The Public Health Benefits of Microbicides in Lower-Income Countries

Model Projections

A Report by the
Public Health Working Group
of the **Microbicide Initiative**
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Note: The views expressed in this document do not necessarily reflect the opinions of individual members of the Working Group, nor the policies of their respective agencies or organizations.

Executive Summary

Introduction

Globally it is estimated that in 2001 there were 5.3 million new HIV infections. HIV/AIDS is having devastating consequences for many countries, particularly in sub-Saharan Africa, where the economic and health gains of the past thirty years have been rapidly negated. There is also substantial potential for the epidemic to spread rapidly in several other regions of the world. For example, the Indian government estimates that in 2000, 3.85 million of their citizens were infected with HIV, and it is estimated that by 2010 China may have 20 million people who are HIV-infected.

Worldwide, heterosexual sex is the main mode of HIV transmission. Women of all ages are more likely than men to become infected with HIV during unprotected vaginal intercourse. This biological vulnerability is compounded by socio-economic and cultural factors that accord women lower status than men, and limit the extent to which women can negotiate male condom use. There is an urgent need for female-controlled barrier methods that can be used consistently. Microbicides are products—including gels, creams, suppositories, and other chemical methods used vaginally or anally—that can reduce the transmission of HIV, and potentially other STDs as well. As it is expected that microbicide use would not necessarily depend upon the cooperation of a male partner, microbicides would be an important addition to current forms of HIV/STD prevention. While almost three dozen potential products are at different stages of pre-clinical testing, none have been through a phase 3 trial, and so their potential impact on HIV transmission remains untested and unquantified.

The study uses epidemiological modeling and economic analysis to estimate the potential public health impact of the introduction of an effective microbicide in lower-income countries. The measurement of this public health impact is done in two ways: first, in terms of the number of HIV infections that could be potentially averted over three years by widespread microbicide introduction and use; and second, by estimating the global economic benefits of preventing these HIV infections.

Methods

The focus of the analysis is on quantifying the public health benefit of the widespread distribution and use of microbicides in seventy-three lower-income countries. This includes all countries with a GNP per capita of less than US$1200 per year (US$ 1999)[1] and, given the substantial HIV burden, all countries in sub-Saharan Africa, independent of their economic performance. Throughout the analysis we use a country-specific approach—conducting a separate analysis of the likely number of HIV infections averted, and the economic benefits from the introduction of microbicides for each of the seventy-three lower-income countries considered. We consider the distribution of a microbicide product that could be made available without prescription, and can therefore be considered a complementary adjunct to existing HIV-prevention, contraceptive, and educational services.

For the analysis, in each country we consider four groups that could potentially access microbicides through existing services: sex workers in contact with HIV prevention services; sexually active adolescents in school; injecting drug users in contact with HIV prevention services; and

[1] US$ 1999 means that the GNP per capita is measured in constant U.S. dollars for the year 1999.

women in regular partnerships receiving contraceptive services. For each group we estimate the proportion in contact with services, and consider the impact on HIV transmission of providing a 60% HIV efficacious microbicide to 20% of these people. We assume a 10% reduction in condom use following microbicide introduction; and that both inconsistent and non-condom users use microbicides 50% of the time that a condom is not used. Four existing epidemiological models of microbicide impact and country-specific data on the prevalence of HIV infection in each group are used to estimate the cumulative number of HIV infections averted over three years. Country-specific data on total fertility and infant mortality are used to estimate the subsequent number of mother-to-child HIV infections prevented by averting the infection of a woman of reproductive age in a regular partnership. Sensitivity analysis is conducted to explore how the impact estimates are affected by the assumptions made about microbicide efficacy and coverage.

The economic benefits of averting HIV infection are measured in terms of the lifetime treatment costs saved by averting an HIV infection, as well as a conservative estimate of the avoidance of productivity losses to the economy associated with HIV illness and death. To estimate the benefits to health services of averting the care and treatment costs related to HIV/AIDS, we consider a simple model of HIV/AIDS illness throughout an infected person's lifetime. We only consider the forms of care and treatment that are generally available in lower-income countries, such as palliative care, inpatient and outpatient care, treatment of opportunistic illnesses, and home-based care. In addition, the costs of care and treatment can only be avoided if the costs would be incurred in treating HIV-infected people. In the seventy-three lower-income countries considered, 81% of the population have access to health services, and so we only estimate the magnitude of the health savings associated with these people. We also do not consider savings averted from treatment of the HIV/AIDS virus itself (including Highly Active Anti-Retroviral Therapy), as current estimates suggest that coverage in lower-income countries is less than 1%. For the analysis we estimate the lifetime health-care costs associated with HIV infection. Since these will occur at different

Three-year cumulative HIV infections averted and their associated health and productivity gains from the distribution of a 60% HIV efficacious microbicide to 20% of groups in contact with services in 73 lower-income countries

	Three-year cumulative HIV infections averted (number of HIV infections averted)	**Present value of direct cost savings to health systems** (billions, '000,000,000 US$ 2002)	**Present value of productivity gains** (billions, '000,000,000 US$ 2002)
60% HIV efficacy, 20% coverage of groups in contact with services			
East Asia and Pacific	793,577	1.30	0.43
Eastern Europe and Central Asia	128,246	0.20	0.04
Latin America and the Caribbean	50,444	0.06	0.03
South Asia	882,642	0.65	0.17
Sub-Saharan Africa	682,790	0.48	0.36
Total	**2,537,700**	**2.69**	**1.04**

points in time, we present the cost savings in terms of present (US$ 2002) values.

In addition to these direct savings, there is a range of productivity losses that may be prevented by averting the transmission of HIV infection. For the analysis we adopt a conservative approach, and value the time lost from work that would be avoided, as well as the costs of training replacement staff. Again, this is presented in present-value terms, as these losses occur at different points in time in the future.

Results

The findings suggest that widespread microbicide use in lower-income countries has the potential to yield significant public health benefits. Even using relatively conservative assumptions about microbicide efficacy and coverage, the three-year cumulative impact of microbicide use could result in 2.5 million HIV infections averted among females, males, and children in lower-income countries. In broader terms, this could lead to a US$2.7 billion savings (in present-value terms) for health-system costs averted, and an additional US$1 billion in productivity savings gained from preventing absenteeism and retraining and replacing workers. The regional estimates of microbicide impact illustrate the extent to which there is substantial potential to avert infection in regions where the epidemic is still nascent or concentrated. Furthermore, even when the epidemic is generalized, as in sub-Saharan Africa, the rate of adult HIV infections averted is still relatively high.

The estimate of microbicide impact is dependent upon the assumptions made about the microbicide efficacy against HIV and against other STDs. At 20% coverage of groups that are in contact with existing services, the number of HIV infections averted ranges from 1.6 million for a microbicide of 40% HIV and 0% STD efficacy to 2.7 million HIV infections averted for a microbicide of 60% HIV and 40% STD efficacy. The associated direct cost savings to the health system range from US$1.77 billion to US$2.88 billion, and the productivity benefits range from US$0.67 billion to US$1.13 billion.

The magnitude of microbicide impact is also strongly influenced by the extent of microbicide coverage and use**.** For a 60% HIV and 0% STD efficacious microbicide, at 10% coverage of groups in contact with services, 1.4 million HIV infections could be averted. At 30% coverage, up to 3.7 million HIV infections could potentially be averted—46% greater impact than at 20% coverage. Even assuming that a microbicide is 40% HIV efficacious, at 20% coverage 1.7 million HIV infections would be averted, illustrating how the widespread use of even a relatively low-efficacy microbicide could have an important impact on HIV transmission.

Three-year impact and economic benefits of the introduction of a microbicide with different HIV and STD efficacy to 20% of groups in contact with services in 73 lower-income countries

Efficacy scenarios	Three-year cumulative HIV infections averted (number of HIV infections averted)	Present value of direct cost savings to health systems (billions, '000,000,000 US$ 2002)	Present value of productivity gains (billions, '000,000,000 US$ 2002)
40% HIV, 0% STD	1,662,344	1.77	0.67
40% HIV, 40% STD	1,856,885	1.96	0.76
60% HIV, 0% STD	2,537,700	2.69	1.04
60% HIV, 40% STD	2,735,177	2.88	1.13

Discussion

The findings suggest that widespread microbicide use in lower-income countries has the potential to yield significant public health benefits to men, women, and children. Microbicides provide new hope for HIV prevention. Sustained donor interest and political commitment are required if we are to realize this potential.

1 Introduction and Background

1.1 Introduction

This study has been undertaken for the Public Health Benefits Working Group of the Microbicide Initiative funded by the Rockefeller Foundation, whose objective is to mobilize the international community (public and private sectors) to develop and deliver effective microbicides as rapidly as possible. While nearly three dozen potential products are at different stages of pre-clinical testing, none have been through a phase 3 trial, and so their potential impact on HIV transmission remains untested and unquantified.

The study uses epidemiological modeling and economic analysis to estimate the potential public health impact of the introduction of an effective microbicide in lower-income countries. The measurement of this public health impact is done in two ways: first, in terms of the number of HIV infections that could be potentially averted over three years by widespread microbicide introduction and use; and second, by estimating the global economic benefits of preventing these HIV infections.

Estimating the public health impact of microbicide introduction is a central issue when considering what may be an appropriate degree of public-sector investment in microbicide development and distribution. A key rationale for public-sector intervention is that markets may fail, and therefore they are unable to achieve social goals. Markets operate by bringing together demand for commodities by consumers who are willing and able to pay for them, and sellers of these commodities who are able to recover their costs and possibly generate profits (Hanson et al. 2001). When individuals use market criteria in their decision to purchase or produce a good, the amount of the good that is purchased or produced is based on how they value the good and its benefits for themselves. This is described as the ***private benefit***. However, there may be additional benefits for society in the production and use of the goods, which will not be valued by individuals. These are known as ***social benefits***. Because individuals do not fully take into account social benefits when making decisions about production in the private market, products with relatively high social benefit are likely to be under-invested or under-produced by private providers in the market (Kumaranayake et al. 2001a). From an economic perspective, microbicide development is a classic case of this, where private firms do not value the social benefits of reducing the widespread transmission of HIV and STD. Thus, a reliance on market mechanisms has led to a limited participation of private firms in the development of microbicides. Evidence of a substantial social benefit (and, more specifically, a public health benefit) associated with microbicide distribution would support the economic justification for increased public-sector investment.

The report is divided into seven sections. Section 2 gives a brief introduction and background to the study. Section 3 gives an overview of the general methodology used to estimate impact and to value economic benefits. Section 4 presents a detailed description of the methods used to calculate the impact on HIV transmission of widespread microbicide use, and presents the estimates of the cumulative number of HIV infections averted over three years through the use of a 60% HIV efficacious microbicide in seventy-three lower-income countries. Section 5 presents the methods used to estimate the economic benefits associated with averting HIV infection,

and the estimated total economic value of the HIV infections averted. Section 6 presents a univariate sensitivity analysis that illustrates the degree to which the estimates of impact are dependent on the assumptions made about the clinical efficacy of the microbicide against HIV and other STDs; the degree of microbicide demand; and assumptions related to methods used to obtain an economic value associated with averting HIV infection, such as the discount rate. The study concludes in section 7 with a discussion of the results and future work. Technical annexes are provided for readers wishing to see more detail about the methods.

1.2 The magnitude of the HIV/AIDS epidemic in low- and middle-income countries

Globally it is estimated that there are 5.3 million new HIV infections annually. HIV/AIDS is having devastating consequences for many countries, particularly in sub-Saharan Africa where economic progress over the past thirty years has rapidly been negated. HIV/AIDS is now the largest cause of mortality in sub-Saharan Africa (SSA), accounting for 3 million deaths in 1999—more than double the number of deaths from malaria, and one-and-a-half times the mortality from tuberculosis (WHO 2000). Globally, estimates suggest that at the end of 2000 there were over 36 million HIV-infected people. HIV/AIDS is now the fourth cause of death in the world. HIV infections are concentrated in the developing world, and have reached epidemic proportions in sub-Saharan Africa, with 24 countries already having adult HIV prevalence rates over 5%, and 29 countries with an antenatal prevalence of more than 2% (UNAIDS 2000a). Because of these high prevalence levels among the antenatal population, it is estimated that 10% of all new infections in SSA will occur in infants, through mother-to-child HIV transmission. In the most affected countries HIV has had a significant socio-economic impact, with falling life-expectancies and GNP. In January 2000, the UN Security Council declared that AIDS was a threat to world security (Kumaranayake and Watts 2001).

There is substantial potential for the epidemic to spread rapidly in several regions of the world. For example, the Indian government estimates that in 2000 3.86 million of its citizens were infected with HIV (Ramasundaram 2002). In China, the number of reported HIV infections has risen by 67% during the first six months of 2001, compared with the same period in the previous year. It is estimated that by 2010, China may have 20 million people who are HIV-infected (*The Economist* 2001).

1.3 Women and HIV/AIDS

Worldwide, heterosexual sex is the main mode of HIV transmission. For many reasons, women are more vulnerable to acquiring HIV infection than men. Biologically, women are two to five times more likely to acquire HIV from an HIV-infected male partner than the other way around (Downs and De Vicenzi 1996). In addition, it is thought that adolescent girls may be even more susceptible, due to their physical immaturity. This biological vulnerability is compounded by socio-economic and cultural factors that accord women lower status than men, and limit the extent to which women can negotiate male condom use. In addition, young women may have sex with much older men as a means of acquiring money or material goods. Because older men have a higher chance of being already infected, this can result in high incidence rates among young girls. For example, in Carletonville, a South African mining town, the HIV prevalence among the general population of young women (ages 14 to 24) is more than three times that of young men of the same age (34% versus 9%, respectively). In this setting 67% of the women are infected with HIV at age 24 (Auvert et al. 2001). More generally, women are often financially dependent on men, especially in situations of poverty (Laga et al. 2001), and culturally may find it difficult to discuss sexual matters and negotiate safe sex with their partners. In addition, where sex is being sold, there may be strong economic disincentives to condom use: sex workers in India earn 42% less for a sex act protected by a condom than an unprotected sex act (Rao et al. 2001).

Women also have more limited options for HIV prevention than men, as the main strategies for HIV prevention (use of condoms, reduction of number of sexual partners, and treatment of sexually transmitted diseases) are not feasible for many women. In general the use of the male condom depends on the consent of the male sexual partner. Particularly within regular partnerships, the use of a condom is associated with an assumption of infidelity and lack of trust, and in practice the prevalence of condom use within regular partnerships is very low, ranging from 2% to 6% (*Population Reports* 1999). A reduction in the number of sexual partners is also difficult for women who, due to limited educational and employment opportunities, survive either by selling sex or by obtaining a number of long-term sexual partners who support them in exchange for sex. Furthermore, even monogamous women are at high risk of HIV infection if their partners are unfaithful to them. And because STD infections in women are often asymptomatic, women are less likely to seek treatment, and syndromic management of their STDs is less precise (Population Council and IFH 2001).

1.4 Microbicides: A female-controlled method of HIV/AIDS prevention

Given the socio-economic and biological factors surrounding women's vulnerability to HIV infection, there is an urgent need for female-controlled barrier methods that can be used consistently.

Microbicides are products—including gels, creams, suppositories, and other chemical methods used vaginally or anally—that can block the transmission of STD/HIV, and would complement other forms of HIV/STD prevention. Like today's spermicides, a microbicide could be produced in many forms, including gels, creams, films, suppositories, and sponges. It is expected that its use would not depend upon the cooperation of a male partner, so its availability would allow women greater control over its use. Even where microbicide use is negotiated with a male partner, the likelihood that it will be less obtrusive than condoms suggests that it would also be easier to use consistently than condoms. In addition, some microbicide formulations will not only offer protection against potential HIV/STD transmission, but will allow women to conceive and have children, and so could provide a method of HIV protection to women at risk of HIV infection who wish to conceive.

1.5 The importance of estimating the public health benefit of widespread microbicide use

The quantification of the social benefits of potential microbicides is an important step in the advocacy process, providing a rationale for public-sector investment in microbicide development. Currently nearly sixty compounds are at some stage of development. Of these, one is expected to enter phase 3 trials in 2002; four are in phase 2 clinical trials, and another six are in phase 1 trials (Rockefeller Foundation-funded Microbicide Initiative 2002). Experts predict that the efficacy of the first generation of microbicides is likely to be less than that of the male condom (Cobb et al. 2002). As yet no microbicide has entered a phase 3 trial that could be used to measure its effectiveness. The blockage in product testing at phase 3 is due to the substantial costs and technical difficulties associated with conducting these trials. The lack of involvement or investment by large-scale pharmaceutical firms results from the scientific uncertainty about microbicide efficacy, perceptions about limited market size and profitability, and the availability of other, less risky and more profitable, areas of research and development investment.

2

Overview of General Methodology Used to Estimate HIV Impact and Economic Benefits

This section gives an overview of the general methodology used. Section 3 describes the methods in more detail, and presents the results from the analysis.

2.1 Country-specific approach

The analysis estimates the levels of impact on HIV transmission and economic benefit over a three-year period following the introduction of a microbicide. We use a country-specific approach—conducting a separate analysis of the likely number of HIV infections averted, and the economic benefits from the introduction of microbicides for each of the seventy-three countries considered. Regional estimates are then obtained by summing the country-specific results.

The scope of this analysis is lower-income countries. For our analysis, lower-income countries have been defined as those having a GNP per capita of less than US$1200 (US$ 1999)[2], as defined by the World Bank (World Bank 2001). Given the substantial HIV burden in sub-Saharan Africa, all countries of this region have been included in the analysis, independent of their economic performance. This approach is consistent with other international initiatives to identify resource requirements for global investment in public health (Commission on Macroeconomics and Health 2001). The seventy-three countries used in the analysis are presented by region and HIV classification in annex 1.

The focus of the analysis is on quantifying the social and public health benefits of averting HIV infection, without valuing the benefits of averting STD infection. Some of the current compounds in development have properties that limit the transmission of STDs, while others principally work to prevent HIV infection. In the analysis conducted, we consider that a microbicide may also be efficacious against other STDs, but we only consider and value this element in terms of its role in preventing HIV transmission, and do not value the benefits of averting STD per se. We also do not include many other potential benefits, such as averting unwanted pregnancy. Thus it should be recognized that the analysis is likely to be conservative in its estimate of the public health benefits of widespread microbicide use.

In the study there are five key steps that are used to estimate the public health benefit of widespread microbicide introduction in seventy-three lower-income countries (figure 2.1). These steps are:

1. identification of the size of the groups that could potentially access microbicides;
2. determining the numbers in these groups that would potentially use microbicides over three years;
3. estimating the cumulative number of HIV infections averted over three years;
4. estimating the savings to the health sector by averting these HIV infections; and
5. estimating the productivity benefits to the economy associated with averting these HIV infections.

[2] US$ 1999 means that the GNP per capita is measured in constant U.S. dollars for the year 1999.

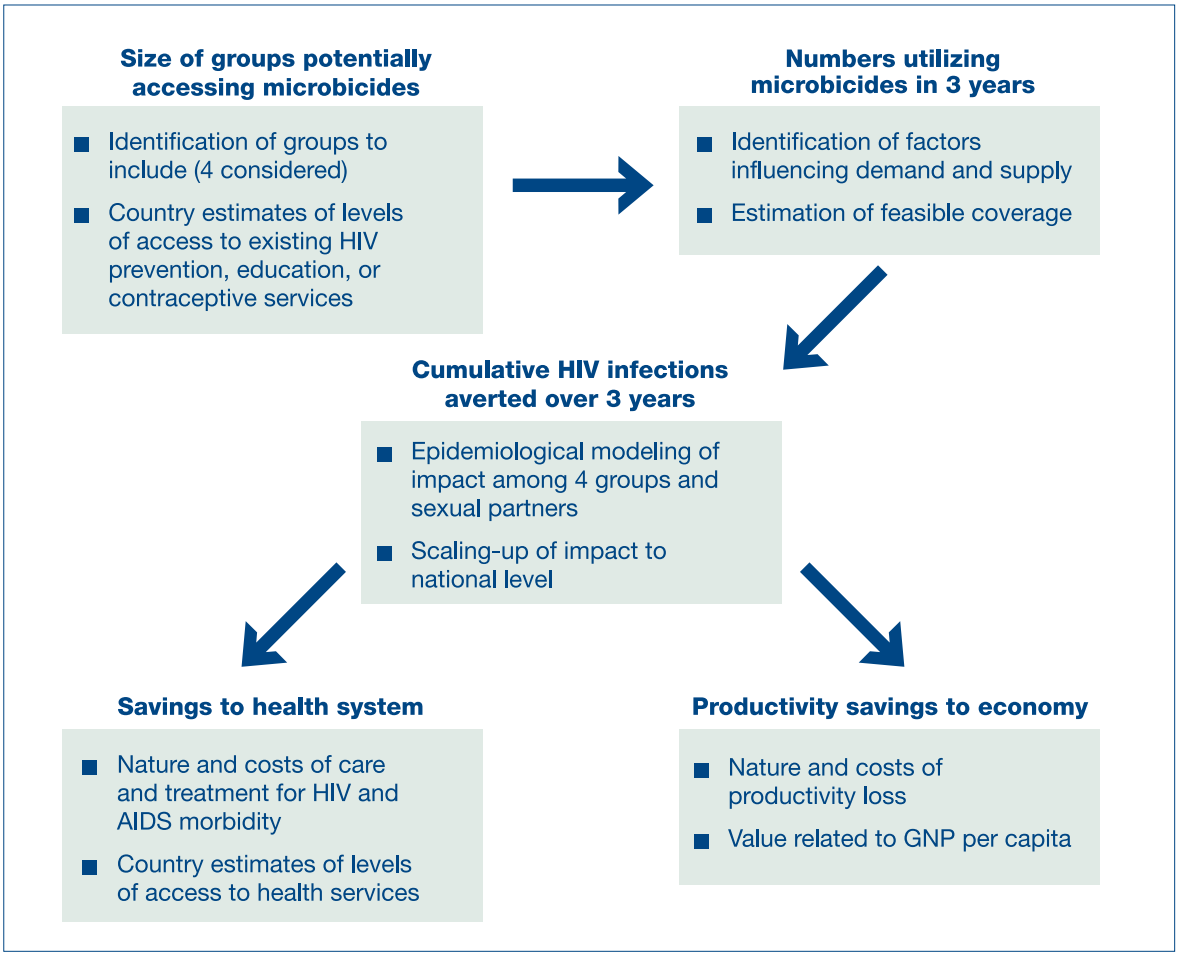
2.2 Identification of the size of the groups that could potentially access microbicides

In order to estimate the benefits of microbicide use we need to consider the nature of the mechanism for delivery of microbicides and the potential sub-populations that could benefit substantially from microbicide introduction. Particularly at the early stages of microbicide distribution, the delivery of microbicides is likely to be added as a complementary adjunct to existing services. Thus, an additional key consideration is the degree to which different groups in lower-income countries are already accessing services. For this analysis we consider four groups that could benefit substantially from microbicide delivery—sex workers and their clients; sexually active youth; injecting drug users and their sexual partners; and women in regular partnerships—and estimate the extent to which, in each country, these groups have contact with either HIV-prevention, education, or contraceptive services.

2.3 Determining the numbers in these groups potentially utilizing microbicides over three years: Demand and supply factors

The level of microbicide use within each group will be determined by both demand and supply-side factors. In lower-income countries it is likely that several factors will affect the demand for a microbicide. These include the relative price of the microbicide in comparison to other products,

Figure 2.1 Framework to estimate the impact and economic benefits associated with microbicide use in 73 lower-income countries



such as the condom; the level of perceived risk of HIV infection; and the relative acceptability and safety of microbicides in contrast to condoms. This is consistent with standard economic demand theory, which relates the level of demand to the price of the product, income, and prices of complementary or substitute goods and preferences. A recent study on the potential demand for microbicides suggests that demand is highly inelastic at prices above twice the condom price, and that there is a kink in the demand curve that occurs at about twice the condom price (Hill et al. 2000). Above that price, the level of demand for a microbicide remains fairly inelastic, and is not strongly influenced by price. However, the demand curve is more elastic at prices between the condom and twice the condom price, suggesting that demand is much more responsive to price and will increase substantially as the price drops.

The actual level of microbicide use will also be affected by supply-side characteristics related to the availability and distribution of microbicides. A key factor influencing this will be whether microbicides are available without prescription, or whether they will require a prescription. If microbicides are only available on prescription, their availability will be substantially limited. For this analysis we consider a product that can be made available without prescription, and that is distributed through existing HIV prevention, education, and contraceptive services. Although price may be a key factor affecting utilization, for lower-income countries where family planning is often highly subsidized, we can conceivably think of a scenario where distribution is largely through the public and nonprofit sectors, at a subsidized price. In this case, the price of the microbicide and income of an individual may not be key determinants of levels of utilization or uptake of a microbicide, although the price of substitutes may still be important. Instead, it is likely that individual preference may be a key driver—with more interest among individuals who perceive themselves to be at high risk of HIV infection. In settings where the epidemic is generalized, this may include a large proportion of the population. In settings where the epidemic is still nascent or concentrated, interest may be much higher among the most vulnerable groups, such as sex workers and their clients and partners, or injecting drug users and their sexual partners.

On the supply side, the means of distribution will determine the level of access to microbicides. For the analysis we use different measures of the potential levels of access that the different groups being considered may have with existing HIV prevention and contraceptive services (Kumaranayake and Watts 2000). We then consider what may be the proportion of these groups that could potentially have access to microbicides within a three-year period. The framework for estimating microbicide coverage and impact is summarized in figure 2.2. For each group we consider the coverage of existing services. We then estimate the proportion within this group that may be reached in a three-year timeframe, and their potential patterns of microbicide use. The baseline estimates of 20% coverage reflect the underlying patterns of demand and supply, as well as utilization. The horizontal yellow oval on the left-hand side of figure 2.2 represents the proportion of each group that may receive microbicides. The vertical yellow oval on the right-hand side represents the additional dynamic impact of microbicide introduction that may be achieved among the sexual partners of the groups targeted by different strategies, and by averting future mother-to-child HIV transmission.

There is substantial potential for the epidemic to spread rapidly and become generalized in several other regions of the world. For example, it is estimated that India will soon surpass South Africa as the country with the largest number of people living with HIV/AIDS. In China, the number of reported HIV infections has risen by 67% during the first six months of 2001, compared with the same period last year. It is estimated that by 2010 China may have

20 million people who are HIV infected (*The Economist* 2001).

2.4 Estimating the cumulative number of HIV infections averted over three years

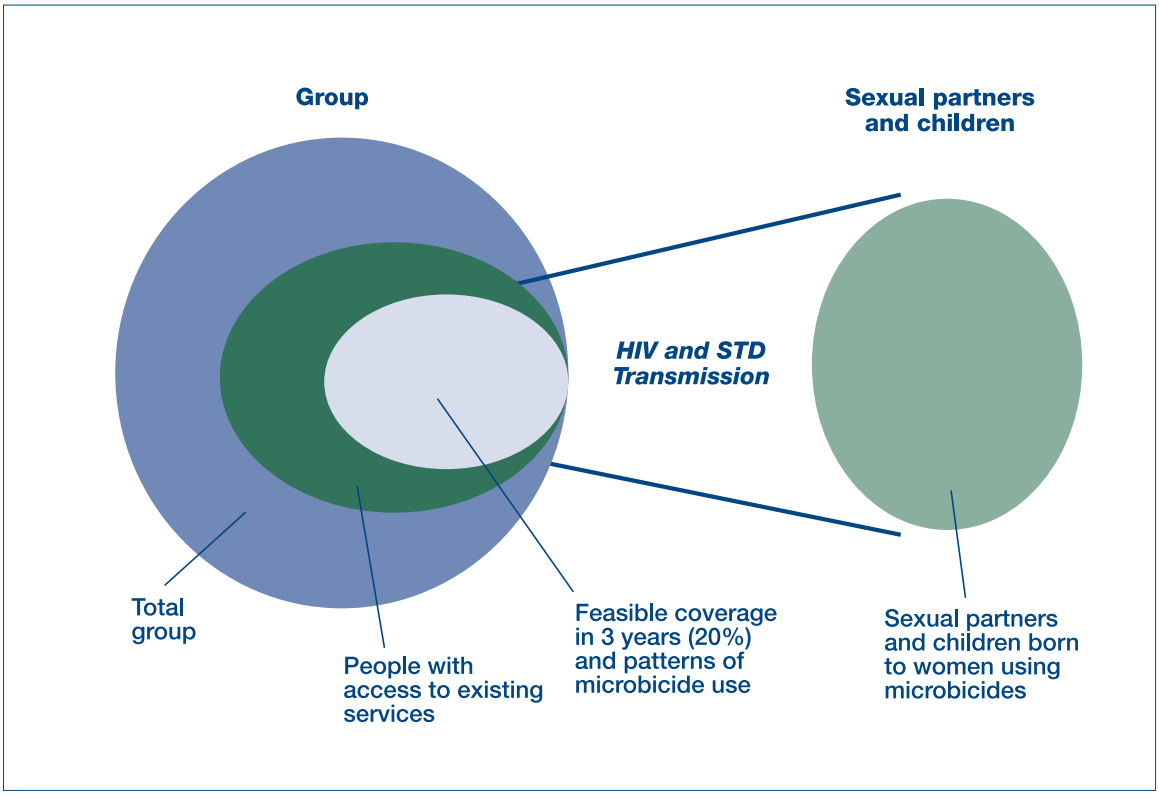
The cumulative number of HIV infections averted in a country as a result of microbicide use will depend on existing levels of HIV infection; existing patterns of sexual behavior and condom use; levels of microbicide use (including consistency); and the clinical efficacy of a microbicide against HIV and other STDs. Many of these factors will differ for each group being considered, and for different stages of the HIV epidemic. For the analysis a two-step process is undertaken:

Step 1. For a range of initial HIV prevalence, estimate the impact of a microbicide introduced among four different groups that could potentially access microbicides: sex workers and their clients; sexually active youth; women in regular partnerships; and injecting drug users and their sexual partners.

Step 2. Use country-level estimates of the size of each sub-population in urban and rural areas; the current prevalence of HIV infection in the main group being targeted; the proportion that are in contact with services and the proportion accessing microbicides; and the estimates of impact from step 1 to obtain country-level estimates of microbicide impact.

In step 1, estimates of microbicide impact on HIV transmission are obtained using four dynamic epidemiological models of HIV and STD transmission. For each of the four different groups that could potentially access microbicides, an epidemiological model is used to estimate the

Figure 2.2 Framework to conceptualize coverage and HIV impact among different groups in each country



patterns of STD and HIV transmission in the presence and absence of a microbicide. In each case, the model estimates the cumulative three-year impact of microbicide introduction among women in the targeted group and their sexual partners. The models include the role of high viraemia and other STDs in facilitating HIV transmission. They also include a number of factors that will affect the impact of microbicide introduction, including inputs describing the efficacy of a microbicide against both HIV and one other STD; the consistency of microbicide use; and the potential degree of migration away from the condom. The models do not explicitly include population growth over the three-year period used for the analysis; instead, they consider the impact among women in each group of fixed size and their sexual partners.

For each of the groups being considered, an average of 148 model runs were used to estimate the impact of microbicide introduction on HIV transmission, at a range of initial HIV prevalence levels, different microbicide efficacy levels, and levels of uptake. The findings were used to obtain estimates of the number of HIV infections averted per 10,000 people targeted, for different assumptions about initial HIV prevalence, microbicide efficacy, and levels of microbicide coverage and use.

In step 2, these findings were used to scale up the estimates to urban and rural populations in each country, based on 2002 projections of the size of each of the groups that could potentially access a microbicide, and estimates of the initial HIV prevalence in each group. The total was used to estimate the number of HIV infections averted by the use of microbicides by different groups on a national level. In addition, country-specific data on total fertility and infant mortality rates were used to estimate the subsequent number of mother-to-child HIV infections prevented by averting the infection of a woman of reproductive age in a regular partnership.

2.5 The economic benefits to the health sector

One benefit of averting HIV infection is that the care and treatment related to HIV/AIDS is also avoided. In order to consider the extent of treatment savings to the health sector, we consider a simple model of HIV illness throughout an infected person's lifetime. For the analysis, we only consider forms of care and treatment that are generally available in lower-income countries: palliative care, inpatient and outpatient care, treatment of opportunistic illnesses, and home-based care. In addition, the costs of care and treatment can only be avoided if the costs would be incurred in treating HIV-infected people. Within the seventy-three lower-income countries considered, 81% of the population have access to health services, and so we only consider the costs of care and treatment averted among these people with access to health services. We do not consider the savings averted from treatment of the HIV/AIDS virus itself (for example, Highly Active Anti-Retroviral Therapy), as current estimates suggest that coverage in lower-income countries is less than 1% (Kumaranayake et al. 2001b). For the analysis, we estimate the lifetime costs associated with HIV infection. Since these will occur at different points in time, we present the cost savings in terms of present (US$ 2002)[3] values.

2.6 The productivity benefits to the economy

In addition to the direct savings associated with avoided treatment costs, preventing HIV infection will mean that HIV-associated productivity loss will be averted. There is a range of productivity losses that may be prevented by averting the transmission of HIV infection: loss of staff due to absenteeism, loss of staff due to premature death, and increased expenses due to retraining and replacing workers. Given the great deal of uncertainty related to the measurement of all of these losses, we adopt a conservative approach and value the time lost from work that would be avoided. The valuation of this loss is related to

[3] US$ 2002 means that the GNP per capita is measured in constant U.S. dollars for the year 2002.

per capita GNP for each country. Again, this is presented in present-value terms, as these losses occur at different points in time in the future.

2.7 Baseline scenario for estimation of impact and economic benefits

The estimates of microbicide impact are highly dependent on the choice of values for key variables. Table 2.1 shows the baseline scenario used to estimate microbicide impact and economic benefits that are presented in sections 3 and 4. These values have been chosen to present a relatively conservative estimate of impact and economic benefits. Given the uncertainty surrounding some of these parameters, in section 5 we undertake a univariate sensitivity analysis to illustrate how the values of key input parameters influence the overall impact estimates obtained.

For the baseline analysis, we model a conservative estimate of intervention impact, assuming

Table 2.1 Baseline scenario for estimation of impact and economic benefits

Key parameters and values for baseline scenario
Estimate of levels of contact of different groups with access to education, HIV prevention, or contraceptive services
Youth: All sexually active urban and rural youth aged 15 to19 enrolled in secondary school (using country-specific estimates of male and female secondary-school enrollment rates, and the proportion of 15- to 19-year-olds that are sexually active)
***Regular partnerships*:** All urban and rural women aged 15 to 49 in regular partnerships, using modern contraceptive methods (using country-specific data on levels of use)
***Sex workers and clients*:** All sex workers in urban settings in contact with HIV-prevention interventions (it is assumed that 3% of women aged 15 to 49 in SSA, 1% in EAP, 2% in EEC, 2% in LAC, 2% in SA sell sex, and that 30% of sex workers are in contact with HIV-prevention interventions)
IDUs and sexual partners: All IDUs in urban settings in contact with HIV-prevention activities (in countries where HIV infection among IDUs is documented, it is assumed that 0.75% of the male urban population aged 15 to 49 and 0.25% of the female urban population aged 15 to 49 inject drugs, and that 30% are in contact with intervention activities)
Coverage of microbicide among groups in contact with services in three years
20% of each group
Patterns of microbicide use
10% migrate from using condoms to using microbicides
Inconsistent and non-condom users use microbicides 50% of the time that a condom is not used
Microbicide efficacy
60% per-sex-act efficacy against HIV
0% per-sex-act efficacy against STD
Discount rate for present-value calculation
5%
Access to health services
Use estimates of national access to health services
GNP per capita
Use constant value of 1999 GNP per capita for years in the future (assume no growth in GNP per capita)

Note: Regional classifications are provided in annex 5. EAP = East Asia and Pacific; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean; SA = South Asia; SSA = sub-Saharan Africa.

the introduction of a microbicide with 60% efficacy against HIV transmission. In the sensitivity analysis, we also consider how the impact estimates are affected by the assumptions made about microbicide efficacy. We also use a conservative estimate of a 20% coverage of groups in contact with existing services. In the sensitivity analysis, we allow the microbicide coverage among groups in contact with services to vary (to 10% and 30%), and we also consider the potential impact if the level of demand varies by the stage of the HIV epidemic.

Impact is also dependent on patterns of microbicide use, including the extent to which condom consistency could potentially decrease following microbicide introduction (migration from the condom). We assume that there is 10% migration from the condom, and that both inconsistent and non-condom users use microbicides 50% of the time that a condom is not used. It is beyond the scope of the current analysis to vary the patterns of microbicide use in the sensitivity analysis, or to explore how the impact results are affected by the assumptions about the underlying patterns of sexual behavior. We do, however, explore how different assumptions about the size of the sex worker population affect the impact estimates obtained.

3 Estimating the Potential Impact of Microbicides

3.1 Epidemiological modeling of intervention impact on HIV transmission

Estimates of the potential impact of different HIV-prevention activities are difficult to make. Due to the dynamic nature of infectious-disease transmission, calculating the full impact of the intervention requires that both the infections averted among the people having contact with the intervention, and the secondary infections averted because a further chain of transmission has been broken, must be considered. Because of this, mathematical epidemiological models that simulate patterns of HIV transmission over time are increasingly being used to estimate the impact of different forms of intervention, and the potential impact of new forms of HIV-prevention technology (for example, van Vliet et al. 1998; McLean, A.R. and Blower, S.M. 1993; Perrucci 1992; Garnett and Anderson 1994; Korenromp et al. 2000; Vickerman and Watts 2001a).

In practice, the impact of a microbicide introduced within a specific setting will be dependent upon epidemiological, behavioral, and intervention-specific considerations. As well as being dependent upon the clinical efficacy of a microbicide against HIV, the impact of microbicide introduction will be dependent upon the prevalence of HIV and other STDs among the groups accessing microbicides; the extent to which a microbicide prevents the transmission of other STDs; and existing patterns of sexual behavior and condom use. Insights into the potential impact of a microbicide product can be obtained using mathematical epidemiological models that simulate patterns of HIV and STD transmission over time. Such models have been used to estimate the additional impact of introducing a microbicide as a complement to condom use in different settings (Watts and Vickerman 2001).

3.2 Mathematical and epidemiological models of microbicide impact

With funding from the Global Campaign for Microbicides, headquartered at the Program for Appropriate Technology in Health (PATH), the *HIVTools* Research Group at the London School of Hygiene and Tropical Medicine has previously developed four deterministic epidemiological models that can be used to estimate the impact of microbicide introduction among specific groups:

1. *Sexworkmicrob*: A model to estimate the impact of microbicide use on HIV and STD transmission among sex workers and their clients (Watts and Vickerman 2000)
2. *Youthmicrob*: A model to estimate the impact of microbicide use on HIV and STD transmission among sexually active male and female youth (including the possibility that male and/or female youth may have both peer-age and older sexual partners) (Vickerman and Watts 2000)
3. *Regularmicrob*: A model to estimate the impact of a microbicide on HIV and STD transmission among a cohort of regular partnerships, with specified levels of discordancy, and the possibility that males and/or females may have other sexual partnerships (Vickerman 2001)
4. *IDUmicrob*: A model to estimate the impact of microbicide use on patterns of HIV transmission among IDUs and their sexual partners (Vickerman and Watts 2001b)

Each of these models uses demographic-, epidemiological-, behavioral-, and intervention-specific data to estimate the impact of microbicide use on the cumulative HIV infections averted among the groups reached by each form of intervention and their sexual partners.

For the analysis, the first step in estimating microbicide impact was to estimate the number of HIV infections that would be averted if a microbicide of specified efficacy was used by a proportion of each group, and varying the assumptions about the proportion that were already HIV-infected (the initial HIV prevalence). The stages of this analysis are outlined below:

- Compile country-specific demographic and health-related data that could be used to estimate the size of the specific sub-populations being considered, and their extent of access to contraceptive and HIV-prevention services (annex 2).
- Search literature and review post-intervention behavioral data from sexual behavior surveys of adolescents, sex workers, regular partnerships, and IDUs (using a Medline and Popline literature search from 1980 onward).
- For each model, identify the behavioral-parameter file of sexual behavior and condom use to be used in the epidemiological impact models (annex 3).
- For each country, estimate the HIV prevalence among specific country population intervention target groups. (The maximum values from the UNAIDS 1999 data for urban and rural ANC populations, youth aged 15 to 24, sex workers, and male STD clients were used. Where these were not available, the values were estimated by conducting a regression analysis of the UNAIDS 1999 country data). Country-specific data from Kenya and Zambia on the age distribution of HIV infection among males and females aged 15 to 19 and 20 to 24 were used to estimate the initial distribution of HIV infection among male and female youth aged 15 to 19 (Glynn et al. 2001).
- Using the model parameter input file, conduct multiple runs using each of the four epidemiological models to estimate the three-year cumulative number of HIV infections averted per 10,000 population targeted and their sexual partners, for 1) different initial prevalence of HIV infection; 2) different levels of microbicide coverage; and 3) different levels of clinical efficacy.
- For each group considered, use a bivariate regression analysis of the model outputs to describe the relationship between initial HIV prevalence and the three-year estimate of cumulative HIV infections averted for a specified coverage and microbicide efficacy.

3.3 Model projections of the cumulative impact of different levels of microbicide introduction among specific groups at different stages of the HIV epidemic

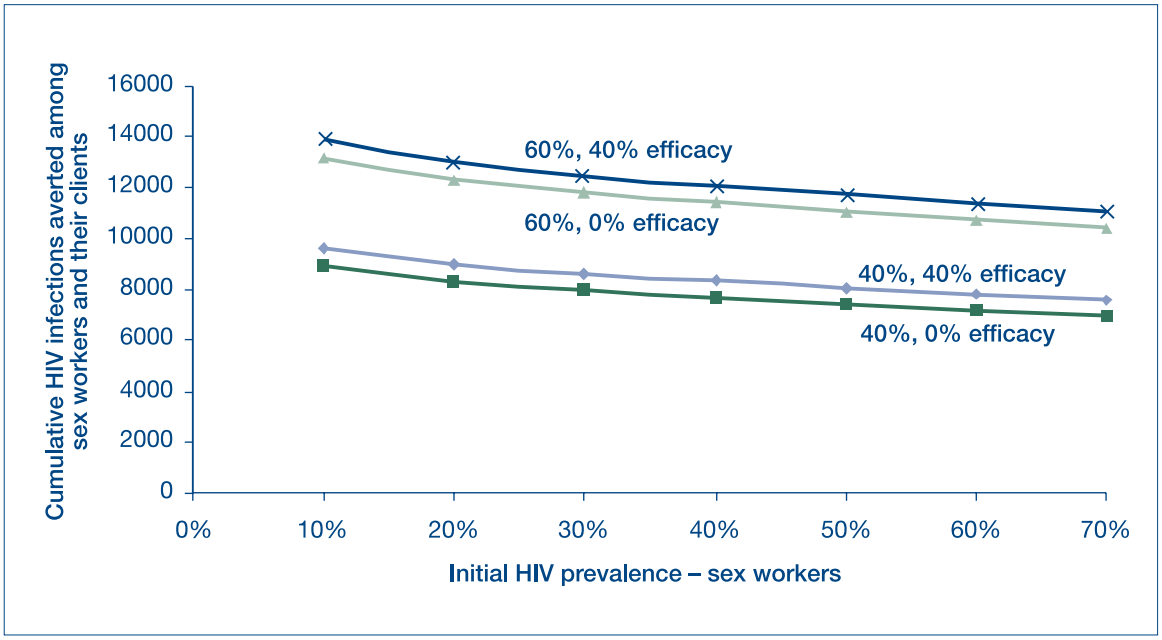
Figure 3.1 shows the sex-work model projections of the cumulative number of HIV infections averted over three years, following microbicide introduction among 20% of 10,000 sex workers, for different levels of microbicide efficacy against HIV and STD. At each level of microbicide efficacy, the projected number of HIV infections averted decreases with increasing initial HIV prevalence. The number of HIV infections averted is relatively large, as the impact estimates include the substantial number of HIV infections averted among the clients of sex workers. Among this sub-population, the level of impact achieved is influenced more strongly by the clinical efficacy of a microbicide against HIV than by the microbicide's efficacy against STD. The lack of dependence of the microbicide impact on the clinical efficacy against STD is due to the high STD prevalence among these groups, and the far greater probability of STD transmission as compared to the probability of HIV transmission.

Figure 3.2 shows the three-year cumulative HIV infections averted among IDUs and their non-IDU sexual partners, for a microbicide distributed to 20% of 10,000 injecting drug users and their sexual partners for different initial HIV prevalence levels, and different levels of microbicide efficacy. The numbers of HIV infections averted is relatively small, as the majority of HIV transmission is through injecting drug use.

Figure 3.3 shows the cumulative number of HIV infections averted among a cohort of 10,000 youth, 20% of whom have access to a microbicide, for different initial prevalence levels of HIV infection among boys, and for different levels of microbicide efficacy. For each level of microbicide efficacy, the three-year cumulative number of HIV infections averted decreases with greater initial HIV prevalence. The relatively small number of HIV infections averted reflects the low HIV prevalence among adolescents considered. Although the model considers the impact of a microbicide introduction to female youth, between 35% and 48% of HIV infections averted are among male youth. In contrast to the sex-worker projections, for this group there are far greater gains associated with a microbicide's efficacy against other STDs. This is due to the relatively low levels of STD infection among youth, and the greater prevalence of STD infection among older sexual partners.

Figure 3.4 shows the cumulative number of HIV infections averted among a cohort of 10,000 regular partnerships, for different initial prevalence levels of HIV infection among women, and assuming a 10% greater prevalence of HIV infection among their regular male partners. For each level of microbicide efficacy, the number of HIV infections averted decreases with greater initial HIV prevalence. For each efficacy level, up to an initial HIV prevalence of approximately 47%, the

Figure 3.1 Three-year cumulative HIV infections averted for a microbicide distributed to 20% of 10,000 sex workers for different initial HIV prevalence levels, and different levels of microbicide HIV and STD efficacy



Key assumptions: that (1) a microbicide is offered to 20% of the 10,000 sex workers, and is used by these sex workers 50% of the time that a condom is not used; (2) sex workers have an average of 84 clients per month; (3) at introduction 50% of sex workers use condoms all of the time, 25% use condoms half of the time, and 25% do not use condoms; and (4) there is 10% condom migration upon introduction of a microbicide.

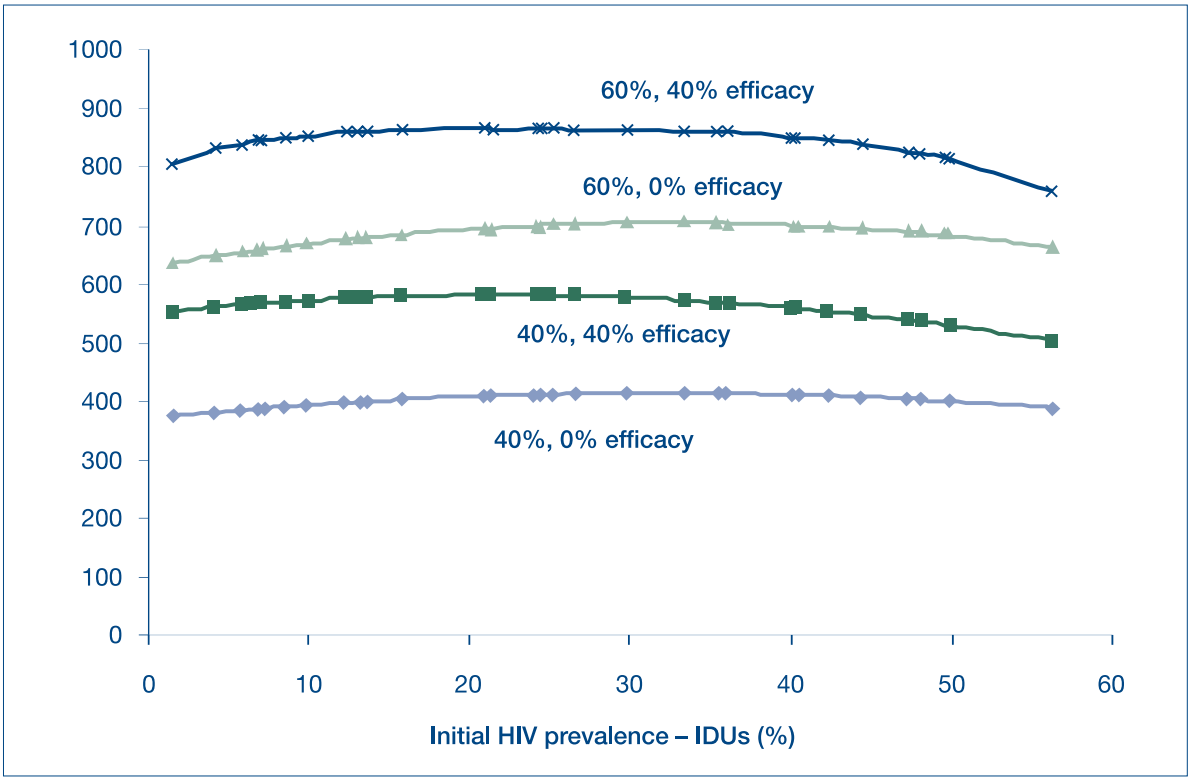
cumulative number of HIV infections averted increases with increasing initial HIV prevalence. At initial HIV prevalence greater than 50%, the cumulative number of HIV infections averted decreases, reflecting that at these levels of infection the majority of partnerships already are HIV-infected, and so there is increasingly limited potential to avert further transmission.

3.4 Method used to obtain national-level urban and rural estimates of microbicide impact

Based on these results, estimates of the cumulative number of HIV infections averted over three years were made for each of the seventy-three countries. The methods used are these:

- For each country, use country-specific demographic and behavioral data to estimate the size of each group in urban and rural areas (sex workers, IDUs, women in regular partnerships, and sexually active female adolescents aged 15 to 19).
- Use country-specific data on (1) levels of female use of modern contraceptives; (2) levels of male and female enrollment in school; and (3) HIV-intervention coverage levels among sex workers and IDUs, to estimate the overall size of each of these groups that could potentially access microbicides within a three-year timeframe.

Figure 3.2 Three-year cumulative HIV infections averted for a microbicide distributed to 20% of 10,000 injecting drug users and their sexual partners for different initial HIV prevalence levels, and different levels of microbicide efficacy



Key assumptions: that (1) a microbicide is offered to 20% of IDUs, and is used by these IDUs 50% of the time that a condom is not used; (2) 10% of IDUs are not sexually active, 45% have 2.4 sexual partners per year, and 45% have 4.2 sexual partners per year; (3) 50% of their sexual partners are non-IDUs; (4) 40% of IDUs do not use condoms, 30% use condoms inconsistently, and 30% use condoms consistently; and (5) there is 10% condom migration following microbicide introduction.

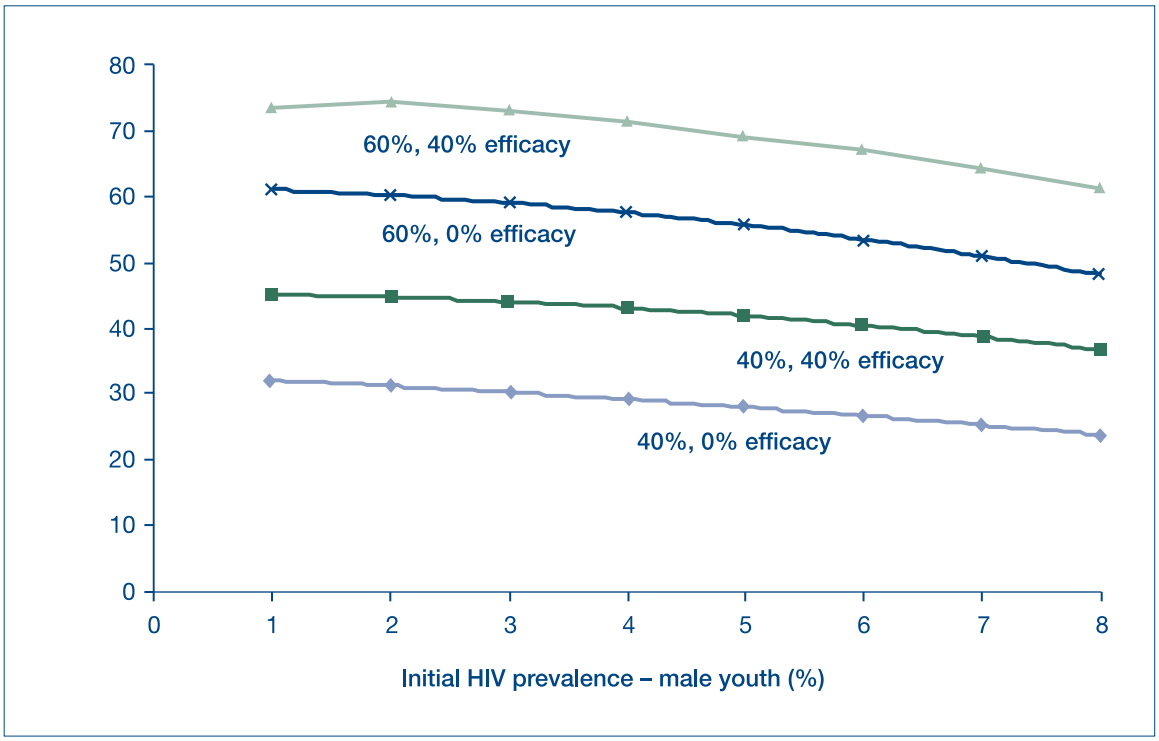
- For each group potentially accessing microbicides through existing services, use the model impact estimates and HIV-prevalence estimates for each group to assess the potential impact of microbicides introduced among individuals in the intervention target group and their sexual partners (for the different levels of microbicide efficacy, and for different levels of microbicide uptake).
- Use country-specific data on total fertility and infant mortality to estimate the number of mother-to-child HIV infections that have been averted as a result of averting the infection of a woman in a regular partnership.

3.5 Results: Baseline impact estimates

Table 3.1 presents the national-level estimates of cumulative HIV infections averted, summarized by region, and disaggregated by adults and infant mother-to-child HIV infections averted. In total, it is estimated that 2.5 million HIV infections would be averted following the three-year use of a microbicide of 60% HIV efficacy for a 20% coverage of four groups with access to HIV-prevention, contraceptive, or educational services.

Thirty-five percent of HIV infections averted among adults are in South Asia, 31% in East Asia

Figure 3.3 Three-year cumulative HIV infections averted for a microbicide distributed to 20% of 10,000 sexually-active-in-school youth, for different initial HIV prevalence levels, and different levels of microbicide efficacy



Key assumptions: that (1) a microbicide is offered to 20% of female youth, and that it is used by these youth 50% of the time that a condom is not used; (2) 30% of female youth have 3 sexual partners per month, and 30% have 1 partner every two months; (3) condoms are used 20% of the time in youth-youth partnerships; (4) condoms are used consistently by girls in only 15% of youth-adult partnerships, and inconsistently in 25% of youth adult partnerships; and (5) there is 10% condom migration upon introduction of microbicides.

and the Pacific, and 27% in sub-Saharan Africa. This distribution reflects both the large differences in population sizes between different regions (with the East Asia and Pacific estimates being driven by the estimates from China, and the South Asian estimates being driven by the findings from India), and the relative stages of the HIV epidemic in each country. As the epidemic is emerging in many Asian countries, there is a large potential for HIV-prevention activities to avert substantial HIV infection.

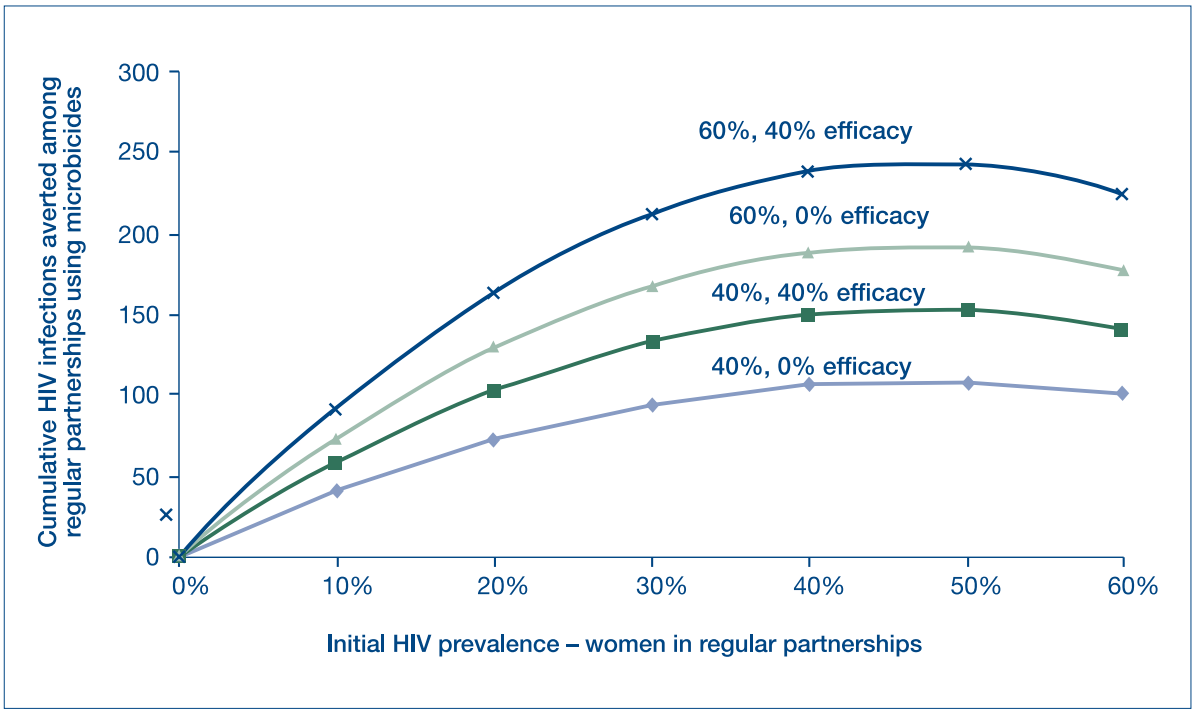
Within the short timeframe considered in this analysis, a relatively small number of infections are averted among infants, through the prevention of an HIV infection subsequently averting mother-to-child HIV transmission. Of these, 80% are in sub-Saharan Africa and 15% in South Asia. This reflects both demographic factors and the fact that in sub-Saharan Africa, antenatal HIV prevalence is greater than 5% in many countries, and is greater than 5% in some antenatal populations in India.

If we compare the cumulative three-year adult HIV infections averted per 1000 population aged 15 to 49, the greatest rate of cumulative HIV infections averted is in the LAC and the EEC countries considered. This reflects the higher levels of existing services, and the potential to avert substantial HIV infection among the most vulnerable groups when the HIV epidemic is relatively concentrated. The rate is also high in SSA, reflecting the generalized stage of the epidemic in this region.

The analysis conducted is limited in the following ways:

1) No data were available on the projected prevalence of HIV among the specific sub-populations in each country. The most recent

Figure 3.4 Three-year cumulative HIV infections averted per 10,000 regular partnerships, for different initial HIV prevalence levels, and different levels of microbicide efficacy



Key assumptions: that (1) a microbicide is offered to women in regular partnerships, and it is used by these women 50% of the time that a condom is not used; 2) there is a 10% greater HIV prevalence among males than females in regular partnerships; 3) regular partners have 12 sex acts per month, and a baseline of 20% consistency of condom use in regular partnerships; 4) a microbicide is used in all regular partnerships 50% of the time that a condom is not used; and 5) there is 10% migration from the condom.

Table 3.1 Three-year cumulative HIV infections averted from the distribution of a 60% HIV efficacious microbicide to 20% of groups in contact with services in 73 lower-income countries

	Adults: Cumulative HIV infections averted	HIV infections averted per 1000 population aged 15–49	Infants: Cumulative HIV infections averted
Total	2,526,779	1.27	10,921
EAP	793,150	0.83	428
EEC	128,219	2.29	27
LAC	50,282	2.53	163
SA	881,034	1.29	1,609
SSA	674,096	2.53	8,695

Note: Regional classifications are provided in annex 5. EAP = East Asia and Pacific; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean; SA = South Asia; SSA = sub-Saharan Africa.

data were from 1998 (UNAIDS 2000). As it was recognized that many of the HIV-prevalence levels may underestimate the current prevalence, we used the maximum HIV-prevalence levels among specific sub-populations documented in 1998. These may not accurately reflect HIV-prevalence levels for 2002. Furthermore, particularly in populous countries such as India and China, aggregated estimates of HIV prevalence do not accurately reflect the degree of national heterogeneity in HIV prevalence.

2) There was limited data on the size of the sex-worker population in different countries or regions. However, particularly in regions where the HIV epidemic is nascent or emerging, the projected magnitude of future transmission (and the associated impact of microbicides) is highly dependent upon the extent to which people engage in risk activities. Because of this, conservative estimates of the proportion of women aged 15 to 49 who sell sex in each region were used for the baseline estimates.

3) For each sub-population considered, a generic set of behavioral parameter inputs is used to estimate microbicide impact. Although these inputs were developed following a detailed review of behavioral studies among different sub-populations, it is a broad generalization to apply the same set of behavioral assumptions across a wide range of settings. This approach was adopted both because of the time limitations associated with the study, and due to the difficulties associated with interpreting reported patterns of sexual behavior. Another key step would be to explore the sensitivity of the projections to the specific behavioral assumptions used. In general, for each model the underlying levels of condom use have been overestimated, to try to ensure that a conservative estimate of microbicide impact is obtained.

4) There were limited available data on the extent to which IDUs and sex workers are in contact with HIV-prevention activities. For the analysis, fixed assumptions about coverage were made, based upon previous research. Particularly in settings where HIV is nascent, it may be that intervention coverage is lower. Depending on the extent to which vulnerable groups can access HIV-prevention or contraceptive services, and the potential coverage among this group that could be achieved in a three-year period, the estimates of impact among sex workers and their clients and

IDUs may reflect either an overestimate or underestimate of microbicide impact.

5) For the analysis, we used four existing epidemiological models to estimate the impact of microbicide introduction among people in different groups and their sexual partners. Particularly for high coverage levels, there is the potential for double counting (such as the client of a sex worker also having a regular partner). This is less likely to occur for low assumptions about microbicide coverage.

6) There are a number of other potential mechanisms for microbicide delivery that have not been considered in this analysis, and other sub-populations that could benefit from microbicide introduction. This includes workplace HIV-prevention activities, and the use of microbicides as part of a voluntary counseling and testing program. As we have not developed epidemiological models to estimate the impact of microbicide introduction among such groups, considering these other sub-populations was beyond the scope of the current analysis.

7) As in other impact and cost-effectiveness analyses, we focus on quantifying the number of HIV infections averted over a relatively short timeframe, three years (Grosskurth et al. 1995), and do not assess the sustainability of the achieved impact.

8) The analysis solely attempts to quantify the public health benefit of a microbicide in terms of the number of HIV infections averted. We have not attempted to estimate the other possible benefits of microbicide introduction—including STD infections averted and possibly unwanted pregnancies.

Despite these limitations, the findings provide a best estimate of microbicide impact, based upon available demographic and epidemiological data, current epidemiological models of microbicide impact, and current understanding of factors affecting HIV transmission.

4

Economic Benefits of Using Microbicides to Avert HIV Infection

4.1 The economic benefits of averting HIV infection

There is a broad range of economic benefits associated with averting HIV infection. For the analysis we focus on two forms of economic benefit: (1) the savings gained by not having to treat and care for HIV-infected people in the health system, and (2) productivity that is not lost due to absenteeism from the workplace and the retraining of replacement workers.

4.2 The cost of medical care for HIV/AIDS-infected people

4.2a Lifetime costs of care

In order to consider the costs of care and treatment saved, we need to estimate the cost of medical care borne by HIV/AIDS-infected people. As we are valuing the cost savings associated with the prevention of HIV infection, we estimate the lifetime cost of care and treatment for an HIV/AIDS-infected person, and then associate this cost with the number of HIV infections being averted with the use of microbicides. Given the different relative prices across the countries in our analysis, we also need to take into account differences in lifetime costs by region and level of economic development.

We undertook a review of the cost data available on care and treatment for HIV/AIDS-related illnesses. Given the substantial methodological variation and definitions of HIV/AIDS (discussed in annex 4), there were no appropriate studies for the lifetime costs of care that could be used for the analysis. We thus adopted a modeling approach to estimate lifetime costs based on knowledge about the natural history of the illness, the number of episodes of illnesses, and the cost of an episode of illness.

4.2b Progression of HIV/AIDS illness

WHO (1990) provides a clinical staging system to describe the natural history of HIV infection and AIDS disease. The four stages are:

Stage 1: Asymptomatic (no symptoms)

Stage 2: Progression of HIV with minor symptoms such as weight loss, minor skin and oral problems, and herpes zoster

Stage 3: Onset of more severe symptoms such as tuberculosis (TB), oral candidiasis, and greater than 10% weight loss associated with diarrhea

Stage 4: Onset of clinical AIDS accompanied by more serious opportunistic infections and illnesses such as advanced TB

There is very little information about the rate of disease progression between stages from African countries (Grant et al. 1997; Gilks et al. 1998), due to the limited number of natural history studies in developing countries. Even in industrialized countries, disease progression varies among individuals. The length of survival with HIV can range from as little as two years to more than ten to fifteen years. Opportunistic infections (OIs) mark the progression of HIV/AIDS and the onset of clinical AIDS. In low-income countries, TB is the most common OI, occurring in 40-60% of HIV-infected people (World Bank 1997). Other common OIs in developing countries include bacterial pneumonia, chronic diarrhea, and fungal infections such as cryptococcus. Due to higher exposure to OIs and poor/inadequate health care in areas where resources are scarce, many people with HIV die early on, before

full-blown AIDS has developed. Among upper-income groups in developing countries, OIs similar to those in industrialized countries are also found.

Thus, in resource-poor contexts, survival is likely to be shorter. The average length of survival after being infected with HIV may be six to seven years in SSA (Gilks et al. 1998). In a review of African natural history studies, Grant et al. (1997) found that the reported median time to AIDS (stage 4) from HIV ranged from two to seven-and-a-half years. Shorter times were reported for those with HIV-1 relative to HIV-2. This is much lower than industrialized countries, where, in the absence of treatment, the median time to progression to AIDS is about ten years. Among symptomatic populations recruited at health facilities (who may be older and sicker), the median time to death after a diagnosis of AIDS was very short (two to six months for HIV-1 and five to eight months for HIV-2). Again, this is much shorter than the twelve to eighteen months found in industrialized countries.

Information about the rate of progression from asymptomatic to symptomatic is also limited. Based on sero-prevalence data, one study suggests that there is a three- to four-year period of being asymptomatic, and then two years of being symptomatic (stage 2 and stage 3) before the onset of AIDS for HIV-1 in Uganda (Grant et al. 1997). However, these studies may be biased in terms of length of life and the progression of the disease, as it is unknown when most of the individuals actually became infected. Current monitoring of a cohort of the general population in Uganda has found that, eight years into the study, only 40% of the people who are HIV positive had developed AIDS, with death occurring nine to ten months later (Cohen 2000).

While a more complex approach to modeling care requirements would use a Markov model and data on transition probabilities to model the progression of disease from stage to stage, given the lack of data we adopt a simpler approach.

For the purposes of this report, we make three distinctions:

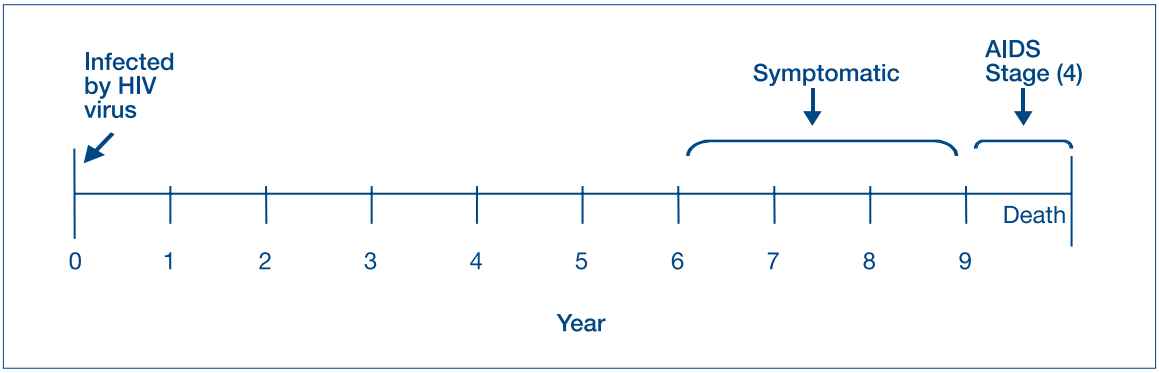
- Asymptomatic people
- Symptomatic people (stages 2 and 3)
- People living with AIDS (PLWA) (stage 4)

We assume that, on average, people live nine years after becoming infected; that people living with HIV/AIDS (PLHA) are symptomatic for three years; and that the onset of AIDS occurs one year before death. This progression of illness is illustrated in figure 4.1.

4.2c Estimation of the lifetime costs of care

Based on figure 4.1, the lifetime costs of care are estimated on the basis of the expected frequency

Figure 4.1 Assumed progression of HIV/AIDS disease used to estimate lifetime costs



of use of services, the costs of the use of services, and access to health care. In lower-income countries, we focus on four types of health service used for HIV/AIDS-related illnesses:

a) **Palliative care**—defined as the "relief of pain symptoms such as headache, pain, diarrhea, and shortness of breath" (World Bank 1997). Many of the early infections and many symptoms of HIV-positive patients can be managed adequately, and much relief and comfort can be provided, with inexpensive essential drugs that are generally expected to be available through the primary health care system (Foster 1991).

b) **Outpatient care**—for symptoms and opportunistic illnesses related to HIV/AIDS.

c) **Inpatient care**—for symptoms and opportunistic illnesses.

d) **Home-based care**—We envisage that at the terminal stage of the illness, care will be provided at home, rather than in a health facility. The delivery of home-based care can be done through the community or through hospital-instituted schemes linked to the formal health system.

Here we exclude the potential cost of treatment of the virus with antiretrovirals (ARVs) such as Highly Active Anti-Retroviral Therapy (HAART), as our focus is lower-income countries, and current use of ARVs is extremely limited in these countries. For each of these types of care, we were able to obtain an annual cost of care for an HIV/AIDS patient in low- and middle-income sub-Saharan Africa, as shown in annex 4. The data were collected from a number of different years, and were converted into US 2002 dollars, using a 3.2% average annual inflation rate (Kumaranayake 2000).

In order to convert these annual costs into lifetime costs, three adjustments were made:

1. As shown in table 4.1, assumptions were made about the frequency of use (where appropriate) for each of the different types of health-service use by stage of illness.

2. Given differences in relative prices by stage of economic development, countries were divided into low- and middle-income categories by region, using the World Bank's classification (World Bank 2001). This listing is provided in annex 5. As we were only able to obtain a consistent set of prices for the sub-Saharan African region, we used the purchasing-power-parity (PPP) weightings to derive relative prices for other regions in order to undertake a country-specific approach to estimating costs. In order to make the costs comparable, non-traded components of

Table 4.1 Assumptions related to frequency of use of health service by stage of illness

Type of health service use	Symptomatic stage (years 6–8)	Stage 4—AIDS (year 9)
Palliative care	Used average annual consumption of palliative care as represented by cost data in annex 4, for each year	Used average annual consumption of palliative care as represented by cost data in annex 4
Outpatient care	Assumed monthly contract with health system in symptomatic stage	Assumed monthly contract with health system in last year of life
Inpatient care	Assumed one inpatient hospitalization stay each year of symptomatic stage	Assumed two inpatient stays in last year of life
Home-based care	None	Used in last year of life with an average of four visits by health staff

costs were adjusted for PPP. For example, low-income East Asian prices were about 90% of low-income sub-Saharan African prices. Then the non-traded part of the unit cost from sub-Saharan Africa was lowered by 10% in order to reflect relative price differentials in East Asia. Though PPP adjustments are used to estimate different unit costs, the cost estimates are not in PPP-adjusted dollars, but rather in current US 2002 dollars. That is, the costs reflect how many actual dollars would need to be spent in East Asia (Kumaranayake et al. 2001b).

3. The lifetime costs of care are incurred at different points of time in the future. If we add the costs from different periods together, we fail to capture the opportunity cost borne by spending money in present and future periods; if we spend money in the current time period, we forego the opportunity of investing this money and earning interest. In general, as much as possible, we prefer to delay spending to the future. This is known as **time preference**[4] (Walker and Kumaranayake 2002). The notion of time preference implies that future costs are worth less, and hence discounted more, to reflect the individual and societal preference to have resources and money now rather than in the future. For example, if there were two health interventions, both of which had the same effects, but one cost $100 in year 1, and the other cost $100 in year 2, we would prefer the intervention that would have the costs in year 2 (Togerson and Raftery 1999), if we allow for time preference. In order to adjust for this time preference, the practice of discounting is used. When discounting, the present value of all costs is calculated, taking into account when these costs are incurred and their opportunity cost. In general, we use a rate r (the discount rate) to represent either the real rate of return in the private sector or some social rate of time preference. In general we express the costs in a future period n in present-value terms, as:

   Present value of year n costs = (costs of year n) / $(1 + r)^n$

For the baseline scenario we adopt a discount rate of 5%, and costs are discounted based on the year in which spending is anticipated.

Using these assumptions regarding frequency of health-service use, PPP conversions to the annual unit costs, and a present-value calculation, we derive the lifetime costs to be used for the estimation of the medical costs (table 4.2).

4.3 Results: Savings to the health system through microbicide use

Using the present value of lifetime costs and the country-specific estimates of impact obtained in section 3, we can estimate the extent of savings to the health system. However, savings are gained only if the money is actually spent in treating patients. In lower-income countries, the degree to which people are treated is heavily dependent on access to health care. So in order to estimate the *true savings gained*, we estimate savings based on existing estimates of access to health care for inpatient, outpatient, and home-based care. It is assumed that there are more informal sources for palliative care outside the formal health system, including private markets, and so access is not as restricted. Thus, palliative care costs are not constrained by access to care.

Table 4.3 presents the estimates of the present 2002 value of the lifetime cost savings to the health system of averting 2.5 million HIV infections between 2002 and 2005. The total estimated cost savings to the health system of the cumulative HIV infections averted are

[4] A similar concept applies for benefits, where people prefer to enjoy benefits in the present, relative to the future. However, it should be noted that the concept of discounting benefits has aroused much controversy. There is a lack of consensus on whether benefits should be discounted at all, and among those who agree that benefits should be discounted, there is disagreement over the rate. An important consequence of discounting is that preventive programs are penalized because future benefits appear devalued relative to initial investments resulting in lower cost.

Table 4.2 Estimated annual lifetime costs for care and treatment of HIV/AIDS-related illnesses, using a 5% discount rate for a three-year period of impact

Region	Palliative care	Outpatient care	Inpatient care	Home-based care	Total present value of lifetime costs
SSA low	58	205	623	92	977
SSA mid	58	409	1331	128	1927
EAP low	58	188	562	83	891
EAP mid	58	412	1343	130	1942
SA low	58	178	521	78	834
SA mid	58	409	1330	128	1925
EEC low	58	189	563	84	893
EEC mid	58	447	1480	101	2086
LAC low	58	201	610	90	959
LAC mid	58	542	1854	175	2629

Note: Regional classifications are provided in annex 5. SSA = sub-Saharan Africa; EAP = East Asia and Pacific; SA = South Asia; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean.

US$2.7 billion. These cost savings accrue over the lifetime of subsequent care and treatment averted by preventing HIV infection currently.

Forty-eight percent of the overall cost savings are attributable to East Asia and the Pacific, largely reflecting the middle-income country cost structure of China. Twenty-four percent of cost savings are in South Asia, and eighteen percent in sub-Saharan Africa. These differences reflect the relative distribution of HIV infections averted, and the relatively poor levels of access to health services in SA and SSA.

4.4 Estimating the productivity benefits of microbicide use

4.4a HIV/AIDS and its impact on productivity

The links between good health and economic development have been clearly established (Jamison et al. 1998). Improved health promotes economic growth by 1) reducing production losses caused by worker illness; 2) increasing productivity; 3) providing greater opportunities to obtain better-paying jobs; and 4) leading to longer working lives for individuals. It has been shown that poor health and nutrition reduce the ability to learn; the probability of enrolling and remaining in school; and, subsequently, future productivity and income. The links between ill health, low education, and poverty are particularly pronounced for girls and women, and the impact of poor health is also felt intergenerationally through effects on their children's health and education (Thomas et al. 1990). Improved health frees resources for alternative uses—resources that would otherwise be spent to treat illnesses (World Bank 1993). The economic gains of improved health are relatively greater for the poor, as they are the most likely to be affected by ill health.

The impact of HIV/AIDS on the economy has been documented at the macro and micro levels. Although early studies of macroeconomic impact (Bloom and Mahal 1997, using pre-1992 data) found little evidence of impact on GNP, the rapid impact of the epidemic has now been documented in its effect on the macro-economy in a number of countries. As HIV/AIDS affects the adult population, which is economically the most productive segment of society, it has led to decreases in GNP growth in numerous countries.

Especially hard hit is sub-Saharan Africa, where HIV/AIDS has reached endemic levels. During the 1990s, estimates show that HIV/AIDS reduced economic growth by an average of 0.8% (Bonnel 2000). Estimates for South Africa show a 17% decrease in GDP by the year 2010 (Arndt and Lewis 2000). Income inequality may also worsen as a result of HIV/AIDS. In South Africa, for example, the infection rate of semi-skilled and unskilled workers is nearly three times the infection rate of highly-skilled workers (ING Barings 1999). The impact of HIV/AIDS has also significantly reduced life expectancies. For example, Zimbabwe—with an HIV prevalence of more than 25%—now has a life expectancy of 43.5 years, a reduction of more than 15 years relative to its peak (UNDP 2000).

There are an increasing number of empirical studies on the direct and indirect costs of HIV to firms in developing countries (Aventin and Huard 2000; Morris et al. 2000; Rugalema 1999; Roberts 1996). The framework for estimating the costs to business has been laid out in a number of studies (Simon et al. 2000; UNAIDS 2000b; Morris et al. 2000; Moore 1999; Aventin and Huard 2000). Direct costs include any benefits an HIV/AIDS-infected worker (or family) may receive, such as health care benefits and death benefits, recruitment, and training costs. Recruitment and training are considered direct costs by some. Indirect costs to firms include productivity losses and other costs, such as organizational disruption because of high worker turnover, decrease in skill level of the workforce, and institutional memory. ***Productivity*** is the amount of output produced by unit of input. HIV/AIDS leads to decreased labor productivity due to increased absenteeism and morbidity while at work.

Recent studies on the impact of HIV/AIDS on firms in highly endemic areas have shown that HIV/AIDS could lead to high costs to businesses and the economy (Aventin and Hurd 2000; Morris et al. 2000; Rosen et al. 2000; Simon et al. 2000; Greener 1997). These costs are due to increased absenteeism, lower productivity of ill workers, higher medical and death benefits (if provided) and a higher turnover of workers (replacement and training costs). In addition, labor scarcities may lead to higher wages for skilled workers. Costs attributable to AIDS were as high as 9% of firm profits (AIDSCAP 1995). Stover and Bolliger (1999) show costs in six African firms ranging from US$49 to US$300 per employee.

From a household perspective, the costs of a family member with AIDS include loss of income of the affected person during illness and after death, opportunity cost of the primary caregiver,

Table 4.3 Estimated cost savings to health system of averting 2.5 million HIV infections through microbicide use between 2002 and 2005

	Present value of lifetime cost savings after three years of impact (billions, '000,000,000 – US$ 2000)	**Per capita present value of lifetime cost savings** (US$ 2002)
Total	**2.69**	**0.68**
EAP	1.30	0.73
EEC	0.20	1.77
LAC	0.06	1.44
SA	0.65	0.46
SSA	0.48	0.77

Note: Regional classifications are provided in annex 5. EAP = East Asia and Pacific; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean; SA = South Asia; SSA = sub-Saharan Africa.

and funeral costs, in addition to the direct medical expenditures (Bollinger et al. 1999). Characteristics of the deceased individual (age, sex, income, etc.), the household (composition and assets), remaining family members (female family members tend to carry the greatest household burden of having an ill family member), and the community (willingness and ability to assist) can influence the overall economic impact of an HIV/AIDS death on the remaining family members (World Bank 1997). Most studies so far have used household surveys to collect data on the household impact. A major flaw of these surveys is that they will not pick up the worst-affected cases, in which families dissolve completely.

4.4b Method for estimating productivity gains

These studies on the sector-level impact of HIV cannot be applied generally to obtain national-level estimates, as they only represent a small subgroup of workers working in specific areas. There is also a broad range of possible productivity effects that are very specific to the nature of work that an HIV-infected person may be doing; the nature of the remuneration package (including pension and sickness benefits); and the types of skills and training required. As we are interested in estimating a range of productivity losses for a number of countries, it is not possible to obtain such level of detail on HIV-infected persons and the nature of their employment.

In order to obtain a conservative estimate of the lost productivity, we have adapted the method used by Anand et al. (1999) to estimate the impact of HIV/AIDS on the national economy of India. While a broader range of productivity losses is possible, we focus on the productivity loss resulting from absence from work because of illness. In addition, we estimate the expected cost of recruitment and treatment of replacement workers due to loss of skilled workers to the workplace.

We assume that employees are absent from work the entire time they are ill and could be seeking care and treatment at health facilities (e.g., table 5.1), as well as an additional six months before death. We do not constrain this estimate by access to health services, as people will likely be absent from the workplace if they are ill, even if they cannot access health services. In low-income countries, the average length of stay in hospital was approximately eight days (Hansen et al. 2000), and seventeen-and-a-half days in middle-income countries (Floyd et al. 1997). We assume that half a day is lost for outpatient attendance (Morris et al. 2000). We assume that

Table 4.4 Estimated productivity benefits associated with averting 2.5 million HIV infections through microbicide use between 2002 and 2005

	Present value of lifetime productivity benefits (billions, '000,000,000 – US$ 2000)	**Per capita present value of lifetime productivity benefits** (US$ 2002)
Total	**1.04**	**0.26**
EAP	0.43	0.24
EEC	0.04	0.33
LAC	0.03	0.78
SA	0.17	0.12
SSA	0.36	0.59

Note: Regional classifications are provided in annex 5. EAP = East Asia and Pacific; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean; SA = South Asia; SSA = sub-Saharan Africa.

in these six months, time will also be lost in the workplace by a caregiver. In order to calculate the costs of training and replacing workers, we used an average of 60% of the costs due to absenteeism from work. This figure was derived from the average of the relative proportions from workplace studies (Bollinger et al. 1999; Morris et al. 2000).

The productivity calculations are then based on the number of days lost from work and assessed at the average wage rate. The average wage rate is dependent on the nature of the job. To simplify, we proxy the average wage rate in a country by its per capita GNP. The 1999 GNP per capita estimates were used (World Bank 2001), although converted to constant US 2002 dollars. Again, these productivity savings are likely to be realized six to ten years in the future, and so the productivity savings have been assessed at their present value.

4.5 Results: Estimates of productivity savings associated with averting 2.5 million HIV infections

Table 4.4 represents the present value of the lifetime productivity benefits associated with averting 2.5 million HIV infections between 2002 and 2005. In total, it is estimated that US$1.04 billion would be saved, reflecting the benefits associated with averting absences from the workplace due to illness, and thus eliminating the training and replacement costs of new workers.

Forty-one percent of productivity benefits are in East Asia and the Pacific, 35% in sub-Saharan Africa, and 16% in South Asia. These differences reflect the relative distribution of adult HIV infections averted and GNP per capita.

Table 4.5 shows the relative magnitude of the productivity benefits in comparison to the estimated health-system cost savings. Overall the productivity benefits are 39% of health- system savings, with the greatest relative proportion being in SSA, and the lowest being in EEC. The findings are largely driven by the relative levels of access to health services in each region, which constrain the potential health service savings associated with averting HIV infection.

Table 4.5 Relationship between productivity benefits and health system cost savings

	Productivity benefits as a percentage of cost savings
Total	**39%**
EAP	33%
EEC	19%
LAC	54%
SA	26%
SSA	72%

Note: Regional classifications are provided in annex 5. EAP = East Asia and Pacific; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean; SA = South Asia; SSA = sub-Saharan Africa.

5 Sensitivity Analysis

5.1 Changes in key parameters related to modeling of impact

In this section, we explore how changes in key parameters affect the estimates of impact and economic benefits. Two crucial assumptions made in the analysis relate to the efficacy of the proposed microbicide against both HIV and STD transmission, and microbicide coverage among specific groups. In the results presented in section 3, we assume that the microbicide is 60% efficacious against HIV transmission (60%-0%), and that the demand for microbicides resulted in a 20% coverage among each group in contact with services. We here consider how efficacy and changes in coverage affect the estimates of impact and economic benefit.

5.2 The relationship between microbicide efficacy and public health benefits

We consider three microbicide-efficacy scenarios:

a) 40% HIV efficacy, 0% STD efficacy (40%-0%);

b) 40% HIV efficacy, 40% STD efficacy (40%-40%)

c) 60% HIV efficacy, 40% STD efficacy (60%-40%)

Table 5.1 shows the levels of impact and economic benefits of microbicide use by region, for 20% coverage of groups in contact with services, and different assumptions about microbicide efficacy against HIV and STD. The estimated three-year cumulative number of HIV infections averted ranges from 1.7 million (for a microbicide of 40%-0% efficacy) to 2.7 million (for a microbicide of 60%-40% efficacy). The associated direct cost savings to the health system range from US$1.8 billion to US$2.9 billion for a 40%-0% and 60%-40% efficacy microbicide, respectively. The productivity benefits range from US$0.67 billion to US$1.13 billion for a microbicide of 40%-0% efficacy and 60%-40% efficacy, respectively.

The extent to which a microbicide's HIV efficacy affects microbicide impact can be considered by comparing the impact estimates for a microbicide of 60%-0% efficacy with a microbicide of 40%-0% efficacy. Relative to a microbicide of 40%-0% efficacy, the overall impact increases by 53%—with the greatest relative increase in impact being in SSA. Similarly, a microbicide of 60%-40% efficacy has a 47% greater impact than a microbicide of 40%-40% efficacy.

There is a similar relationship between the health-service costs and HIV infections averted. For example, relative to a microbicide of 40%-0% efficacy, a microbicide of 60%-0% efficacy will also result in a 52% increase in the overall health-service cost savings.

5.3 The relationship between coverage and public health benefits

The second critical assumption is related to assumptions about microbicide utilization (as determined by demand-and-supply factors). The baseline case in section 3 was a 20% level of feasible coverage of microbicides across all groups in contact with services. Assuming a

Table 5.1 Three-year impact and economic benefit by region of microbicide with different efficacy levels, assuming 20% coverage of groups in contact with services in 73 lower-income countries

	Total cumulative HIV infections averted (number of HIV infections averted)	**Present value of direct cost savings to health system** (billions, '000,000,000 US$ 2002)	**Present value of productivity benefits** (billions, '000,000,000 US$ 2002)
Baseline (60%-0% efficacy)			
Total	**2,537,700**	**2.69**	**1.04**
EAP	793,577	1.30	0.43
EEC	128,246	0.20	0.04
LAC	50,444	0.06	0.03
SA	882,642	0.65	0.17
SSA	682,790	0.48	0.36
40%-0% efficacy			
Total	**1,662,344**	**1.77**	**0.67**
EAP	525,071	0.86	0.29
EEC	84,733	0.13	0.02
LAC	33,081	0.04	0.02
SA	584,723	0.43	0.11
SSA	434,736	0.30	0.23
40%-40% efficacy			
Total	**1,856,885**	**1.96**	**0.76**
EAP	577,124	0.94	0.32
EEC	93,832	0.15	0.03
LAC	37,041	0.04	0.02
SA	642,090	0.47	0.12
SSA	506,797	0.35	0.27
60%-40% efficacy			
Total	**2,735,177**	**2.88**	**1.13**
EAP	845,835	1.38	0.46
EEC	137,355	0.22	0.04
LAC	54,473	0.06	0.03
SA	941,136	0.70	0.18
SSA	756,377	0.53	0.41

Note: Regional classifications are provided in annex 5. EAP = East Asia and Pacific; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean; SA = South Asia; SSA = sub-Saharan Africa.

Table 5.2 Coverage assumptions for each group where coverage is related to HIV prevalence in the ante-natal population

HIV prevalence ANC population	< 5%	5%-10%	10%-15%	> 15%
Feasible level of coverage	10%	20%	20%	30%

60%-0% microbicide efficacy, we consider how the impact and economic benefits vary for three different assumptions about coverage:

a) For each group, 10% coverage of those in contact with services

b) For each group, 30% coverage of those in contact with services

c) Coverage of those in contact with services influenced by the stage of the HIV epidemic (as a proxy to levels of perceived risk)—defined in table 5.2

Table 5.3 shows the impact and economic benefit of microbicide use by region for different coverage levels, for a 60%-0% efficacy microbicide. The findings illustrate the degree to which microbicide impact is influenced by the extent of microbicide coverage and use. Increasing coverage from 10% to 20% across each group increases the cumulative HIV infections averted by 79%. An increase from 10% to 30% coverage results in a 160% increase in impact. There is a decreasing rate of return associated with increased coverage: an increase in coverage from 10% to 20% results in a 79% increase in impact, and an increase from 20% to 30% coverage results in a 46% increase in impact. In general, the extent to which increasing coverage increases impact will be affected by the underlying assumptions about patterns and consistency of microbicide use.

Considering the third scenario, the overall impact on HIV transmission is increased by 56% relative to 10% coverage, and is reduced by 13% relative to 20% coverage levels. In SSA, the impact on HIV transmission if uptake is influenced by the stage of the epidemic is 27% higher than with the 20% coverage scenarios. The substantial increase in impact in SSA reflects the high prevalence of HIV infection in many countries of this region, and the associated assumptions about the high potential levels of demand for a microbicide.

Considering how the health-service savings are affected by coverage levels, an increase from 10% to 20% coverage leads to a 78% increase in health savings. An increase from 10% to 30% coverage results in a 160% increase in direct health savings. For the third scenario, relative to the 20% coverage scenario, there is a 21% increase in health savings in SSA.

The findings are relatively similar for productivity benefits. An increase from 10% to 20% coverage results in a 79% increase in productivity. An increase from 10% to 30% coverage results in a 160% increase in productivity. For the third scenario, there is a 42% increase in productivity savings in SSA relative to 20% coverage.

5.4 The relationship between the size of the urban sex-worker population, HIV infections averted, and economic benefits

The third critical assumption relates to premises about the size of the sex-worker population. In general, there is extremely limited data about the extent to which women sell sex (or men buy sex) in different regions of the world. Yet this will have a strong influence on the rate at which the HIV epidemic will spread in settings where the HIV epidemic is nascent or emerging.

Table 5.3 Three-year impact and economic benefit by region of a 60% HIV efficacious microbicide for different coverage of groups in contact with services in 73 lower-income countries

	Total cumulative HIV infections averted (number of HIV infections averted)	**Present value of direct cost savings to health system** (billions, '000,000,000 US$ 2002)	**Present value of productivity gains** (billions, '000,000,000 US$ 2002)
Baseline (60%-0% efficacy), 20% coverage of groups in contact with existing services			
Total	**2,537,700**	**2.69**	**1.04**
EAP	793,577	1.30	0.43
EEC	128,246	0.20	0.04
LAC	50,444	0.06	0.03
SA	882,642	0.65	0.17
SSA	682,790	0.48	0.36
10% coverage of groups in contact with existing services			
Total	**1,419,223**	**1.51**	**0.58**
EAP	444,061	0.73	0.24
EEC	72,432	0.11	0.02
LAC	28,329	0.03	0.02
SA	496,526	0.37	0.09
SSA	377,875	0.26	0.20
30% coverage of groups in contact with existing services			
Total	**3,697,349**	**3.92**	**1.51**
EAP	1,156,799	1.89	0.63
EEC	186,190	0.29	0.05
LAC	73,368	0.09	0.05
SA	1,283,553	0.95	0.24
SSA	997,439	0.70	0.54
Coverage of groups in contact with existing services based on stage of HIV epidemic			
Total	**2,217,222**	**2.05**	**0.95**
EAP	452,883	0.73	0.24
EEC	74,338	0.12	0.02
LAC	35,206	0.04	0.02
SA	788,111	0.58	0.15
SSA	866,683	0.58	0.51

Note: Regional classifications are provided in annex 5. EAP = East Asia and Pacific; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean; SA = South Asia; SSA = sub-Saharan Africa.

In the baseline scenario, we assumed that the sex-worker population is 3% of urban females in SSA, 2% in SA, LAC, EEC, and 1% in EAP. Here we consider the difference in the estimates if the sex-worker population were larger (4% urban women aged 15 to 49), and equal in size in each setting (table 5.4 – large sex-worker population).

Increasing the size of the sex-worker population increases the microbicide impact estimates two-and-a-half-fold. The greatest difference is in EAP, where the baseline estimates of the size of the sex-worker population were most conservative (1%). For the large sex-worker population scenario, the overall impact figures are determined primarily by the impact estimates from China and India.

5.5 The relationship between discount rates and health-care cost and productivity savings

There are several critical assumptions related to the modeling of the direct costs and productivity gains that will influence the magnitude of the estimated economic benefits of microbicide use. In the analysis we calculate the lifetime health-care and productivity cost savings of averting an HIV infection, and present this in present-value terms. The measurement of these savings is sensitive to the choice of discount rate. For the baseline analysis we use a 5% discount rate to calculate the present value of lifetime costs for averting HIV infection. In general, the rates used in the literature vary from 2%-10%, although most recently, rates of 3% and 5% have been

Table 5.5 Three-year impact and economic benefit by region of a 60% HIV efficacious microbicide with 20% coverage levels of groups in contact with services in 73 lower-income countries, for different-sized sex-worker populations

	Total cumulative HIV infections averted (number of HIV infections averted)	**Present value of direct cost savings to health system** (billions, '000,000,000 US$ 2002)	**Present value of productivity gains** (billions, '000,000,000 US$ 2002)
Baseline			
Total	**2,537,700**	**2.69**	**1.04**
EAP	793,577	1.30	0.43
EEC	128,246	0.20	0.04
LAC	50,444	0.06	0.03
SA	882,642	0.65	0.17
SSA	682,790	0.48	0.36
Large sex-worker populations			
Total	**6,048,462**	**7.43**	**2.59**
EAP	3,006,403	4.96	1.66
EEC	245,699	0.39	0.07
LAC	94,435	0.11	0.06
SA	1,849,299	1.37	0.35
SSA	852,626	0.60	0.44

Note: Regional classifications are provided in annex 5. EAP = East Asia and Pacific; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean; SA = South Asia; SSA = sub-Saharan Africa.

Table 5.5 Estimates of economic benefits with variation in discount rates

	60%-10% efficacy, 20% coverage of groups in contact with services		60%-40% efficacy, 20% coverage of groups in contact with services	
	Present value of direct cost savings to health system (billions, '000,000,000 US$ 2002)	**Present value of productivity gains** (billions, '000,000,000 US$ 2002)	**Present value of direct cost savings to health system** (billions, '000,000,000 US$ 2002)	**Present value of productivity gains** (billions, '000,000,000 US$ 2002)
Baseline 5% discount rate				
Total	**2.69**	**1.04**	**2.88**	**1.13**
EAP	1.30	0.43	1.38	0.46
EEC	0.20	0.04	0.22	0.04
LAC	0.06	0.03	0.06	0.03
SA	0.65	0.17	0.70	0.18
SSA	0.48	0.36	0.53	0.41
No discounting				
Total	**4.34**	**1.61**	**5.03**	**3.03**
EAP	2.09	0.67	1.27	0.14
EEC	0.33	0.06	0.22	0.05
LAC	0.10	0.05	0.10	0.04
SA	1.05	0.26	0.21	0.07
SSA	0.77	0.56	3.24	2.74
3% discount rate				
Total	**3.44**	**1.23**	**3.99**	**2.32**
EAP	1.66	0.52	1.01	0.11
EEC	0.26	0.04	0.17	0.04
LAC	0.08	0.04	0.08	0.03
SA	0.84	0.20	0.17	0.05
SSA	0.61	0.43	2.57	2.10
10% discount rate				
Total	**2.07**	**0.68**	**2.40**	**1.28**
EAP	1.00	0.29	0.60	0.06
EEC	0.16	0.02	0.10	0.02
LAC	0.05	0.02	0.05	0.02
SA	0.50	0.11	0.10	0.03
SSA	0.37	0.24	1.54	1.16

Note: Regional classifications are provided in annex 5. EAP = East Asia and Pacific; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean; SA = South Asia; SSA = sub-Saharan Africa.

extensively used and recommended (Walker and Kumaranayake 2002). Historically, a 10% rate has been used in evaluations reflecting long-term interest rates in the American bond market, but it also reflects current real rates in different settings such as South Africa. In table 5.5 we consider the estimates for cost savings when using discount rates of 0% (no discounting), 3%, and 10%.

No discounting would lead to a 61% increase of the estimated cost and productivity savings. Using the 3% standard discount rate would lead to a 28% increase in the estimated cost and productivity savings. A 10% discount rate would lower the estimated cost and productivity savings by 23%. Given this variation, a 5% discount will produce a somewhat conservative estimate of cost savings.

5.6 The relationship between access to health services and direct cost savings

In the analysis a measure of access to health services has been used to reflect the reality that in lower-income countries, not all those with HIV infections will receive treatment, due to limited access to health services. However, this approach does not value HIV infections averted among those with no contact with health services. To consider how this affects the estimates of economic benefit, we consider the estimates of cost savings assuming full access to health services. These results are presented in table 5.6.

Assuming 100% access to health services, the estimated cost savings would increase by 38% overall. Regionally, we see that this has a disproportionately greater effect in SSA (where the cost savings would double if the population had full access to services), and in South Asia (where cost savings would increase by 43%).

Table 5.6 Present value of cost savings to health systems for 100% access to health services of HIV-infected population (US$ 2002, billions)

	60%-0% efficacy, 20% coverage of groups in contact with services	
	Current rates	**100% access**
Total	**2.69**	**3.71**
EAP	1.30	1.46
EEC	0.20	0.25
LAC	0.06	0.09
SA	0.65	0.93
SSA	0.48	0.97

Note: Regional classifications are provided in annex 5. EAP = East Asia and Pacific; EEC = Eastern Europe and Central Asia; LAC = Latin America and the Caribbean; SA = South Asia; SSA = sub-Saharan Africa.

6

Conclusions

6.1 The substantial public health impact of microbicides

The findings suggest that widespread microbicide use in lower-income countries has the potential to yield significant public health benefits. Even using relatively conservative assumptions about microbicide efficacy and coverage, the three-year cumulative impact of microbicide use could result in 2.5 million HIV infections averted among females, males, and children in lower-income countries. In broader terms, this could lead to a US$2.7 billion savings (in present-value terms) for health-system costs averted, and an additional US$1 billion in productivity savings gained from preventing absenteeism and retraining and replacing workers. The regional estimates of microbicide impact illustrate the extent to which there is substantial potential to avert infection in regions where the epidemic is still nascent or concentrated. Furthermore, even when the epidemic is generalized, as in sub-Saharan Africa, the rate of adult HIV infections averted is still relatively high.

The estimate of microbicide impact is dependent upon the assumptions made about the microbicide efficacy against HIV and against other STDs. At 20% coverage of groups that are in contact with existing services, the number of HIV infections averted ranges from 1.6 million for a microbicide of 40% HIV and 0% STD efficacy to 2.7 million HIV infections averted for a microbicide of 60% HIV and 40% STD efficacy. The associated direct cost savings to the health system range from US$1.77 billion to US$2.88 billion, and the productivity benefits range from US$0.67 billion to US$1.13 billion.

Table 6.1 Three-year cumulative HIV infections averted and their associated health and productivity gains from the distribution of a 60% HIV-efficacious microbicide to 20% of groups in contact with services in 73 lower-income countries

	Three-year cumulative HIV infections averted (number of HIV infections averted)	**Present value of direct cost savings to health system** (billions, '000,000,000 US$ 2002)	**Present value of productivity gains** (billions, '000,000,000 US$ 2002)
60% HIV efficacy, 20% coverage of groups in contact with services			
East Asia Pacific	793,577	1.30	0.43
Eastern Europe and Central Asia	128,246	0.20	0.04
Latin America and the Caribbean	50,444	0.06	0.03
South Asia	882,642	0.65	0.17
Sub-Saharan Africa	682,790	0.48	0.36
Total	**2,537,700**	**2.69**	**1.04**

The magnitude of microbicide impact is also strongly influenced by the extent of microbicide coverage and use. For a 60% HIV- and 0% STD-efficacious microbicide, at 10% coverage of groups in contact with services, 1.4 million HIV infections could be averted. At 30% coverage, up to 3.7 million HIV infections could potentially be averted—46% greater impact than at 20% coverage. Even assuming that a microbicide is 40% HIV-efficacious, at 20% coverage 1.7 million HIV infections would be averted, illustrating how the widespread use of even a relatively low-efficacy microbicide could have an important impact on HIV transmission.

6.2 Conclusions

This study has used existing mathematical epidemiological models to estimate the public health impact of microbicide use in different groups, and has scaled up these effects to obtain national-level estimates of HIV infections averted in seventy-three lower-income countries. Cost savings to the health system and productivity savings to the economy were then estimated, based on these estimates of cumulative HIV infections averted.

The analysis could be further developed by doing a more detailed sensitivity analysis related to the behavioral assumptions used in the modeling; analysis of the impact and economic benefits of microbicide use on STD transmission; consideration of impact and benefits in both industrialized and developing countries; and consideration of the potential cost-effectiveness of microbicide delivery.

The analysis suggests that widespread microbicide use in lower-income countries has the potential to yield significant public health benefits to men, women, and children. Two-and-a-half million fewer infections also translates into a cost savings of US$2.7 billion in averted health care costs and US$1 billion in productivity benefits for already over-stretched low- and middle-income country economies.

Because the impact of microbicide introduction is dependent upon achieving widespread coverage, it is important—even during the phase 3 trials now commencing—that we look forward to identify how best to ensure widespread microbicide access. The potential impact of microbicides provides a strong rationale for public intervention to ensure widespread coverage and utilization. The appropriate mechanisms to use in different settings require further review, and could range from subsidies to free microbicide provision. For ultimately, while our analysis suggests that there may be substantial benefits arising from widespread microbicide use, sustained donor interest and political commitment are required if we are to realize this potential.

Table 6.2 Three-year impact and economic benefits of the introduction of a microbicide with different HIV and STD efficacy to 20% of groups in contact with services in 73 lower-income countries

Efficacy scenarios	**Three-year cumulative HIV infections averted** (number of HIV infections averted)	**Present value of direct cost savings to health system** (billions, '000,000,000 US$ 2002)	**Present value of productivity benefits** (billions, '000,000,000 US$ 2002)
40% HIV, 0% STD	1,662,344	1.77	0.67
40% HIV, 40% STD	1,856,885	1.96	0.76
60% HIV, 0% STD	2,537,700	2.69	1.04
60% HIV, 40% STD	2,735,177	2.88	1.13

Technical Annexes

Annex 1 – Countries included in analysis by region and stage of HIV epidemic

Region	Stage of epidemic
East Asia and Pacific	
Dem. Peo. Rep. of Korea	Nascent
Indonesia	Nascent
Lao People's Dem. Rep.	Nascent
Mongolia	Nascent
Philippines	Nascent
China	Concentrated
Myanmar	Concentrated
Papua New Guinea	Concentrated
Vietnam	Concentrated
Cambodia	Generalized
South Asia	
Afghanistan	Nascent
Bangladesh	Nascent
Bhutan	Nascent
Pakistan	Nascent
Sri Lanka	Nascent
Nepal	Concentrated
India	Generalized
Latin America and Caribbean	
Bolivia	Nascent
Cuba	Nascent
Nicaragua	Nascent
Guyana	Concentrated
Honduras	Generalized
Haiti	Generalized
Eastern Europe and Central Asia	
Albania	Nascent
Azerbaijan	Nascent
Georgia	Nascent
Kyrgyzstan	Nascent
Republic of Moldova	Nascent
Tajikistan	Nascent
Turkmenistan	Nascent
Uzbekistan	Nascent
Armenia	Concentrated
Ukraine	Concentrated
Sub-Saharan Africa	
Equatorial Guinea	Nascent
Madagascar	Nascent
Mauritania	Nascent
Djibouti	Concentrated
Gambia	Concentrated
Guinea	Concentrated
Guinea-Bissau	Concentrated
Mali	Concentrated
Niger	Concentrated
Senegal	Concentrated
Sierra Leone	Concentrated
Angola	Generalized
Burkina-Faso	Generalized
Chad	Generalized
Dem. Republic of Congo	Generalized
Gabon	Generalized
Togo	Generalized
Benin	Generalized
Cameroon	Generalized
Congo	Generalized
Côte d'Ivoire	Generalized
Ghana	Generalized
Liberia	Generalized
Uganda	Generalized
Botswana	Generalized
Burundi	Generalized
Central African Republic	Generalized
Ethiopia	Generalized
Kenya	Generalized
Lesotho	Generalized
Malawi	Generalized
Mozambique	Generalized
Namibia	Generalized
Nigeria	Generalized
Rwanda	Generalized
South Africa	Generalized
Swaziland	Generalized
United Rep. of Tanzania	Generalized
Zambia	Generalized
Zimbabwe	Generalized

Classification of country by stage of HIV epidemic *(World Bank 1997)*
Nascent epidemic—HIV prevalence is less than 5% in all known sub-populations presumed to practice high-risk sexual behavior.
Concentrated epidemic—HIV prevalence has surpassed 5% in one or more sub-populations presumed to practice high-risk behavior, but the prevalence among women attending antenatal care is still less than 5%.
Generalized epidemic—HIV infection has spread far beyond the original sub-populations with high-risk behavior, which are now heavily infected. Prevalence among women attending urban ANC is 5% or more of the original sub-populations.

Annex 2 – Country-specific demographic and epidemiological inputs used to estimate the impact of widespread microbicide use

Input	Source
Total population 2002 (thousands)	World Development Indicators 2000
% adults aged 15–49 (from 1999 estimate)	As above
Population, female (% of total)	As above
% pop aged 15–49 (1999 data source)	As above
2000 population aged 10–24 (% of total)	As above
Rural population (% total) 1998	As above
% males enrolled in school	UNICEF 2001
% females enrolled in school	UNICEF 2001
Average age of first intercourse	Singh et al. 2000
Median age at first marriage – all women	The World's Youth 2000
% females aged 15–19 sexually active	The World's Youth 2000
Contraceptive prevalence (% of women aged 15–49) (1995–2000 data)	The World's Youth 2000
Fertility rate, total (births per woman)	World Development Indicators 2000
Mortality rate, infant (per 1,000 live births)	As above
Country HIV-prevalence rate (%) in young males (aged 15–24)	UNAIDS 2000
Country HIV-prevalence rate (%) in young females (aged 15–24)	UNAIDS 2000
Estimated male HIV prevalence (aged 15–19)	Extrapolated using Glynn et al. AIDS 2001
Estimated female HIV prevalence (aged 15–19)	Extrapolated using Glynn et al. AIDS 2001
ANC HIV prevalence urban areas (%)	UNAIDS 2000
ANC HIV prevalence outside urban areas	UNAIDS 2000
HIV prevalence STD clients	UNAIDS 2000
HIV prevalence sex workers urban areas (%)	UNAIDS 2000
HIV prevalence IDUs (%)	UNAIDS 2000

Annex 3 – Inputs for microbicide impact modeling

Table A3.1 Inputs used to model microbicide impact among sex workers and their clients

Epidemiological		Behavioral		Coverage and impact		Transmission	
Initial HIV prevalence	0.1 – 0.7	Av. time span women sell sex (months)	60	Total no. sex workers	10,000	Prob. HIV transmission per sex act M to F	0.002
Av. duration STD Sws (months)	1.5	Av. time span men buy sex (months)	120	Proportion receiving STD services	0.1	Prob. HIV transmission per sex act F to M	0.001
Av. duration STD clients (months)	1	Av. no. clients per sex worker	3 per day, 84 per month	Average proportion STDs cured	0.25	Prob. STD transmission per sex act M to F	0.2
Av. duration high viraemia (months)	1.5	Av. no. sex workers per client per month	2	Proportion sex workers with access to microbicides	10%, 20%, 30%	Prob. STD transmission per sex act F to M	0.2
Av. duration before chronic morbidity (months)	84	Av. no. sex acts per commercial transaction	2	Proportion of sex workers using condoms	Never 0.25 Sometimes 0.25 Always 0.5	STD co-factor per sex act	20
				Proportion of time microbicide used when condom not used	50%	Multiplicative factor during high infectivity phase	15
				Proportion migration from condom	Never 0% Sometimes 10% Always 10%	Condom efficacy per sex act HIV and STD	0.8
						Microbicide efficacy per sex act HIV	0.4 0.6
						Microbicide efficacy per sex act STD	0 0.4

Table A3.2 Inputs used to model microbicide impact in regular partnerships

Epidemiological		Behavioral		Coverage, impact discordancy		Transmission	
HIV prevalence male casual partners of females	Extrapo-lated	Number of regular partnerships in cohort	10,000	Proportion of partnerships potentially accessing microbicides	10%, 20%, 30%	Prob. HIV transmission per sex act M to F	0.002
HIV prevalence female casual partners of males	Extrapo-lated	Av. no. sex acts in regular partnership per month	12	Proportion of time that a microbicide is used when a condom is not used	0.5	Prob. HIV transmission per sex act F to M	0.001
Proportion of HIV-infected individuals in high viraemia phase	0.1	Average duration of regular partnership (months)	100	Extent of migration away from the condom	0.1	Prob. STD transmission per sex act M to F	0.2
STD prevalence male casual partners of females	0.15	Average consistency of condom use in regular partnerships	0.2	HIV prevalence women in regular partnerships	ANC HIV prevalence	Prob. STD transmission per sex act F to M	0.2
STD prevalence female casual partners of males	0.24	Mean duration of casual partnerships (months)	M 2 F 6	HIV prevalence males (aged 15–49)	10% greater than females	STD co-factor per sex act	20
Av. duration STD males (months)	1.5	Average number of casual partners per month	M 0.5 F 0.01	Proportion of HIV-infected people in high viraemia phase	0.1	Multiplicative factor during high-infectivity phase	15
Av. duration STD females (months)	2	Average number sex acts per month in casual partnership	M 2 F 2			Condom efficacy per sex act HIV and STD	0.8
Av. duration high viraemia (months)	1.5	Average consistency condom use with casual partner	M 0.4 F 0.3			Microbicide efficacy per sex act HIV	0.4 0.6
Av. duration before chronic morbidity (months)	84	Percentage of time women use microbicides with casual partners when not using condoms	0.5			Microbicide efficacy per sex act STD	0 0.4
		Migration away from the condom	0.1				

Table A3.3 Inputs used to model microbicide impact among sexually active youth

Epidemiological		Behavioral		Size, coverage, impact		Transmission	
Initial HIV prevalence boys (%)	1% to 8%	Definition of low, med, and high nos. of partnerships per mnth boys	Low 0.05 Med 0.5 High 1	Total number of youth	5200 males 4800 females	Prob. HIV transmission per sex act M to F	0.002
Average STD duration boys (months)	1.5	Definition of low, med, and high nos. of partnerships per mnth girls	Low 0.05 Med 1.5 High 3.0	Proportion of female youth potentially having access to microbicides	10%, 20%, 30%	Prob. HIV transmission per sex act F to M	0.001
Average STD duration girls (months)	2.0	Average no. of sex acts per youth / youth partnership	3	Extent of migration away from the condom	0.1	Prob. STD transmission per sex act M to F	0.2
Average duration high viraemia (months)	1.5	Average no. of sex acts per youth / older partnership	10	Average consistency of condom use in youth / youth partnerships	Low 0.2 Med 0.2 High 0.2	Prob. STD transmission per sex act F to M	0.2
Average duration before chronic morbidity (months)	84	Degree of like with like formation of youth partnerships	0.6	Distribution of condom use in boy /adult partnerships	None 50% Half 25% All 25%	STD co-factor per sex act	20
HIV prevalence older male partners of girls (%)	Extra-polated	Proportion males with low, medium and high nos. sexual partners	Low 0.5 Med 0.3 High 0.2	Distribution of condom use in girl / adult partnerships	None 60% Half 25% All 15%	Multiplicative factor during high-infectivity phase	15
HIV prevalence older female partners of males (%)	Extra-polated	Proportion females with low, medium and high nos. sexual partners	Low 0.4 Med 0.3 High 0.3	Migration from condom in youth / youth partnerships	0.1	Condom efficacy per sex act HIV and STD	0.8
STD prevalence older male partners of females (%)	12%	Proportion boys with adult partners	Low 0.3 Med 0.4 High 0.5	Migration from condom in girl / adult partnerships	None 0 Half 0.1 All 0.1	Microbicide efficacy per sex act HIV	0.4 0.6
STD prevalence older female partners of males (%)	24%	Proportion girls with adult partners	Low 0.7 Med 0.8 High 0.9			Microbicide efficacy per sex act STD	0 0.4
Percentage older partners in high viraemia	10%	Proportion of boys total partnerships that are adults (of those with adult partners)	Low 0.6 Med 0.65 High 0.7				
		Proportion girls total partnerships that are adults (of those with adult partners)	Low 0.6 Med 0.7 High 0.8				

Table A3.4 Inputs used to model the impact of microbicides introduced among IDUs and their sexual partners

Types of model input and variables	Definition of model variables and model inputs		Model inputs Male	Female
Epidemiological inputs	Initial HIV prevalence among IDUs		Range	
	Average STD duration among IDUs		6wk	8wk
	Average duration of high viraemia phase (months)		6wk	
	Average duration between HIV infection and severe HIV morbidity (months)		120	
	Estimated size of population of non–IDU sexual partners		8000	8000
	Non–IDU initial HIV prevalence		5%	5%
	Non–IDU STD prevalence for males and females		6%	6%
	Initial proportion of non–IDU sexual partners with high viraemia		10%	10%
Transmission probabilities	Probability of HIV transmission per sex act (male to female)		0.002	
	Probability of HIV transmission per sex act (female to male)		0.001	
	Probability of HIV transmission per needle-sharing act		0.0068	
	Probability of STD transmission per sex act both sexes		0.2	0.2
	Average STD co-factor per sex act		20	
	Sexual transmission multiplicative factor during high viraemia phase		15	
	Injecting transmission multiplicative factor during high viraemia phase		15	
	Condom efficacy per sex act		80%	
	Microbicide efficacy per sex act for HIV transmission		40% or 60%	
	Microbicide efficacy per sex act for STD transmission		0% or 40%	
	Cleaning efficacy per sharing act		20%	
Size of IDU population and intervention coverage	Proportion of male and female IDUs that have been injecting for less than one year	Not reached	0.053	
		Reached	0.053	
	Rate at which IDUs leave the IDU population in the absence of HIV infection	Not reached	0.053	
		Reached	0.053	
	Annual mortality rate (eg., sepsis or drug overdose) for male and female IDUs		40	40
	Initial size of IDU population		750	250
	Proportion of female IDUs reached by microbicide intervention		10%, 20% and 30%	
	Number of IDUs attending the NEPs		1000	
Fixed needle sharing behavior inputs	Definition of ‘low’ and ‘high’ rate of needle-sharing partners	Low	2	
		High	6	
	Definition of ‘low’ and ‘high’ frequency of needle shares per needle-sharing partner	Low	2	
		High	2	
Fixed sexual behavior inputs	Definition of ‘low’ and ‘high’ number of sexual partners per month for males and females	Low	0.2	0.2
		High	3.5	3.5
	Average number of sex acts per month for IDU partnerships with a ‘low’ or ‘high’ number of sexual partnerships	Low	10	
		High	4	
Sexual activity of IDUs	Population distribution of IDUs with respect to their level of sexual activity (with none, low, or high numbers of partners)	None	0.1	0.1
		Low	0.45	0.45
		High	0.45	0.45
Proportion of the IDUs sexual partners that are IDUs	Proportion of IDUs sexual partners that are IDUs for low and high sexual activity	Low	0.5	0.5
		High	0.5	0.5

Table A3.4 Inputs used to model the impact of microbicides introduced among IDUs and their sexual partners (continued)

Types of model input and variables	Definition of model variables and model inputs		Model inputs	
			Male	Female
Proportion of IDUs with different levels of needle sharing	Average consistency of cleaning syringes		0.4	
	Population distribution of IDUs with respect to their level of needle sharing (needle-sharing activity is either none, low, or high)	None	0.4	0.4
		Low	0.3	0.3
		High	0.3	0.3
Condom use in the IDU population	Average consistency of condom use among 'low' sexually active IDUs		0.4	
	Distribution of condom use among 'high' sexually active IDUs	None	0.4	0.4
		Some	0.3	0.3
		All	0.3	0.3
Microbicide use when IDU not using condom	Low sexually active IDUs		0.5	
	Distribution of microbicide use among 'high' sexually active IDUs for different condom use groups	None	0.5	
		Some	0.5	
		All	0.5	
Migration away from condom of those using microbicide	Low sexually active IDUs		0.1	
	Distribution of microbicide use among 'high' sexually active IDUs for different condom use groups	None	0.1	
		Some	0.1	
		All	0.1	

Annex 4 – Calculation of lifetime costs

Using health databases (Medline, Popline, HMIC, SIGLE), a literature search was performed using the terms HIV/AIDS, cost, care, and developing countries. The search came up with 693 records. The abstracts were scanned to find studies including empirical cost of care, and the bibliographies of the studies found were searched for additional articles. The studies found were published between 1987 and 2000. Cost data were compiled for eighteen countries of which five were from Latin America/Caribbean, nine from Africa, and four from Asia. The methodologies and focus of the different studies varied greatly. Only four of the studies reviewed economic costs, including a valuation of all the resources used for HIV/AIDS care. Only five studies provided lifetime costs. The majority of studies used annual costs, but there were also some that used cost per episode (for example, per hospital stay) or cost per day or per visit. Only six studies gave a definition of what they consider to be HIV or AIDS. The definition ranges from serologically HIV-positive patients to patients believed to be HIV-positive by the health-care staff. The annual costs used in the calculation of lifetime costs are presented below.

Annual cost values used in the calculation of lifetime costs
US$ (2002)

Type of care	Low-income SSA	Middle-income SSA
Palliative care (drugs)	22.90	22.90
Cost of outpatient visit (excluding drugs)	6.77	13.54
Cost of inpatient stay	200.77	429.00
Annual cost of home-based care	156.89	219.65

Sources of data: *Palliative care from World Bank (1997); low-income outpatient costs from Sanderson (1995), and middle-income from Kinghorn (1996); low-income inpatient stay from Hansen (2000), and middle-income inpatient stay from Floyd (1997); home-based care costs from Hansen et al. (1994). Middle-income costs obtained by PPP conversion.*

Annex 5 – Classification of countries by region and stage of economic development

Region	Low/Middle Income
East Asia and Pacific	
Cambodia	Low
Dem. Peo. Rep. of Korea	Low
Indonesia	Low
Lao People's Dem. Rep.	Low
Mongolia	Low
Myanmar	Low
Vietnam	Low
China	Middle
Papua New Guinea	Middle
Philippines	Middle
South Asia	
Ethiopia	Low
Afghanistan	Low
Bangladesh	Low
Bhutan	Low
India	Low
Nepal	Low
Pakistan	Low
Sri Lanka	Middle
Latin America and Caribbean	
Haiti	Low
Nicaragua	Low
Bolivia	Middle
Cuba	Middle
Guyana	Middle
Honduras	Middle
Eastern Europe and Central Asia	
Armenia	Low
Azerbaijan	Low
Georgia	Low
Kyrgyzstan	Low
Republic of Moldova	Low
Tajikistan	Low
Turkmenistan	Low
Ukraine	Low
Uzbekistan	Low
Albania	Middle

Region	Low/Middle Income
Sub-Saharan Africa	
Angola	Low
Benin	Low
Burkina-Faso	Low
Burundi	Low
Cameroon	Low
Central African Rep.	Low
Chad	Low
Congo	Low
Côte d'Ivoire	Low
Dem. Rep. of Congo	Low
Ethiopia	Low
Gambia	Low
Ghana	Low
Guinea	Low
Guinea-Bissau	Low
Kenya	Low
Lesotho	Low
Liberia	Low
Madagascar	Low
Malawi	Low
Mali	Low
Mauritania	Low
Mozambique	Low
Niger	Low
Nigeria	Low
Rwanda	Low
Senegal	Low
Sierra Leone	Low
Togo	Low
Uganda	Low
United Rep. of Tanzania	Low
Zambia	Low
Zimbabwe	Low
Djibouti	Middle
Equatorial Guinea	Middle
Namibia	Middle
Swaziland	Middle
Botswana	Middle
Gabon	Middle
South Africa	Middle

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