention programs to the economically important sectors that are most sensitive to HIV infection, to reduce the economic impact in the long term.

Notes

Martha Ainsworth and Mead Over are with the Policy Research Department of the World Bank. This article draws on a background paper prepared for the Symposium on AIDS and Development on May 11, 1993, in Abidjan, Côte d'Ivoire, sponsored by the African Development Bank. It benefits from the work of many individuals within and outside the Bank and the authors' ongoing collaboration with Phare Mujinja, Godlike Koda, George Lwihula, and Innocent Semali in a research project on the household-level consequences of AIDS deaths. The suggestions of Dorothy Black, Nicholas Dodd, Emmanuel Jimenez, Wendy Roseberry, and Richard Sabot on earlier versions are gratefully acknowledged. Mead Over is grateful to the Commission on Behavioral and Social Sciences and Education of the National Academy of Sciences for support during his work on this paper. The opinions expressed are those of the authors and do not necessarily reflect policy of the World Bank or its members.

1. HIV refers to HIV-1. A second strain of HIV, HIV-2, is also spreading rapidly in Africa but is thought to be less pathogenic.

2. The line of argument and examples in this section are taken from Ainsworth and Over (1992).

3. Comparing the cost-effectiveness of alternative policies to mitigate the economic impact of AIDS as in Over and Piot (1993) would be a logical extension of this discussion, but is beyond the scope of this paper.

4. The most comprehensive, publicly available data on seroprevalence rates is the data base maintained by the U.S. Bureau of Census. The data base includes the results of thousands of individual studies of varying quality. Four HIV prevalence estimates for each country are selected as most representative of the epidemic in the year of reference for four specific groups of adults: "low-risk urban," "high-risk urban," "low-risk rural," "high-risk rural." The December 1993 edition of the data base contains estimates of the mid-1993 seroprevalence of "low-risk urban" adults for forty-seven of the fifty-seven Sub-Saharan countries and of "low-risk rural" for twenty-three.

5. Data for twenty-three African countries show a positive correlation of 0.7 between the rural low-risk rate and the urban low-risk rate, with the urban rate always higher. But as figure 1 shows there is considerable noise in that relationship. Rural seroprevalence surveys are infrequent and generally unrepresentative. Two studies from the Mwanza Region of Tanzania (Kigadye and others 1993; Borgdorff and others 1993) find that women attending antenatal clinics had statistically significant lower infection rates up through age thirty-four, when most infections occur, than women of the same age in the general population. But medical researchers often target rural seroprevalence studies to regions where infection is feared to be high. Because of this uncertainty about rural prevalence rates, we compute two estimates of national prevalence, one using the actual rural prevalence rate or, if that is unavailable, the rate estimated from the regression line in figure 1, and a second estimate of rural prevalence as one-fifth urban prevalence in each country (after Chin and Sato 1994). The two approaches yield infection rates for rural African adults of 3.1 and 1.3 percent, which correspond to the two different estimates of the number of infected rural adults presented in the text.

6. For example, a recent UNDP study on the economic impact of AIDS in Asia states that HIV could be called "the poverty virus" in Asia because of its disproportionate effect on the poor (Bloom and Lyons 1993, p. vi). However, Solon and Barrozo (1993) in that volume explicitly argue that in the Philippines the impact of AIDS will be large because of the disproportionately high risk of infection of the overseas contract workers who have higher-than-average incomes.

7. In the context of a full structural model of sexual behavior, these risk factors could be included, provided that instrumental variables could be identified for each. Such a model would be useful for predicting the future path of new infections, but is unnecessary for predicting the economic impact of current patterns of infection.

8. That is, the coefficient on the odds ratio $[p/(1-p)]$ was 1.96, where p is the probability of being infected.

9. For a sufficiently short incubation period of AIDS, this conclusion would be altered.

10. The growth rate of the capital stock is defined as the ratio of investment (new capital) to the existing stock of capital less a constant percentage for depreciation.

11. If, as hypothesized in many modern growth models, returns to scale are increasing rather than constant, the range of impacts is wider.

12. The latter assumption, the "socioeconomic gradient" of the epidemic, is measured in terms of the ratio of infection rates among more-skilled and less-skilled workers. A "gradient" of 0.5 means that risk falls with the skill level of the worker, 1.0 implies that the three groups are equally at risk, and 2.0 that risk rises with the skill level of the worker. With a value of 0.5, each higher-skill group has half as large a risk as the next lowest skill group.

13. Multiplying this amount by the 1,849 confirmed hospitalized AIDS cases in Rwanda in 1991 yields $0.6 million, or 4.6 percent of the public health budget. However, this is clearly a low estimate, since it is not known what percentage of AIDS patients seek inpatient care and how much care went to patients with opportunistic illnesses but who did not satisfy the WHO/Bangui criterion (Ryder and Mgerwa 1994, p. 272) of a positive blood test.

14. Only 0.1 percent of the labor force is in the mining sector, but at Ksh573 million in 1990 it represented a disproportionate share of exports (AIDSTECH 1992, appendix A-9). Agriculture, the largest export, accounted for Ksh10.9 billion; manufacturing for Ksh6.9 million.

15. Portions of this section are excerpted from Ainsworth and Over (1992).

16. Note, however, that this is the cumulative number of children orphaned since the beginning of the AIDS epidemic. By the end of the 1990s, many of the orphans predicted by WHO will be ten years or older, and some will be adults with children of their own. Further, the WHO predictions do not take into account child mortality due to HIV infection. They also assume that all HIV-negative orphans survive—the model assumes no source of child mortality other than AIDS (Burton 1992, personal communication).

17. Enumerations of orphans in Rakai and Masaka districts of Uganda in 1989 estimated 25,634 orphans in Rakai (12.8 percent of children under eighteen) and 22,051 orphans in Masaka (4.95 percent). Twenty-three percent of the orphans in Rakai had lost both parents. A 1991 enumeration of orphans in the Kagera Region of Tanzania counted 35,291 children under the age of fifteen who had lost one or both parents. Neither sample surveys nor enumerations have been able to assess the share of orphans due to AIDS, however.

18. Portions of this section are excerpted from Ainsworth and Over (1992).

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