

The Economics of HIV/AIDS in Low-Income Countries: The Case for Prevention

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There are two approaches to reducing the burden of sickness and death associated with the human immunodeficiency virus (HIV), which leads to acquired immunodeficiency syndrome (AIDS): treatment and prevention. Treatment for HIV/AIDS involving antiretroviral therapy has been proven effective, even in resource-poor settings, in delaying the decline in the immune system, the onset of opportunistic infections, and death—and in extending the life expectancy of those infected by around four years (Ivers, Kendrick and Doucette, 2005). Prevention measures to limit the transmission of AIDS include mass media campaigns; condom distribution; peer education of prostitutes; the prevention of mother-to-child transmission; voluntary counseling and testing; and diagnosis and treatment of other sexually transmitted diseases (since the symptoms of these diseases can make it easier for the HIV virus to spread). Despite large international aid flows for HIV/AIDS, the needs for prevention and treatment in low- and middle-income countries outstrip the resources available (Joint United Nations Program on HIV/AIDS, 2005a). Thus, it becomes necessary to set priorities. The standard policy prescription is that, in order to maximize health with a limited budget, funds should first be allocated to more cost-effective interventions and only then to interventions with lesser cost effectiveness. With limited resources, should the focus of efforts to combat HIV/AIDS be on prevention or treatment?

Antiretroviral treatment is complex and requires regular monitoring of adherence, efficacy and side effects, with consequent changes in treatment regime when needed, requiring large inputs from local health services. Such treatment is expensive. Studies by Marseille, Hofmann and Kahn (2002) and Creese, Floyd, Alban and Guinness (2002) make highly favorable assumptions about the costs and benefits of

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highly active antiretroviral therapy, and they still conclude that a dollar spent on prevention is around 28 times more effective in reducing the burden of disease, as measured by illness and premature death. Thus, they conclude that the limited resources available to combat HIV/AIDS in low-income countries should be targeted toward prevention rather than treatment. These results produced a rapid response at the XIV World AIDS Conference, held in Barcelona in 2002, as described by Boelaert, Van Damme, Meessen and Van der Stuyft (2002, several acronyms in the original are spelled out here):

At the Barcelona conference, Richard Feachem (Global Fund to Fight AIDS, Tuberculosis and Malaria), Gro Harlem Brundtland (World Health Organization) and Jeffrey Sachs voiced their disagreement with the conclusions of the cost-effectiveness analysis studies. All took unequivocal positions, stating, e.g. that ‘The Global Fund will never hire such economists’, ‘prevention and treatment must go hand in hand’, and ‘it is wrong to accept that we have to choose between prevention or care, doing both is easily affordable’. All echoed the call of the activists: ‘10 billion dollars for the Global Fund, now!’ and got the blessing of the international health establishment.

Among international health agencies, the consensus view is for a rapid expansion of treatment programs in developing countries. The World Health Organization has made the treatment of HIV/AIDS using antiretroviral therapies their priority, aiming to have three million people in developing and middle-income countries in antiretroviral therapy by the end of 2005 (the “3 by 5” initiative). While this goal has not been achieved (there were around one million people under treatment in June 2005 (World Health Organization, 2005), the Joint United Nations Program on HIV/AIDS (2005b) has a target of expanding treatment to around 9.8 million people by 2010. Similarly, the United States in its President’s Emergency Program for AIDS Relief, a five-year \$15 billion plan to combat AIDS, will focus 80 percent of its resources on treatment and care, with 20 percent going to prevention efforts. In addition, the World Bank encourages the use of its loans and grants for treatment of HIV/AIDS.

A strong case can be made for funding both prevention and treatment of HIV/AIDS. However, given the limited resources of low-income countries and the fairly low levels of funding developed countries have made available in practice, choices have to be made about priorities. It is clear that the economists’ method, cost-effectiveness analysis, is not the prime consideration in international organizations’ policy-making about HIV/AIDS in developing countries; indeed, cost-effectiveness analysis has been roundly rejected. I argue that this rejection is a mistake. If the goal is to maximize health benefits with the limited resources available, then cost-effectiveness analysis is the right tool. Counterarguments come down either to putting forward goals other than maximizing health benefits with HIV/AIDS spending, or to pretending that resources are not scarce.

I begin with an overview of the effects of the AIDS epidemic in developing countries and discuss the range of prevention and treatment alternatives. I then

examine their cost effectiveness and the arguments that have been raised against such cost-effectiveness analysis, including uncertainties in measurement when behavioral responses, feedbacks, and externalities are present. A central issue that arises is the ethical basis of cost-effectiveness analysis in the public policy approach to HIV/AIDS in developing countries. While other criterion can be used for setting priorities, promoting AIDS treatment using antiretrovirals in resource-constrained countries comes at a huge cost in terms of avoidable deaths that could be prevented by devoting resources to prevention interventions that would substantially lower the scale of the epidemic.

The Health, Economic, and Social Burdens of HIV/AIDS

HIV/AIDS is a major cause of premature death and imposes a large disease burden around the world. Table 1 shows estimates of the number infected, the adult prevalence rate and deaths from AIDS. There were about 40 million people in the world in 2005 infected with HIV, about 26 million of them in Africa, where the prevalence rate is 7.2 percent among the adult population aged 15 to 49. HIV/AIDS is the major health problem in Africa. A standard measure of the health costs and benefits is disability-adjusted life years (DALYs). About 18 percent of all DALYs lost due to health problems in Africa during 2002 were due to HIV/AIDS (World Health Organization, 2004). Most of the burden is due to early death. The disability weight (set by a panel of experts) associated with HIV infection is 0.135 while AIDS has a weight of 0.505, where 0 corresponds to no disability and 1 corresponds to near death. The regional figures mask substantial national variation, particularly in Africa, where a number of countries have exceptionally high prevalence rates; Swaziland, Botswana, Lesotho, Zimbabwe, Namibia and South Africa are estimated to have prevalence rates in excess of 20 percent. Nigeria, the most populous country in Africa, has a relatively low rate but still has a large number of HIV-infected people.

One caution about these estimates should be mentioned. HIV prevalence rates are usually based on samples of pregnant women at antenatal clinics and these figures may overstate prevalence rates due to selection bias (Boerma, Ghys and Walker, 2003). Population-based surveys consistently find lower estimates of prevalence, leading to speculation that actual prevalence rates may be 25 to 40 percent lower than standard estimates (Halperin and Post, 2004).

In addition to the health impact, HIV/AIDS also has large potential impacts on the economy and society. Health can be considered as a form of human capital and health interventions can boost school attendance (Bleakley, 2003; Miguel and Kremer, 2004) and worker productivity (for example, Basta, Soekirman, Karyad, and Scrimshaw, 1979; Savedoff and Schultz, 2000; Schultz, 2002). Shastry and Weil (2002) carry out a calibration based on microeconomic estimates of the effects of health on worker productivity to show that population health should have a substantial effect on national income levels, a conclusion that is supported by

Table 1
HIV and AIDS Estimates in 2005

		<i>HIV infections</i>	<i>Adult prevalence rate (percentage)</i>	<i>Deaths due to AIDS</i>
Sub-Saharan Africa		25,800,000	7.2	2,400,000
National data for end 2003	Swaziland	220,000	38.8	17,000
	Botswana	350,000	37.3	33,000
	Lesotho	320,000	28.9	29,000
	Zimbabwe	1,800,000	24.6	170,000
	South Africa	5,300,000	21.5	370,000
	Namibia	210,000	21.3	16,000
	Nigeria	3,600,000	5.4	310,000
Caribbean		300,000	1.6	24,000
East Europe and Central Asia		1,600,000	0.9	62,000
South and Southeast Asia		7,400,000	0.7	480,000
North America		1,200,000	0.7	18,000
Latin America		1,800,000	0.6	66,000
Oceania		74,000	0.5	3,600
Western and Central Europe		720,000	0.3	12,000
North Africa and Middle East		510,000	0.2	58,000
East Asia		870,000	0.1	41,000
World Total		40,300,000	1.1	3,100,000

Source: Joint United Nations Program on HIV/AIDS (2005b) for regional data. National data for end 2003 are from the UNAIDS/World Health Organization Global HIV/AIDS Online Database, (<http://www.who.int/globalatlas/default.asp>).

Note: The adult prevalence rate is the proportion of those 15 to 49 years of age living with HIV.

cross-country growth studies (Bhargava, Jamison, Lau and Murray, 2001; Bloom, Canning and Sevilla, 2004).

Despite this evidence that population health in general may be associated with higher income levels, there is little evidence that HIV/AIDS has led to a substantial reduction in income per capita (Bloom and Mahal, 1997; Cuddington, 1993). Diseases with high adult morbidity (sickness), such as malaria, will reduce the productivity of workers and lower GDP per capita, while diseases with high child morbidity, such as malaria and hookworm may reduce school attendance. The effect of a disease whose burden is mainly in the form of higher mortality (death) is less clear. The loss of workers will lower output but their deaths will also lower total population, reducing both the numerator and the denominator in GDP per capita. Deaths from HIV/AIDS are concentrated among young adult women and middle-aged men and there was some evidence in the early stages of the epidemic that it was more prevalent among those with high socioeconomic status, though current evidence is more mixed (Wojcicki, 2005), and these selectivity effects could reduce GDP per capita.¹

¹ In a simple economic model, if there is a fixed factor, such as land, then a reduction in the population may increase the income per capita of the survivors (Young, 2004). Of course, in a more complex

Table 2
HIV/AIDS Expenditures

<i>Country</i>	<i>Year</i>	<i>Adult HIV prevalence rate %</i>	<i>HIV/AIDS spending, per capita, \$US</i>	<i>HIV/AIDS spending as percentage of GDP</i>
Kenya	2002	15.0	7.61	2.23
Burkina Faso	2003	6.5	2.04	0.79
Ghana	2003	3.0	1.33	0.47
Guyana	2002	2.7	2.71	0.28
Belize	2003	2.0	6.93	0.19
Honduras	2001	1.6	3.97	0.43
Panama	2003	1.5	4.46	0.11
Thailand	2003	1.3	1.10	0.04
El Salvador	2003	1.0	5.04	0.23
Guatemala	2000	1.0	1.18	0.07
Argentina	2002	1.0	4.53	0.07
Brazil	2000	0.7	3.61	0.10
Costa Rica	2002	0.6	2.44	0.47
Venezuela	2002	0.5	3.05	0.07
Columbia	2002	0.4	1.01	0.05
Uruguay	2002	0.3	3.54	0.07
Mexico	2002	0.3	2.26	0.04
Chile	2002	0.3	1.39	0.03
Nicaragua	2002	0.2	1.61	0.21
Bolivia	2002	0.1	0.45	0.04

Source: HIV/AIDS prevalence rates, expenditures and population from Joint United Nations Program on HIV/AIDS (2004). GDP per capita from World Bank (2005).

While HIV/AIDS does not seem to have reduced income per capita substantially so far, income per capita is not a welfare measure. A more comprehensive welfare measure that included the suffering and death of its victims would show a large welfare reduction in societies with HIV/AIDS (Jamison, Sachs and Wang, 2001; Crafts and Haacker, 2004). In addition to the direct welfare effect of lower health, resources devoted to preventing and treating HIV/AIDS will reduce consumption of other goods. Estimating the size of this effect requires national AIDS accounts that trace the flow of funds spent on prevention and treatment, combining household, government and international donor expenditures. Table 2 reports preliminary results for total expenditures on HIV/AIDS from all sources from national AIDS accounts for a number of countries; these results suggest that in relatively low-prevalence settings financial burdens have so far been small. However, the figures for Kenya indicate that in very high-prevalence and low-income settings, spending on HIV/AIDS can consume a significant proportion of GDP.

While the macroeconomic effects of HIV/AIDS to date have been muted, the long-run effects are potentially large. A shorter prospective lifespan may decrease

economic model with economies of scale and agglomeration, a reduction in population can also decrease income per capita of survivors.

incentives to invest in human capital (Kalemli-Ozcan, Ryder and Weil, 2000) and to save for the future (Bloom, Canning and Graham, 2003). The deaths of parents and the creation of a generation of AIDS orphans may lead to low levels of health and educational investments in these children and low productivity in the future (Bell, Devarajan and Gersbach, 2004). Many African countries have a tradition of fostering relatively large numbers of children to relations, and there is some evidence that existing AIDS orphans can be absorbed into this system with relatively little hardship in terms of nutritional and educational outcomes (Ainsworth and Filmer, 2002)—but this system may break down under the strain of greater numbers of orphans.

High rates of HIV/AIDS can have major effects on social relationships and institutions, although these effects can be difficult to quantify. The high level of stigma associated with HIV/AIDS can reduce trust in the community, while high mortality and the strains imposed by coping with extreme ill health before death can weaken institutions, such as families, community groups, firms and government agencies. The weakening of these elements of social capital may have large, long-run economic consequences (Haacker, 2004).

Epidemiology, Prevention and Treatment

Epidemiology and Transmission

The HIV virus creates a U-shaped path of infection and infectiousness. In the first few months after infection, the HIV virus replicates rapidly and may cause mild flu-like symptoms. In this stage, the viral load (the number of HIV viruses found per milliliter of blood) is high, particularly in genital fluids. The emergence of an immune response, partly through CD4 cells that target the virus, leads to a rapid decline in the viral load to very low, though still detectable, levels. In this stage, which may last for 10 years or more, the disease has few clinical symptoms. The CD4 cells are a target of the virus and are gradually eliminated, however, and over time the immune response weakens. At some point (usually when the CD4 concentration has fallen from its normal level of around 1000 to below 200 per milliliter of blood) the viral load again rises rapidly and is associated with a rapid decline in the overall immune system. At this point the body is open to opportunistic infections (in Africa, tuberculosis is common), usually leading to death within two years. People who have HIV are most infectious to others when their viral load is high, leading to a U-shaped rate of infectiousness. Based on a study of discordant couples (where one partner has the HIV virus, but the other does not) in Uganda, the risk of causing a new infection is highest in the first two and a half months after infection (a transmission risk of 0.0082/coital act) and in the last 24 months of life (0.0028/coital act), with a low of 0.0007/coital act in the middle period (Wawer et al., 2005). While these transmission rates per sex act are low, the cumulative probability of transmission from repeated unprotected sex with an infected partner quickly becomes large.

In developing countries, HIV/AIDS is transmitted mainly through heterosex-

ual sex and through mother-to-child transmission before or during birth, or through breastfeeding. High-risk groups for heterosexual transmission are commercial sex workers and their clients. In many countries, male long-distance truck drivers and temporary migrant workers provide a vector for infection into their local communities. In some countries, despite high infection rates in these high-risk groups, prevalence rates among the general population remain low. If each case in the general population infects less than one other person on average, initial infections tend to have a very limited impact on the general population. However, if each new infection leads to more than one subsequent infection on average, then an epidemic occurs in the general population. These two different cases have implications for whether a country should focus its prevention efforts on the high-risk groups or target the general population.

An important issue is why HIV prevalence rates are so high in some African countries. Halperin and Epstein (2004) argue that while the number of sexual partners reported in Africa is similar to that found in other regions, the pattern of sexual activity may be a factor, with concurrent long-term relationships being common in Africa, as opposed to the serial monogamy found elsewhere. (One-off casual sex and commercial sex are common in many countries.) A study of four African cities with very different levels of HIV (Auvert et al., 2001) comes to the conclusion that the driving force behind the differential rates of HIV prevalence is not differences in sexual practices, such as the number of partners, but the rate of transmission of infection per sexual act, with high levels of transmission being associated with the presence of other untreated sexually transmitted diseases and, for men, being uncircumcised. Oster (2005) uses an epidemiological model to argue that the higher transmission rates in Africa can explain the difference between HIV prevalence in Africa and the United States, though she attributes a greater role to differences in sexual behavior and the timing of the epidemic in explaining differences across countries within Africa.

Prevention Options

A number of prevention measures can dramatically lower the transmission of HIV/AIDS. One set of measures focuses on reducing the rate of HIV transmission through nonsexual pathways, from mothers to children, and through blood transfusions. A second set of prevention measures focuses on promoting changes in sexual activity—for instance, promoting abstinence, a reduction in the number of partners, or condom use—though mass media campaigns, school-based or peer education, condom distribution and voluntary counseling and testing. A third set of prevention measures targets transmission rates per unprotected sex act through the treatment of other sexually transmitted diseases and the promotion of male circumcision.

Without intervention, 15 to 30 percent of children born to HIV-positive mothers (that is, those who have the virus) will be infected either before or during birth, and a further 10 to 20 percent will be infected via breastfeeding. Mother-to-child transmission can be dramatically lowered by giving HIV-positive mothers a single dose of nevirapine at the onset of labor and a single dose to the infant at

birth (Hashimoto, Kapiga and Murata, 2002). This policy may reduce transmission to below 3 percent at birth. The issue of breastfeeding is more difficult, because an argument can be made that in situations of high child mortality the benefits to children of breastfeeding by HIV-positive mothers (without the addition of any foods) for the first six months outweigh the risks from possible HIV transmission (Coutsoudis, Goga, Rollins and Coovadia, 2002). (Breast milk confers direct health benefits to children compared to formula milk and additional health problems can also arise when there is a lack of clean water to make up the formula milk from powder.) Using HIV-infected blood in a transfusion produces almost certain transmission of the disease to the recipient, but it is now easy to test blood products before use.

Reducing the transmission of the HIV virus that occurs through sexual activity can be done either by reducing certain kinds of sexual activity or by making sexual activity less likely to transmit disease. Voluntary counseling and testing for HIV is widely available in developing countries and has a role in prevention strategies. Rapid tests based on finger prick blood spots or mouth swab are cheap and widely available. Due to the likely effect of learning one's HIV status, counseling services are required, both before and after testing. Voluntary counseling and testing can play a role in prevention by reducing risky sexual behavior in those who are HIV-positive, particularly if there is joint counseling of couples.

The effects of national mass media campaigns on behavior are difficult to estimate since a control group is usually not available. The ABC—Abstain, Be Faithful, Use Condoms—initiative in Uganda, combined with a high level of political commitment to HIV prevention, was successful in significantly reducing the prevalence of AIDS (S. Cohen, 2004). In mass efforts such as this, it is difficult to ascribe success to individual components (there is a debate about the relative importance of condoms in the ABC strategy), but they do provide evidence that broad-based and well-supported efforts at behavior change can be effective prevention strategies. The impact of mass media campaigns tends to be short (Vidanapathirana, Abramson, Forbes and Fairley, 2005) and there needs to be an ongoing effort. These mass campaigns can be aided by condom distribution and more-targeted HIV education programs aimed at youth in and out of school.

A number of interventions can reduce transmission rates for unprotected sex. HIV transmission is higher when the presence of other sexually transmitted diseases gives rise to open sores that allow entry by the virus to the bloodstream; such untreated sores are common in sub-Saharan Africa. Treatment of these sexually transmitted diseases is simple and cheap and can prevent the spread of HIV. While some of these interventions have been successful, the effect of such programs appears to be highly dependent on circumstances (Grosskurth et al., 1995; Gilson et al., 1997; Sangani, Rutherford and Wilkinson, 2005).

Observational evidence suggests that HIV rates are higher among uncircumcised men in Africa, and that the countries with highest rates of HIV also have the highest proportions of uncircumcised men (Caldwell and Caldwell, 1996). The foreskin is rich in white blood cells which may act as an entry point for HIV. Recent

evidence from a randomized trial appears to support the beneficial effects of male circumcision in reducing HIV transmission (J. Cohen, 2005).

Treatment

Highly active antiretroviral therapy for HIV/AIDS patients, while effective in most patients, is difficult and requires a high level of medical supervision. Patients should have regular CD4 tests or viral load counts to find if therapy is appropriate and to check if it is proving effective. WHO guidelines call for antiretroviral therapy to begin when the CD4 count is below 200 per milliliter of blood.

Patients usually visit a clinic once a month to get a new supply of drugs, to discuss their symptoms and to take medical tests. The drugs used in treatment are toxic and patients must be monitored for side effects as well as efficacy. In addition, effectiveness depends on high levels of adherence (at least 85 to 90 percent). Counseling and follow-up are required to ensure adherence, especially since many people with HIV/AIDS suffer from depression, which may affect adherence. Antiretroviral therapy treatments can interact with drugs for other illness—a serious problem since half of those entering treatment with a CD4 count of less than 200 are likely to have opportunistic infections that require treatment.

HIV mutates rapidly, and while many mutations are less virulent, resistance to antiretrovirals emerges; antiretroviral therapy usually consists of a cocktail of three drugs to combat the emergence of resistance. Once resistance to the first line of antiretroviral therapy emerges, patients can be treated with second- or third-line drug regimes. Medeiros, Diaz and Filho (2002) find in a Brazilian study that the average duration of benefits from first-line antiretroviral therapy was only 14.1 months. This finding suggests that a need for second-line antiretrovirals will quickly emerge in Africa, but while drug costs of first-line treatment are now low, with generic drugs being available at a cost of around \$175 per year, the costs of the second-line drugs can be ten times higher.

In addition to antiretrovirals, other measures can be used to prevent and treat opportunistic infections. The major opportunistic infection, and leading cause of death for those with AIDS in Africa, is tuberculosis. All HIV-positive patients, particularly those with latent tuberculosis, can take a drug to prevent its emergence. Multivitamin supplements can also reduce the effects of opportunistic infections (Fawzi et al., 2004). Direct treatment of opportunistic infections in HIV-positive patients can be effective (for example, Grant, Kaplan and De Cock, 2001). In particular, the standard treatment of tuberculosis (directly observed treatment, short course) is highly effective in general and can be equally effective in HIV-positive patients (Davies et al., 1999). HIV-positive patients with tuberculosis can also be given drugs to prevent the onset of pneumonia, which can dramatically reduce mortality rates.

The Cost-effectiveness Bottom Line

Many high- and middle-income countries provide both prevention and treatment. Based on the high valuations of health found in cross-country estimates of willingness to pay to avoid a small chance of death (Aldy and Viscusi, 2003),

middle-income countries should certainly be undertaking all of the prevention interventions outlined here, as well as first-line antiretroviral therapy. For example, Brazil is successfully providing universal access to antiretroviral therapy (Teixeira, Vitoria and Barcarlo, 2004).

The tough issue arises in the least-developed countries in which resource constraints are so tight that neither sufficient prevention nor treatment are being carried out. Given the resource constraints, cost-effectiveness analysis is a way of setting priorities. Table 3 sets out the range of cost-effectiveness estimates that have been used in four papers that compare interventions. The figures in the first three columns calculate cost-effectiveness figures using estimates of health benefits and costs found in three studies: Marseille, Hofmann and Kahn (2002), Creese, Floyd, Alban and Guinness (2002), and Masaki, Green, Greig, Walsh and Potts (2003), respectively.

Calculating benefits in cost-effectiveness studies for prevention efforts against an opportunistic disease depends on understanding the epidemiology of the disease. The effectiveness of prevention efforts tend to be higher when incidence rates are high because more instances of transmission can be prevented. The study needs to estimate, not only the number of infections directly avoided by the target group, but the extent to which each infection can cause subsequent infections in a multiplier process. Changing the behavior of the population may also have feedback effects by changing risk and incentives for individuals.

A full cost-effectiveness analysis therefore has to be embedded in an epidemiological model. Oster (2005) does this to examine the effect of treating sexually transmitted diseases on the course of the epidemic. This approach requires modeling different sub-populations. For example, single men and women, married men and women, and commercial sex workers and their clients are often modeled as distinct subgroups, but other groups may also be modeled, such as intravenous drug users and urban versus rural dwellers, depending on their importance in a particular setting. The model needs to include rates of sexual interaction and other types of transmission within and between groups, and the transmission rates of HIV in different sexual activities.

Epidemiological models usually find multiplier effects, arising from the fact that individual actions reducing personal risk also reduce subsequent risk to others. However the interactions in such models are complex and may even reverse the direct effects of a prevention intervention. For example, Kremer and Morcom (1998) show that if HIV-negative people abstain from sexual activity, this can increase the proportion of HIV-positive individuals among the sexually active, thus increasing the chances of infection for others who remain sexually active. This negative externality particularly affects those who are highly sexually active—people who are more likely to get, and then to spread, the disease. Abstinence by those who would otherwise have a small number of partners can thus have the apparently paradoxical effect of increasing prevalence rates, despite reducing overall sexual activity.

The final two columns of Table 3 give cost-effectiveness estimates based on Hogan, Baltussen, Hayashi, Lauer and Salomon (2006). The effects of each inter-

Table 3

Cost Effectiveness of Prevention and Treatment of HIV/AIDS in Africa*(U.S. dollars per loss of disability-adjusted life year averted)*

	<i>Marseille, Hofmann, and Kahn (2002)</i>	<i>Creese, Floyd, Alban, and Guinness (2002)</i>	<i>Masaki, Green, Greig, Walsh, and Potts (2003)</i>	<i>Hogan, Baltussen, Hayashi, Lauer and Salomon (2006)</i>	
				<i>(interventions taken alone)</i>	<i>(interventions combined in optimal sequence)</i>
Mass media campaigns				3	3
Peer education for sex workers		4–7	4		
Peer education and treatment of sexually transmitted infections for sex workers	1			3	4
Condom distribution to commercial sex workers	1	12			
Short-course tuberculosis treatment		2–21			
Blood transfusion safety	8	1–43	3		
Prevention of mother-to- child transmission through single dose nevirapine	11–19	1–81	11	34	46
Diagnosis and treatment of sexually transmitted infections	13	12	22	19–32	68–290
Voluntary counseling and testing	12–78	18–22	22	82	220
Condom distribution to high and medium risk women		48–99			
Preventive therapy for the HIV-positive against tuberculosis			169–288		
Prevention of mother to child transmission through advocating limited breastfeeding or formula milk provision		131–731			
School based HIV/AIDS education				376–530	631
Antiretroviral therapy— first line drugs only	350–2000	1100–1800	1317–2029	556	547
Antiretroviral therapy— first and second line drugs				1977	5175

Note: Costs are in U.S. dollars for different years. Also, costs and effectiveness both depend on assumptions on the rate of discount to be applied to future costs and on the stream of future disability-adjusted life-years gained. I have not tried to rebase to a common year to allow for inflation, nor recalculated all studies with a common discount rate.

vention are embedded in a common epidemiological model. This allows for interactions between interventions and the possibility of complex feedback effects. The first column gives the cost effectiveness of each intervention on its own (if no other interventions were used) while the second gives the incremental cost effectiveness of each intervention based on the optimal sequencing of interventions.

The interventions in Table 3 are ordered roughly in order of cost effectiveness. This ranking suggests that mass media messages are highly cost effective at changing behavior and reducing the transmission of HIV. Peer education, condom distribution, and treatment of sexually transmitted diseases for commercial sex workers are also highly cost effective. The treatment of tuberculosis is highly cost effective in those who are HIV-positive as well as the general population. These interventions cost between \$1.00 and \$21.00 per disability-adjusted year of life gained.

Blood transfusion safety and the prevention of mother-to-child transmission through single-dose nevirapine are next in the ranking, both with costs less than \$50 per disability-adjusted year of life gained. Then comes the diagnosis and treatment of sexually transmitted diseases, voluntary counseling and testing, and condom distribution to medium and high-risk women, which probably have costs less than \$100 per disability-adjusted year of life gained and are always estimated at less than \$300 per disability-adjusted life year. Similarly, preventive therapy against tuberculosis for those who are HIV-positive costs less than \$300 per disability-adjusted life year gained. Prevention of mother-to-child transmission through using formula milk rather than breastfeeding has a wide range of estimated costs and is dependent on the trade-off between avoiding HIV infection and the extra risks to the child that come from using formula milk rather than breastfeeding. School-based HIV/AIDS education has low cost effectiveness due to the relatively small effects on behavior it seems to bring about.

The least cost-effective interventions are treatment using antiretroviral therapy. The studies reported in the first three columns have found that first-line antiretroviral therapy has a cost in excess of \$1,000 per DALY loss averted (the figure of \$350 in the first column reflects only drug costs at the time and not the cost to the health system of providing antiretroviral therapy). The downward trend in drug prices means the figure today is probably somewhat smaller, perhaps between \$500 and \$600 as reported in the most recent study shown in Table 3. Second-line drugs remain expensive in low-income countries making this the least cost-effective intervention we consider. (The figure \$1,977 in the fourth column is the average cost effectiveness of a policy of providing both first- and second-line antiretroviral therapy—as second-line could never be provided on its own—while the figure \$5,175 in the fifth column is the marginal cost-effectiveness of moving to second-line after using first-line antiretrovirals.)

Table 4 shows the costs and the loss of disability-adjusted life-years averted for three different policies in 20 high-mortality countries of Africa. The first policy is using all the prevention interventions with cost effectiveness calculated in the final column of Table 3, with the exception of school-based HIV/AIDS education. These highly cost-effective prevention interventions would avoid the loss of 30.9 million

Table 4

The Cost and Benefits of Prevention and Treatment in 20 High-Mortality Countries in Africa

	<i>Cost</i> (\$ millions)	<i>DALY</i> <i>loss averted</i> (millions)	<i>HIV</i> <i>infections prevented</i> (millions)
Prevention	859	30.9	3.53
Antiretroviral therapy first-line drugs only	1,350	2.4	0.04
Antiretroviral therapy first- and second-line drugs	6,434	3.2	0.04

Source: Adapted from data in Hogan, Baltussen, Hayashi, Lauer, and Salomon (2005).

Note: This covers 20 African countries with high child and very high adult mortality rates listed by the World Health Organization (2003): Botswana, Burundi, Central African Republic, Congo, Côte d’Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia and Zimbabwe. It includes all of the countries in Africa with reported HIV prevalence rates over 20 percent. The effect of each treatment and prevention strategy is relative to no intervention.

disability-adjusted life-years at a cost of \$859 million per year. The alternative policy of providing first-line antiretroviral therapy would avoid the loss of 2.4 million disability-adjusted life-years at a cost of \$1,350 million. Providing both first- and second-line antiretroviral therapy would raise the health gains only marginally, but at a large additional cost.

Focusing on prevention before turning to antiretroviral therapy will bring large health gains, mainly in the form of infections avoided. Table 4 shows that a focus on prevention in the high-mortality countries of Africa will reduce new HIV infections in the region by around 3.53 million per year, as compared with an estimated reduction of 40,000 a year with antiretroviral therapy. If the need for both treatment and prevention could be met, or if there were no resources available at all, priority setting would not be required. The Joint United Nations Program on HIV/AIDS (2005b) estimates that \$8.9 billion will be available for spending on HIV/AIDS in low- and middle-income countries in 2005. This amount is insufficient to meet all needs, but directing it to prevention could have significant effects.

There is natural uneasiness about having to make such a “tragic choice” between prevention and treatment (Calabresi and Bobbit, 1978). Such tragic choices are inevitable in low-income countries where resources are so tightly constrained, highlighting the need for policies to support economic growth and poverty reduction to make such choices less painful in the future.

Is Cost-effectiveness Analysis Trustworthy for Priority Setting?

A number of arguments have been put forward for an emphasis on highly active antiretroviral therapy over prevention, even in the face of the evidence which

suggests it is less cost effective than prevention (for example, Boelaert, Van Damme, Meessen and Vand der Stuyft, 2002; Farmer, 2003; Mukherjee et al., 2003). We consider the arguments in turn.

The Number Infected with AIDS is so High

One argument is that the scale of the HIV/AIDS epidemic is so great and so threatening to overall social and economic development that it constitutes an emergency that requires a direct response (Stabinski, Pelley, Jacob, Long and Leaning, 2003). HIV/AIDS is the biggest single health problem in Africa, accounting for 12 percent of the disability-adjusted years of life lost, followed by malaria, respiratory infections and injuries (11, 10 and 9 percent of total DALYs lost, respectively) (World Health Organization, 2004). Thus, it may seem obvious that health care priorities should be set according to the size of the burden imposed by the disease, and HIV/AIDS imposes the largest burden.

Using the burden of disease as a priority-setting tool, however, makes an elementary mistake. Focusing money on the largest health problem, or in proportion to the size of the problem, equalizes spending across needs, but does not maximize health produced. For example, if nothing could be done to reduce the burden of HIV/AIDS, then spending anything on it at all would be foolish. Maximizing health outcomes requires that at the margin the cost effectiveness of interventions be equalized. We should use the most cost-effective health interventions until they are exhausted (no more cases left to prevent or treat) or until cost effectiveness falls due to diminishing returns (for example, due to the difficulty of identifying rare cases), and then move on to the next most cost-effective intervention. This logic argues that there is no need to know the total burden of each disease for priority setting, only the marginal cost-effectiveness of interventions (Williams, 1999).

One argument against this marginal view of priority setting is that certain health care policies may have fixed costs (Murray and Lopez, 2000). For example, most of the costs of research and development are fixed. In the simplest possible case, where research leads to a breakthrough cure with no marginal cost per patient, the expected cost effectiveness of research is simply the cost of the research times the probability of success, divided by total burden of the disease in disability-adjusted life years (on the grounds that this burden can then be avoided if the research is successful). Development of an effective HIV/AIDS vaccine would bring enormous benefits because of the many millions of HIV infections that could be avoided, which justifies large investments even if the probability of success is low.

There may also be fixed costs in the implementation of interventions. If only a small number of interventions are feasible due to institutional constraints, it may be better to focus on a few reasonably cost-effective interventions for high-burden diseases that will produce a large total health gain rather than implement a similar number of highly cost-effective but small-scale interventions.

In the case of HIV treatment and prevention, however, it is difficult to argue that a focus on antiretroviral treatment, while being less cost effective, will produce a greater total health gain than a focus on prevention. For example, Ainsworth and

Teokul (2000) accept the idea that there are administrative as well as financial constraints and that we should focus on a limited number of interventions, but they still argue for priority to be given to changing the behavior of the groups most at risk, treating opportunistic infections in those with HIV, and preventing the potential economic and social consequences of AIDS—for example, through programs to ensure the welfare of orphans.

Nothing in the consideration of the effects of the scale of the HIV/AIDS epidemic would lead a policymaker to put greater emphasis on treatment rather than prevention. Indeed, the enormous scale of the epidemic and its social and economic consequences suggests the importance of spending available resources as effectively as possible. Prevention efforts will tend to reduce the scale of the disease while treatment focuses on its symptoms. As shown by Table 4, promoting treatment before widespread prevention efforts denies the very interventions that can reduce the scale of the disease.

Cost-effectiveness Analysis Overstates Returns to Prevention and Understates Returns to Treatment

The idea of a disability-adjusted life year, though commonly used in cost effectiveness studies, may be called into question as a measure of health (for example, Anand and Hanson, 1997). The disability-adjusted life year is based on the recommendations of expert committees: it puts different weights on different disability states, weights a year of life at different ages differently, and discounts future disability-adjusted life years at a rate of 3 percent a year. All of these methods raise questions. Cost-effectiveness analysis also requires a number of judgment calls by the researcher, such as how to allocate overhead costs among several activities. However, most of the burden of HIV/AIDS is in the form of premature death, making it relatively insensitive to how disability is weighted. The other factors seem unlikely to produce a bias in favor of prevention.

With regard to the reliability of cost-effectiveness estimates of prevention efforts, the results on the cost effectiveness of mother-to-child transmission through single-dose nevirapine are high and fairly uniform across a range of studies. The effectiveness of treatment of sexually transmitted diseases, on the other hand, seems to be dependent on context (Sangani, Rutherford and Wilkinson, 2004). For interventions such as information, education and counseling, short-run behavior change can be observed, but studies do not usually provide convincing evidence of effects on long-run behavior or disease incidence (Walker, 2003). The impact of prevention efforts depends on the epidemiological context (Grassly, Garnett, Schawarlander, Gregson and Anderson, 2001), and an epidemiological model should be used to estimate the effect of the behavior change on prevalence rates.

The case for prevention through behavior change largely rests on the experience of Uganda (the ABC mass media campaign) and Thailand (where efforts concentrated on commercial sex workers), where a high level of political commitment and multiple channels of communication translated into successful efforts to reduce the spread of HIV/AIDS. There is the question of how replicable these success stories are in other countries.

Overall, the evidence for the cost effectiveness of prevention is clear-cut for the nonsexual pathways: mother-to-child transmission and blood transfusion safety. The effects of interventions that change behavior, or change transmission rates, need to be calculated in an epidemiological model that calculates how incidence and prevalence rates respond to the change. Using an epidemiological model always raises questions, because many parameters need to be calibrated, but such models can still generate reliable results.

The cost effectiveness of treatment could also change if full account is taken of measurement problems and externalities. One important issue is that the effectiveness of antiretroviral therapy is highly dependent on keeping individual adherence to the therapy regimen above 85 percent, since below this level of adherence, the efficacy of the treatment falls off quickly. While adherence levels have been high in small-scale research studies in Africa, there is a real concern that rapid expansion of treatment provision will lead to lower levels of counseling and support, and a fall-off in adherence (Gill et al., 2005).

The case for prevention is based, to a large extent, on the externality that each infection leads to added transmission to others so that the public benefits of prevention efforts outweigh the private benefits. Treatment may also have externalities that are not included in cost-benefit analysis. One such benefit is that making HIV/AIDS a treatable illness may reduce the stigma associated with it (Castro and Farmer, 2005), though evidence on this is meager so far. Another possible externality is that when treatment reduces the viral loads in those who have HIV/AIDS, it also can reduce the possibility of infecting sex partners—though this effect is counterbalanced somewhat by the longer life span and additional sexual activity of those in treatment, which increases opportunity for transmission.

Possible externalities of treatment on behavior may also arise. Since the availability of treatment raises the possibility that testing may lead to treatment, testing for HIV may become more common, allowing people who learn they are HIV-positive to change their sexual behavior. However, the current WHO-recommended treatment regime in low-income countries is to begin antiretroviral therapy at a CD4 count of 200, at which time opportunistic infections are likely to be present. Under this standard, early testing for HIV is unlikely to lead to earlier treatment than waiting for AIDS to become manifest through opportunistic infections, and then seeking testing and treatment.

A major possible negative externality is that, because the availability of treatment lowers the cost of being infected, people may become more risk taking. There is evidence of such an effect in the United States (Goldman, Lakdawalla and Sood, 2004) as well as evidence of widespread reductions in condom use in Kenya in response to (incorrect) announcements of cures for AIDS being found (Over et al., 2004). Treatment may also have another negative externality in the form of the development and transmission of drug-resistant strains of HIV, though existing evidence on this suggests that it may not be a major concern in Africa in the foreseeable future (Blower, Bodine, Kahn and McFarland, 2005).

Cost-effectiveness analysis measures only the health benefits of interventions; any wider economic and social benefits should be added to the calculation. In

addition to the health loss, HIV/AIDS leads to a reduction in employment and earnings, while patients undergoing antiretroviral treatment may be able to continue working, generating an economic benefit (Thirumurthy, Graff-Zivin and Goldstein, 2005). Other spillovers from HIV/AIDS are caused by the reduction in care to other members of the family when an AIDS victim dies. The death of a father or mother may reduce family income or the provision of child care, and may have enormous repercussions on children's development. But these externalities also apply to HIV/AIDS cases avoided through prevention methods and so are unlikely to tip the balance.

An important possible negative externality of a focus on treatment is that it absorbs scarce health sector workers from other activities, including cost-effective treatments of other diseases. In the long run the supply of doctors and nurses can respond to the additional demand, but in the short run the high level of funding for AIDS treatment may reduce health sector workers available for other activities (Over, 2004). The shortage of even basic medical facilities and personnel in the poorest countries of Africa, particularly in the rural areas, makes it difficult to see how antiretroviral treatment can be rolled out to provide close to universal coverage in the next few years. Many low-income countries have difficulty providing very simple (and highly cost-effective) medical services such as vaccinations for children, which makes it seem implausible that they can provide national networks of AIDS treatment facilities.

Another possible externality to treatment interventions is that "learning by doing" can increase future cost effectiveness. Even modest gains in cost effectiveness would increase the number of countries for whom antiretroviral therapy would become an affordable intervention. For example, Farmer et al. (2001) experiment with basing initiation of antiretroviral therapy on the failure of conventional treatments for opportunistic infections, rather than laboratory tests such as CD4 counts. Badri et al. (2004) suggest that while using symptoms as a guide to initiating antiretroviral therapy reduces the number of eligible patients, relative to using a CD4 count, it does not affect mortality rates. However, most current treatment programs explicitly exclude research as a goal.

Evidence on these positive and negative externalities is not conclusive and more research into their magnitudes is required. My reading of the existing evidence is that the risk of negative externalities of treatment—that is, widespread treatment leading to higher infection rates—is at least as high as the possibility of positive externalities from treatment. Thus, using positive externalities as an argument for a large-scale treatment would require new evidence of a large net positive spillover effect. Until then, given the very large gap between the cost-effectiveness estimates for prevention and treatment, it is not likely that correcting measurement errors will reverse the ranking.

Ethical Arguments

Three common ethical arguments are put forward for emphasizing antiretroviral treatment: the need to save those whose lives are immediately at risk, the

presence of a common bond with AIDS patients, and the need to treat all people with AIDS equally.²

One common argument in favor of highly active antiretroviral therapy in developing countries is the “rule of rescue” (Jonson, 1986), which argues that people feel a psychological imperative to save those whose lives they see to be in immediate danger, irrespective of opportunity cost. While the rule of rescue has undoubtedly been a strong force in making antiretroviral therapy a priority (Feachem, 2002), it raises difficult issues. McKie and Richardson (2003) examine the conflict between the rule of rescue and cost-effectiveness analysis. In the cost-effectiveness analysis of treatment and prevention of HIV/AIDS, those who are ill with full-blown AIDS do not receive a higher weight than those who could be prevented from getting an HIV infection in the first place (though the later gains are discounted by time). In contrast, the rule of rescue gives absolute priority to currently identifiable victims at the expense of a larger number of potential victims who have not yet been identified. It is difficult to argue that being identifiable gives extra moral weight to a person’s claim on resources.

The rule of rescue implies a commitment to treat a future AIDS case, even if those resources could have been allocated to preventing that same person becoming infected today, when prevention is a much cheaper way of overcoming the problem and when the person would prefer not to be infected—which seems bizarre. The rule of rescue also suggests that antiretroviral therapy would still need to be compared in cost effectiveness to other treatments for life-threatening conditions. There are many highly cost-effective, life-saving interventions in developing countries—for example, treatment of tuberculosis and basic vaccinations for children—which cost around \$20 per loss of disability-adjusted life year averted.

One reason for an emphasis on treatment is that there exists a global community of people concerned about HIV/AIDS, and people in this community feel a common bond with those with HIV/AIDS, wherever they may be. I once spoke for more cost-effective use of resources at a conference and a more politically knowledgeable participant whispered to me afterwards that if we did not use the funds for AIDS treatment, there would be no funds at all. While it might be more efficient in social welfare terms to concentrate resources on prevention, the group whose welfare we are considering may be *defined* as those with HIV, so that the feeling of community and obligation only occurs after infection. Funding for HIV/AIDS treatment could be viewed as a form of charitable giving similar, say, to giving by alumni to their college or university. Such charitable giving is always subject to the critique that the funds might have been spent with greater effect elsewhere, but such giving is still a desirable form of redistribution, raising the welfare of both recipient and giver.

Both the rule of rescue and common-bond arguments essentially deny that our goal should be to maximize overall population health, and instead propose that the

² There are also a number of arguments that could be summarized under the heading of “political economy,” such as that treating some people will raise political pressure for further treatment and prevention. These issues are not dealt with here but seem unlikely to have effects large enough to lead to a support of treatment over prevention.

focus should be on a particular group. While private charity may focus disproportionately on some group, there is a strong ethical counterargument that public policy should give a more equal weighting across people, as is done in cost-effectiveness analysis.

A third ethical argument is that the same standard of health care should apply around the world. Since antiretroviral therapy is generally available in high-income countries, this argument holds that it would be unethical to deny such treatment to those in low-income countries. It could be argued that taking ethical claims to our national borders and then stopping shows a lack of moral stamina. However, ethics frequently draws some distinctions between the imperatives that apply to smaller communities with stronger ties, such as within the nuclear family or a nation-state, and imperatives that relate to fairness and sharing with weaker ties, as in the global community. Even weak ties provide a strong ethical argument that the international community should help provide basic goods, such as health care, that are essential elements of creating capabilities in developing countries. But the argument does not suggest complete equality across countries, nor does it imply a priority to AIDS treatment over prevention.

One way of interpreting the argument that the standard of health care should be the same around the world is that we should not prioritize between treatment and prevention interventions; instead, the international community should make sufficient funds available to do both. But the argument that sufficient funds for both should be provided comes up against the hard reality that this is not being done and low-income countries do face a resource constraint. As a consequence, antiretroviral treatment has a cost in terms of prevention efforts foregone.

Conclusion

Developed, middle-income, and even many low-income countries around the world can finance both prevention efforts and antiretroviral treatment for HIV/AIDS, but countries with very low incomes face binding resource limitations. In these countries, the issue is to what extent the international community should fund antiretroviral therapy. Private charity can of course choose to focus disproportionate attention on any particular group to which it feels a strong connection. However, if the goal is to maximize the health benefits produced, developing-country governments and international institutions should focus their health spending first on the prevention of HIV transmission, before moving on to treatment. The opportunity cost of emphasizing HIV/AIDS treatment before undertaking prevention in a resource-constrained environment is measured in millions of lives needlessly lost.

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