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HIV Infection and Sexually Transmitted Diseases

Mead Over and Peter Piot

The health programs of developing countries have not traditionally accorded a high priority to the prevention and control of diseases which are predominantly transmitted by sexual intercourse. With the realization that sex is the primary mode of transmission for the human immunodeficiency virus (HIV), however, international donors are helping national health ministries of developing countries allocate large human and financial resources to the fight against at least one sexually transmitted disease (STD). In many cases these programs for the prevention of acquired immunodeficiency syndrome (AIDS) are large enough to rival preexisting programs to prevent other diseases, like malaria and measles, which currently kill more people in most of these countries. By supporting this proposed expenditure pattern, the international donors and national health ministries have implicitly raised the priority attached to the prevention of STDs far above the position formerly occupied by this class of diseases. In addition, because of a growing awareness that at least one important cancer (cervical cancer) and a significant proportion of maternal morbidity and mortality result from STDs, there is a renewed interest in STD control in the public health community.

Our objective in this chapter is to examine the case for assigning a high priority to the prevention (primary and secondary) of the spread of STDs, including AIDS and its causative agent, HIV. Although it would be possible and in some ways more convenient to separate the discussion of AIDS from that of other STDs, a central theme of this chapter is the examination of the epidemiological, medical, and economic arguments for integrating AIDS prevention efforts with efforts to combat other STDs. Furthermore, the transmission dynamics of all STDs have strong similarities, which benefit from a common analytical examination. These considerations lead us to address AIDS and "classic STDs," or CSTDs, in the same chapter but often to separate the discussions into different sections.

The Epidemiology of STDs

Both CSTDs and HIV are mainly transmitted through sexual intercourse, although in many cases they may also be transmitted vertically from mother to child or by blood-contact. More than fifty CSTDs have now been recognized, many of which were identified only during the last decades, partly as a result of improved laboratory techniques.

Distinctive Features of STD Epidemiology

A list of common sexually transmitted agents and the diseases they cause are presented in table 20-1. In this chapter, we focus on HIV infection and on selected CSTDs, including gonorrhea, genital chlamydial infections, syphilis, and chancroid. The contribution of the sexually transmitted human papilloma viruses to the causation of cervical cancer will not be discussed, although both in Africa and in Latin America the incidence of cervical cancer is among the highest in the world, and sexual activity is the main risk factor for this common neoplasm (Reeves, Brinton, and Brenes 1985; Rosenberg, Schultz, and Burton 1986; and Reeves, Rawls, and Brinton 1989).

An in-depth discussion of the biology and epidemiology of even the main STDs is beyond the scope of this chapter but can be found in several textbooks and monographs (Osoba 1987; Arya, Osoba, and Bennett 1988; Holmes and others 1989). Appendix 20A includes a summary of medical information on the individual diseases considered here.

The epidemiology of STDs is distinctive because of common behavioral and biological features. First, STDs typically have long latent or incubation periods before symptoms become apparent, during which transmission can occur. Second, the genetic structure of most STD agents varies so much that researchers have been unable to design a vaccine against them. Third, STDs are primarily spread by a class of behavior which is inherently resistant to change, because it is highly motivated, often clandestine, and varies so much both within and between social and ethnic groups.

A common biological feature of many of the microorganisms causing STDs is their unique and often exclusive adaptation to humans, the main mode of transmission being genital mucosal contact—for example, sex in most instances. Whether a microbial agent is mainly sexually transmitted in a given population, however, depends not only on its biology but also on behavioral and environmental conditions. Thus, in many developing societies some infections are mainly acquired in childhood because of low hygienic standards or poor living conditions,

Table 20-1. Important Sexually Transmitted Agents and Diseases

Agents	*Disease or syndrome*
Bacteria	
Neisseria gonorrhoeae	Urethritis, epididymitis, proctitis, bartholinitis, cervicitis, endometritis, salpingitis and related sequelae (infertility, ectopic pregnancy), perihepatitis; complications of pregnancy (e.g., chorioamnionitis, premature rupture of membranes, premature delivery, postpartum endometritis); conjunctivitis; disseminated gonococcal infection (DGI)
Chlamydia trachomatis	Same as *N. gonorrhoeae*, except for DGI; also trachoma, lymphogranuloma venereum, Reiter's syndrome, infant pneumonia
Treponema pallidium	Syphilis
Haemophilus ducreyi	Chancroid
Mycoplasma hominis	Postpartum fever, salpingitis
Ureaplasma urealyticum	Urethritis; low birth weight,[a] chorioamnionitis[a]
Gardnerella vaginalis and others	Bacterial vaginosis
Calymmatobacterium granulomatis	Donovanosis
Group B β-hemolytic streptococcus[a]	Neonatal sepsis, neonatal meningitis
Viruses	
Herpes simplex virus	Primary and recurrent genital herpes; aseptic meningitis; neonatal herpes and associated mortality or neurological sequelae; spontaneous abortion, premature delivery
Hepatitis B virus	Acute, chronic, and fulminant hepatitis B, with associated immune complex phenomena and sequelae, including cirrhosis and hepatocellular carcinoma
Cytomegalovirus	Congenital infection; gross birth defects and infant mortality, cognitive impairment (e.g., mental retardation, sensorineural deafness); heterophile-negative infectious mononucleosis; protean manifestations in the immunosuppressed host
Human papilloma virus	Condyloma acuminata, laryngeal papilloma in infants; squamous epithelial neoplasias of the cervix, anus, vagina, vulva, and penis
Molluscum contagiosum virus	Genital molluscum contagiosum
Human immunodeficiency virus	AIDS and related conditions
HTLV-1 (Human T-lymphotropic virus)	T-cell leukemia, lymphoma; tropical spastic paraparesis
Protozoon: Trichomonas vaginalis	Vaginitis; urethritis,[a] balanitis[a]
Fungus: Candida albicans	Vulvovaginitis, balanitis, balanoposthitis
Ectoparasites	
Phthirius pubis	Pubic lice infestation
Sarcoptes scabiei	Scabies

a. Causative relationship uncertain.
Source: Based on compilation of the literature.

whereas in industrial countries the same infections are mainly sexually transmitted among adults (hepatitis B, cytomegalovirus infection). In general, infections become more often sexually transmitted with an increasing standard of living, because opportunities for person-to-person transmission are decreasing during childhood.

Risk factors for STDs are directly related to patterns of sexual behavior. They include a large number of sex partners, a history of STDs, urban residence, being single, and being young (Piot and Meheus 1983). Prostitutes are named by up to 80 percent of male patients as the source of infection in some, but not all, developing countries as compared with less than 20 percent in Europe and North America (Rajan 1978; D'Costa and others 1985) and are probably an important reservoir of STDs in many parts of the world. Still, significant differences in sexual behavior patterns exist within continents and even within countries.

The highest rates of STDs are found in urban men and women in their sexually most active years, that is, between the ages of fifteen and thirty-five. On the average, women become infected at a lower age than men. Increasing urbanization with disruption of traditional social structures, increased mobility for economic or political reasons, poor medical facilities, a large proportion of the population composed of teenagers and young adults (who have the highest incidence of STD), and high unemployment rates are all contributing to the high incidence of STDs and their complications and sequelae (Piot and Holmes 1989).

STDs Are Communicable

Preventing or curing one case of an STD often prevents many other cases. This obvious consequence of the fact that STDs are communicable introduces a complication into the analysis of the priority to assign to their prevention. It is not sufficient to weigh against the cost of preventing a case only the benefits of preventing that single case; the so-called "dynamic benefits" that accrue to others than the immediately affected individual must also be included.[1]

A key epidemiological concept in this connection is that of the "reproduction rate."[2] Defined as the number of new (or

secondary) cases infected by an average case, the reproduction rate can be used to multiply the number of prevented primary cases in order to obtain a crude measure of the total beneficial effect of the prevention effort.[3] Clearly the inclusion of these extra cases among the benefits of an STD prevention program will increase the measured cost-effectiveness of preventive efforts. It can be argued that the failure of decisionmakers to consider sufficiently the benefits of the prevention of secondary and subsequent cases has contributed to the undervaluation of the priority to assign to CSTD control in developing countries. In contrast, it is clear that the present attention allocated to AIDS prevention is almost entirely due to fear of a high reproduction rate.

In addition to its importance in estimating the benefits of preventing a communicable disease, the reproduction rate plays a key role in the analysis of the future course of an epidemic. To understand this, consider that a communicable disease characterized by a reproduction rate less than unity is headed for extinction as each individual case fails to replace itself entirely in the population. Contrarily, a disease whose reproduction rate is greater than unity can be predicted to explode geometrically. For any communicable disease in the early stages of an epidemic, the value of the reproductive rate (R) can be simply calculated as the product of three parameters: the probability of infection on each contact (Q), the number of contacts per time period between an infected person and a susceptible one (a), and the duration of infectivity of the infected person (D). Note that the first of these three values is primarily determined by characteristics of the disease, whereas the second is primarily behavioral. The third parameter, the duration of infectivity, is typically affected by both the biology of the particular disease and the effectiveness of public health strategies for either curing or isolating the infective individual. Later in this chapter we use estimated reproduction rates or their analogues both to characterize epidemic patterns and to estimate benefits of case prevention.

The Dynamics of Sexual Transmission

A turning point in the public health perspective toward STDs occurred with the realization in the late 1970s that a key distinction between STDs and other epidemics is the importance of the *heterogeneity* of sexual behavior in understanding the disease process. The simplest useful characterization of heterogeneous sexual behavior, introduced to the analysis of gonorrhea epidemics in 1978 by Yorke, Hethcote, and Nold (1978), is to posit two separate groups, a "core group" of highly sexually active individuals and a "noncore group," which is much less so. The characterization becomes more realistic as the number of groups is increased or as the behavior of individuals is allowed to vary within a group. However characterized, the heterogeneity of sexual behavior plays an extremely influential role in determining both the course of an STD epidemic and the choice of control strategy.

The definition of the reproduction rate and its importance as a simple indicator of the likely future course of an epidemic of any communicable disease were described earlier. The relationship $R = QaD$ can be applied directly to characterize the course of an STD epidemic, where a is interpreted as the rate of acquisition of new sexual partners and that rate is the same for all members of the population. If each individual in the population, however, has a different rate of sexual partner change, a_i, then it is not sufficient to use the average of these rates in order to estimate R. Instead, Anderson and May (1988) have shown that the heterogeneity in the sexual behavior, as measured by the variance of the a_i, adds substantially to the reproductive rate, and thus to the likely future rate of growth of the epidemic.[4] In addition, it is increasingly clear that there is considerable heterogeneity over time in the infectivity of individuals with HIV infection, adding to the complexity of the dynamics of viral spread in populations.

Current Levels and Trends in the Developing World

Reflecting the low level of priority assigned to CSTDs in most countries, data on the levels of CSTD infection in many populations in the developing world are poor and largely confined to selected groups (and samples of convenience). Therefore, the figures presented here should be considered as approximate and not necessarily representative for the general population. From a public health perspective, however, the overall prevalence or incidence rates in the general population may not be as critical as the size of the segment of the population that is at risk and the rate of infection in each risk group. For example, even if the nationwide prevalence of HIV infection in a country is low, there may still be a significant problem in the cities.[5]

CLASSIC SEXUALLY TRANSMITTED DISEASES. Two parameters important in estimating the burden of CSTDs are the prevalence of infection and the rate of complications and sequelae. The degree of health-seeking behavior and the quality of health services and STD control programs directly control the latter and, by reducing transmission, indirectly control the former.

In table 20-2, we present selected data on the prevalence of gonococcal and genital chlamydial infection and serologic evidence of present or past syphilis among samples of adult women in different parts of the world in the 1970s and 1980s. With the exception of the population-based surveys of women in Senegal and Uganda, the samples are drawn from the population of pregnant women. Although pregnant women imperfectly represent all adults, these data are as representative of the general population as one can get in the literature. Because infertile women are excluded from these series, there may be a bias to lower prevalence rates. Still, because the clinical manifestations of such CSTDs as gonococcal and chlamydial infection are less specific in women than in men, and their diagnoses therefore technically more complex, the prevalence rates of infection, but not necessarily the incidence rates, are usually higher in women than in men. Partly for this reason, morbidity and mortality rates from all CSTDs except syphilis are also much higher in women.

Table 20-2. Prevalence of Gonococcal and Genital Chlamydial Infection and Positive Serologic Test for Syphilis among Urban Pregnant Women

Country	*Neisseria gonorrhoeae*	*Chlamydia trachomatis*	VDRL/RPR TPHA/FTA-Abs[a]	Source
Africa				
Cameroon	15	n.a.	10	Nasah and others 1980; Kaptue and others 1990
Ethiopia	9	n.a.	n.a.	Perine and others 1980
Gabon	5.5	8.3	n.a.	Yvert and others 1984; Leclerc and others 1988
The Gambia	6.7	6.9	17.5, 7.2	Mabey and others 1984
Ghana	3.4	7.7	n.a.	Bentsi and others 1985
Kenya	7	8.9	3.8	Laga and others 1986b; Temmerman and others 1990
Mozambique	n.a.	n.a.	6.3	Liljestrand and others 1985
Nigeria	5.2	6.5	2.1	Okpere, Obaseiki-Ebor, and Oyaide 1987; Aladesanmi, Mumtaz and Mabey 1989; Fakeya, Onile, and Odugbemi 1986
Rwanda	5	16	4	Senyonyi 1987; Dabis and others 1989
Senegal	1.5	7	7.5	de Schampheleire and others 1990; Ndoye 1991[b]
Somalia	n.a.	n.a.	3	Jama and others 1987
South Africa	11.7	13	n.a.	Welgemoed and others 1986; Ballard, Fehler, and Piot 1986
Swaziland	3	n.a.	13.1	Meheus and others 1980; Guiness and others 1988
Tanzania	6[b,c]	n.a.	16.4	Cooper-Poole 1986
Uganda	18/2[b,c]	n.a.	n.a.	Arya, Taber, and Nsanze 1980
Zaire	1.8	6.3	0.9	Luyeye and others 1990
Zambia	11.2	n.a.	14.3, 12.5	Ratnam and others 1982
Americas				
Chile	2	n.a.	n.a.	Donoso and others 1984
Jamaica	11[d]	n.a.	n.a.	George 1974
United States	1/9[d]	n.a.	n.a.	Mtimavalye 1987
Asia				
India	10	n.a.	n.a.	Jha and others 1978
Malaysia	0.5	n.a.	n.a.	Mtimavalye 1987
Thailand	12	n.a.	n.a.	Mtimavalye 1987

n.a. Not applicable.

a. Test for *Treponema pallidum*, the etiologic agent for syphilis, was used for both diseases. Acronyms—VDRL: Venereal Disease Research Laboratoary/RPR: Rapid Plasma Reagin/TPHA: Teponema Pallidum Hemagglutination Assay/FTA: Fluorescrent Teponema Antibody.

b. Women in general population.

c. Low fertility district/high fertility district.

d. White/black.

Sources: See last column.

The morbidity of CSTDs occurs mostly between the ages of fifteen and forty-five years—not only the sexually most active period in life but also the most economically and demographically productive age. Geographic differences in prevalence are obvious from table 20-2, but extrapolations on the scale of a continent cannot be made. Prevalence data on genital ulcerations in the general population are not available from the developing world, but rates of 4 to 8 percent have been found in female prostitutes in Central and East Africa (D'Costa and others 1985; Laga and others 1989). Genital ulcers do not directly lead to mortality. Without treatment, the very painful chancroid lesions take two to three months to heal. The time between onset of disease and the individual's presentation at a medical facility is often two to four weeks in Sub-Saharan Africa (Plummer and others 1983).

In men, the incidence of both gonococcal and chlamydial infections may be very high (up to 20 percent annually between the ages of fifteen and forty-five years in high-risk groups). Because the associated morbidity (urethritis) is mostly limited in severity and duration (one to five weeks), delay before seeking treatment may be as long as two years (Population Information Program 1983). Mild to severe urethral stricture may occur after urethritis in up to 3 percent of men, with the time between onset of urethritis and acute urinary retention ranging between a few days and several years (Bewes 1973; Osegbe and Amaku 1981). Treatment is difficult and time consuming, and such cases constitute up to 80 percent of the practice of urologists in some parts of Africa (Bewes 1973). Acute and chronic epididymitis may occur in 1 to 10 percent of cases of urethritis and may be associated with long-term morbidity and infertility. The proportion of cases of infertility in the male due to CSTDs has not been well defined, but it is estimated at 20 to 40 percent in the developing world (Population Information Program 1983).

In women, uncomplicated cervical infection with *Neisseria gonorrhoeae* or *Chlamydia trachomatis* is usually associated with nonspecific genital signs and symptoms, which interfere only minimally with daily activities. Complicated disease and its

sequelae are a significant cause of morbidity, however, and an important proportion of reproductive mortality, even in the United States (Grimes 1986).

Studies in Sweden have shown that 8 to 10 percent of women with gonococcal or chlamydial infection develop pelvic inflammatory disease (PID [Weström 1980]). The annual incidence of PID among urban women in Sub-Saharan Africa can be estimated at 1 to 3 percent between the ages of fifteen and forty-five, with incidence rates of 0.4 to 1.2 percent, and 0.4 to 1.5 percent for gonococcal and chlamydial PID, respectively (assuming that 20 to 40 percent of cases of PID are due to *N. gonorrhoeae* and 20 to 50 percent to *C. trachomatis*). Half of these cases occur during the puerperal period. The annual mortality directly attributable to PID in women of fifteen to forty-five years would then be 0.1 to 0.5 per 1,000 (assuming a 1 percent case-fatality rate). These figures are probably much lower in rural areas and in other parts of the developing world, but data are lacking.

The annual incidence of bilateral tubal occlusion (leading to infertility) is estimated at 0.3 percent to 1.5 percent in urban women in Sub-Saharan Africa, with gonococci and chlamydia each being responsible for 20 to 40 percent of cases (assuming a 15 to 40 percent risk of tubal occlusion after one episode of PID [Weström 1975; Weström and others 1979]). Whereas bilateral tubal occlusion is found in 50 percent of African women who are infertile, this is the case in only 14 to 20 percent of such women in Asia, Latin America, and the Middle East (Cates, Farley, and Rowe 1985).

The annual incidence of ectopic pregnancy in urban Africa resulting from PID is estimated at 0.01 to 0.04 percent, with an annual mortality rate of 0.001 to 0.005 percent for women between the ages of fifteen and forty-five (Urquhart 1979).

Finally, maternal mortality due to gonococcal and chlamydial infection (postpartum infectious complications) may be as high as 0.04 to 0.2 percent annually in Sub-Saharan Africa (with a maternal mortality rate of 0.5 to 1 percent and a 10 to 20 percent incidence of postpartum infections). Even in the United States, deaths due to STDs account for 20 percent of maternal mortality (Grimes 1986). In general, the overall mortality from STDs is not well defined. It is often a hidden mortality and morbidity because of a long latency period between the acute infection and the complication or sequela leading to death. In addition, the association between CSTDs and some of these complications is not well understood (Brunham, Holmes, and Embree 1989).

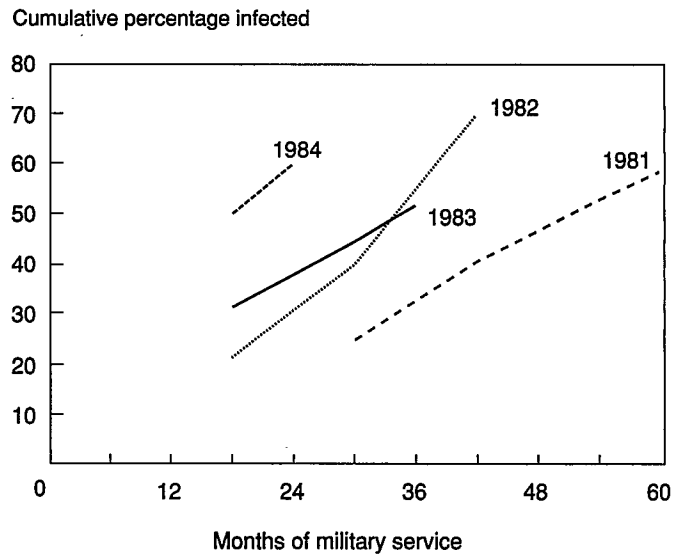
In neonates, conjunctivitis and respiratory disease are the main causes of morbidity due to *N. gonorrhoeae* and *C. trachomatis* infection in the mother. Their incidence depends on the prevalence of these infections in pregnant women. The occurrence of gonococcal ophthalmia neonatorum in neonates depends on whether effective eye prophylaxis is implemented at birth. Disablement from gonococcal neonatal infection is due to keratitis and blindness, and disablement from chlamydial infection results mainly from chronic respiratory disease.

Whereas prevalence rates of positive serologic tests for syphilis are available for numerous populations (see table 20-2), the morbidity and mortality due to the different stages of syphilis have not been documented for adults in the developing world. The consequences of syphilis for pregnancy have been better documented and are impressive. Approximately 10 to 12 percent of infants born to mothers with a positive syphilis serology will die during the neonatal period if untreated, yielding a mortality as high as 1 to 3 percent among under fours (in populations with a prevalence of a positive test for syphilis of more than 30 percent), in addition to a 20 to 25 percent stillbirth rate in the same group (Ratnam and others 1982; CDC 1986; Hira and Hira, 1987). Congenital syphilis is multiorganic and may result in severe physical and mental handicaps. Overall it occurs in 25 to 75 percent of exposed infants.

Trends for CSTDs and their complications between the early 1970s and the mid-1980s in the developing world are unknown. In Swaziland the prevalence rate of reactive syphilis serology among pregnant women remained at a level of approximately 30 percent between 1978 and 1987 (Ursi and others 1981; Guinness and others 1988), and in Rwanda the annual incidence of gonorrhea continuously increased among military recruits between 1981 and 1984 (Piot and Caraël 1988; see figure 20-1). Both sets of data suggest that the incidence of CSTDs in these countries remained at the same high levels during these periods. In contrast, the impressions gained from clinic-based data are that CSTD incidence has increased recently, particularly in urban populations.

HIV INFECTION. Because AIDS is a new disease, data on morbidity and mortality in the developing world are still fairly limited. Still, a growing set of data on the prevalence and incidence of HIV infection, as well as on the incidence of AIDS cases, is becoming available. The former data are probably the more important ones, because they indicate the number of

Figure 20-1. Gonorrhea Prevalence among Rwandan Military Recruits, by Months of Service



Source: Piot and Caraël.

people who will develop AIDS in the next decades. For the sake of simplicity, we equate morbidity and mortality rates for AIDS, because no widespread effective treatment is available in the developing world.

There is considerable variation in the prevalence and incidence of HIV infection throughout the world, on a given continent and even within countries, making extrapolations speculative. For instance, the male-to-female ratio of AIDS cases is less than one in Zaire and Uganda, but two to four in both Côte d'Ivoire and Senegal (Piot and others 1990). These variations are often not well understood, and the elucidation of their causes may provide important clues for preventive programs. The interaction among demographic, behavioral, and political factors probably determine how and where HIV spreads.

The three modes of transmission of HIV include sexual intercourse, parenteral exposure to blood and blood products, and vertical transmission from mother to child. For Africa and the Caribbean, it is estimated that more than 80 percent of those who are infected with HIV acquired their infection heterosexually. In Latin America, homosexual men account for the majority of cases (15 to 80 percent) of HIV infection, but heterosexual transmission appears to be increasing in several countries in the region. Finally, in Asia, where the virus has been introduced more recently, HIV is spread mainly among people with multiple sexual contacts and among intravenous (IV) drug users. The latter group appears to be particularly vulnerable, as shown by the rapid spread of HIV infection among drugs users in Thailand and Burma (Phanuphak and others 1989). The features of these three epidemiologic patterns in the world are summarized in table 20-3.

The rate of transmission of HIV varies with the mode of acquisition and seems influenced by a number of parameters. Thus, it is thought that the basic risk of acquiring HIV infection through vaginal intercourse is 0.1 to 0.5 percent and through receptive anal intercourse is probably ten times higher (Piot and others 1987; Johnson and Laga 1988). In the presence of other STDs, however, particularly those associated with genital ulceration, both the susceptibility to HIV infection and the infectiousness of an HIV-infected individual are increased several fold (five to ten times [Piot and others 1988; Pepin and others 1989]). In addition, the infectivity of an HIV seropositive person seems to increase just before or when he or she develops clinical disease (Johnson and Laga 1988). This may at least partly explain why HIV has spread more quickly in the hetero-

Table 20-3. Three Epidemiologic Patterns of HIV Infection

Characteristic	*Pattern I*	*Pattern II*	*Pattern III*
Major group affected	Homosexual and bisexual men and IDU	Heterosexuals	Persons with multiple sex partners
Period when introduced or began to spread extensively	Mid-1970s or early 1980s	Early to late 1970s	Early to mid-1980s
Sexual transmission	Predominantly homosexual. Over 50 percent of homosexual men in some urban areas infected. Limited heterosexual transmission occurring, but expected to increase.	Predominantly heterosexual. Up to 25 percent of 20- to 40-year age group in some urban areas infected and up to 90 percent of female prostitutes. Homosexual transmission not a major factor.	Both homosexual and heterosexual transmission just now being documented. Very low prevalence of HIV infection even in persons with multiple partners, such as prostitutes (except in some areas of Southeast Asia and India).
Parenteral transmission	After homosexual transmision, intravenous drug abuse accounts for the next largest proportion of HIV infections, even in Europe. Transmission from contaminated blood or blood products not a continuing problem, but existing cohort of persons infected by this route before 1985.	Transfusion of HIV-infected blood is major public health problem. Nonsterile needles and syringes account for undetermined proportion of HIV infections.	Not a significant problem at present in most countries, but growing problem in IDU in Southeast Asia.
Perinatal transmission	Documented primarily among female IDU and women from HIV-1 endemic areas	Significant problem in those areas where 5 to 15 percent of women are HIV-1 antibody positive.	Currently not a problem.
Distribution	Western Europe, North America; some in South America, Australia, New Zealand.	Africa, Caribbean, some areas in South America.	Asia, the Pacific Region (except Australia and New Zealand), Middle East, Eastern Europe, some rural areas of South America.

IDU Injecting drug users.
Source: Piot and others 1988.

Table 20-4. Estimated HIV-1 Seroprevalence by Residence and High-Risk Category, Developing Countries, 1990
(percent)

Country	Residence		
	Urban	Rural	High Risk[a]
Africa			
Angola	1.3[b]	—	14.2[b]
Benin	0.1	6.7	4.5
Botswana	0.8[c]	0.1[c]	1.2[c]
Burkina Faso	1.7[d]	3.1[b]	16.9[b]
Burundi	17.5	—	18.5[d]
Cameroon	1.1	0.4	8.6
Cape Verde	0.0	—	0.0
Central African Republic	7.4	3.7	20.6
Chad	0.0	0.0	—[d]
Congo	3.9	1.0	34.3[b]
Cote d'Ivoire	8.5[b]	3.3[b]	23.8[b]
Djibouti	0.3	0.0[d]	2.7
Egypt	0.0	—	0.2
Equatorial Guinea	0.3	0.3	—
Ethiopia	2.0	0.0	18.2
Gabon	1.8	0.8	—
The Gambia	0.1	—	1.7[b]
Ghana	2.2	—	25.2
Guinea	0.6[b]	0.2	—
Guinea Bissau	0.1	0.0	0.0[d]
Kenya	7.8	1.0	59.2
Lesotho	0.1	—	—
Liberia	0.0	0.0[c]	0.0[d]
Libya	0.0	—	—
Madagascar	0.0	—	0.0
Malawi	23.3	—	55.9
Mali	0.4	—	23.0[b]
Mauritania	0.06	—	0.0
Mauritius	0.0	—	—[d]
Morocco	0.0	—	7.1
Mozambique	1.1	0.8	2.6
Namibia	2.5	—	—
Niger	—	—	5.8
Nigeria	0.5	0.0	1.7
Rwanda	30.3	1.7	79.8[c,d]
Senegal	0.1[b]	0.0[d]	2.3[b]
Sierra Leone	3.6[b]	—	2.7[b]
Somalia	0.0	—	0.4
South Africa	0.1	—	3.2
Africa (continued)			
Sudan	0.0	—	16.0[d]
Swaziland	0.0[c,d]	—	—
Tanzania	8.9	5.4	38.7
Togo	—	—	—
Tunisia	0.0	—	1.9
Uganda	24.3	12.3	86.0[d]
Zaire	6.0	3.6	37.8
Zambia	24.5[d]	13.0[d]	54.0[d]
Zimbabwe	3.2[c]	1.4	—
Latin America			
Antigua and Barbuda	—	—	1.7
Argentina	0.3	0.1	5.8
Bahamas	0.5	—	—
Barbados	0.1	—	—
Bolivia	0.0	—	0.0
Brazil	0.3	0.0	3.0
Colombia	0.1	—	14.6
Costa Rica	0.0	—	0.0
Cuba	0.0	—	0.0
Dominican Republic	1.6	—	2.6
Ecuador	0.0	—	0.0[d]
Guadalupe	0.2	—	—
Guyana	—	—	0.0[d]
Haiti	4.9	3.0	41.9
Jamaica	0.3	—	14.6[d]
Martinique	0.5	—	38.9[d]
Mexico	0.7	—	2.2
Panama	0.0	—	0.0
Peru	0.1	—	0.3
Trinidad and Tobago	0.9	—	13.0
Venezuela	0.0	0.0	—
Asia/Oceania			
Burma	—	—	1.9
India	0.1	—	18.1
Papua New Guinea	0.0	0.0[d]	0.7
Philippines	0.0	—	0.1
Thailand	0.0	—	0.2

— Data not available.
a. Prostitutes and clients, STD patients, or other persons with known risk factors.
b. Infection with only HIV-1 and dual infection (HIV-1 and HIV-2).
c. Data prior to 1986.
d. Data not necessarily reliable because small sample size (less than 100).
Source: U.S. Bureau of the Census 1991.

sexual population in Africa than in North America and Europe; genital ulcer disease seems to be more common in several African populations, and HIV has probably been present for a longer time among heterosexuals in Africa, resulting overall in a higher infectiousness of the HIV-infected population (Piot and others 1988).

Risk factors for HIV infection are generally those of other STDs, such as having a high number of sex partners, being single, having a history of STDs, and having sex with prostitutes or being a prostitute. Urban populations usually have much higher infection rates than rural populations (see table 20-4), though this may change when the epidemic spreads. Lack of circumcision has been claimed to be a risk factor for HIV infection in men, but this remains controversial (Van de Perre and others 1987; Simonsen and others 1988; Bongaarts and others 1989).

The efficiencies of transmission by a blood transfusion or by intravenous needle sharing are probably close to 100 percent. Because of a high rate of infection among young adults in several populations, and because of the incomplete availability of HIV antibody tests, HIV infection through blood transfusion makes up a larger proportion of cases of AIDS in pattern II countries than in Europe or North America. This is particularly the case in children, who are the main consumers of blood transfusions in large areas of the developing world, together with pregnant or parturient women. This is due to a high incidence of severe anemia caused by malaria or obstetrical problems (Greenberg and others 1988; Ryder and Mhalu 1988). In addition, indications for blood transfusion may not always be rational, and proper blood banks, involving voluntary, low-risk donors, are rarely functioning. Finally, there are now several reports of probable HIV transmission to blood donors through contaminated plasmapheresis equipment (Laga and Piot 1988).

Whereas it is often assumed that intravenous drug use is a prerogative of the rich West, the AIDS epidemic has dramatically shown that intravenous drug use is spreading rapidly in many developing countries. Thus, more than 40 percent of Thai IV drug users were infected by early 1989, as compared with 1 percent in 1987 (Phanuphak and others 1989). It is anticipated that similar outbreaks of HIV infection among IV drug users will occur in other developing countries. The role of contaminated medical injections in the spread of HIV infection is probably marginal (Piot and others 1988; Van de Perre and others 1987, Berkley 1991).

The rate of vertical transmission from mother to child is of the order of 25 to 50 percent in Africa, with women who are more advanced clinically being more infectious for their offspring (Lallemant and others 1989; Ryder and others 1989). Because of the mainly heterosexual spread of HIV in Africa, and increasingly in the Caribbean, a large and growing proportion of AIDS cases are infants and children. The incidence of AIDS is probably underestimated, however, because of technical problems in the diagnosis of AIDS and HIV infection in infants. In addition, there is growing evidence that an as yet unknown proportion of perinatally infected children do not become ill until the age of seven to ten years. This implies that it will take at least another decade before the full spectrum of morbidity and mortality of perinatally acquired HIV infection is known.

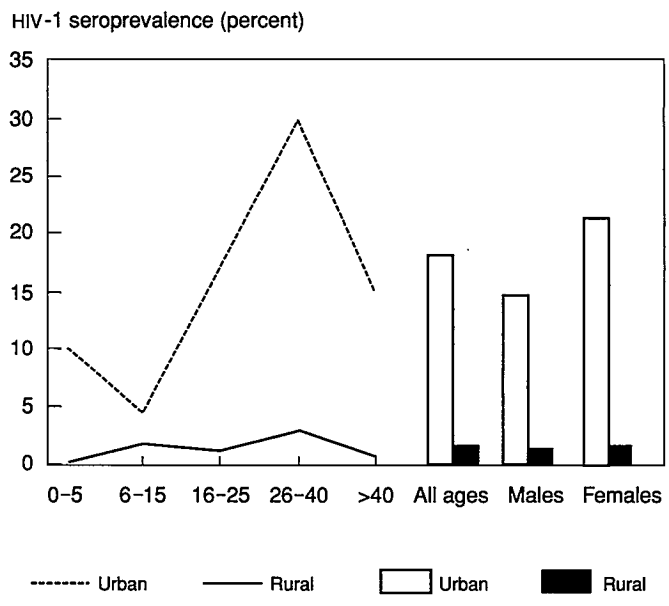
Although a limited number of anecdotal cases of HIV infection acquired through breastfeeding have been reported (Ziegler and others 1985; Colebunders and others 1988; Hira, Kamanga, and Bhat 1989), it appears that contaminated breast milk does not contribute significantly to the transmission of HIV infection from mother to child (Ryder and others 1990). Furthermore, Kennedy and others (1990) have convincingly argued that the health damage from bottle-feeding would probably exceed any gains from the averted transmission by breast milk.[6] Thus, there is currently no reason to modify current promotion of breastfeeding in HIV endemic areas in the developing world.

Finally, the effect of HIV infection on the natural history of childhood diseases, such as measles and malaria, is incompletely understood. Preliminary data suggest that HIV infection in children does not influence the response to childhood immunizations, though, again, it is not clear what the effect of HIV infection on protective immunity will be when the immune status of these children deteriorates (Mvula, Ryder, and Manzila 1989).

In pattern II countries, on which we focus (mainly Sub-Saharan Africa), the overall female-to-male ratio of people with HIV infection usually approaches one to one, though regional variations have been reported. A marked variation in sex ratio, however, has been found by age group in some countries (for example, Zaire), where HIV-seropositive women largely outnumbered men between fifteen and thirty years of age, whereas there were more infected men than women above that age (Ryder and Piot 1988). Several surveys in Africa have also found that the HIV seroprevalence rate is highest in individuals between twenty and forty years of age and that peak seroprevalence rates occur at a younger age in women than in men (Ryder and Piot 1988). This age pattern for both sexes combined is illustrated in figure 20-2; in the figure the HIV-1 seroprevalence rates are shown by age group as found in a national serum survey in Rwanda in 1986, in which a random cluster sampling method was used. The Rwandan data also indicate a higher infection rate for urban women than urban men (Rwandan Seroprevalence Study Group 1989).

In table 20-4 we summarize seroprevalence data in various groups of adults in different developing countries. The highest rates are consistently found in Central Africa, but epidemic foci start appearing in other parts of the continent as well, for

Figure 20-2. Seroprevalence of HIV-1 in Rwanda, by Age, Residence, and Gender, 1986



Source: Bugingo and others 1988; Rwandan seroprevalence study group 1989.

instance, in Côte d'Ivoire. In addition, within each country, prostitutes are at a much higher risk of infection and constitute part of a "core" group of highly sexually active individuals whose special role in the epidemic is described below. In the Latin American cities homosexuals also show the higher prevalence rates associated with core groups.

Annual incidence rates of 0.5 to 1.8 percent for HIV infection among adults without particular risk factors have been documented in Central Africa (N'Galy and others 1988). Still, such rates were as high as 10 to 40 percent among highly exposed prostitutes in Kinshasa and Nairobi (Laga and others 1989; Plummer and others 1991).

In table 20-5 we present the cumulative number of cases of AIDS by continent reported to the World Health Organization (WHO) as of August 1989. The data from Africa in particular probably represent gross underestimations, and a figure of 250,000 AIDS cases by 1988 seems closer to reality. These morbidity data ultimately also indicate the number of deaths due to HIV infection.

Although HIV infection has been introduced recently in all populations (mid-1970s to mid-1980s), it has spread more rapidly in some than in others (figure 20-3). Possible patterns of morbidity and mortality during the next twenty-five years are difficult to predict because of inadequate knowledge of the natural history of the disease, of behavioral patterns in different populations, and of the potential changes in the relative contributions of different modes of spread of HIV. Based on current trends in some Latin American and Caribbean countries, however, it is anticipated that heterosexual transmission will become much more important in the Americas, and perhaps also in Asia, than it is at the present time. In the near future, it appears that proportionately more women and more poor people will be among those with HIV infection and AIDS. Furthermore, dense urban populations with high rates of drug use or STDs, like those of Abidjan and Bangkok, may soon experience rapidly spreading HIV epidemics (De Cock, Pozter, and Odehouri 1989; Phanuphak and others 1989).

In 1989, WHO (1989c) estimated that by the year 2000 annual adult AIDS cases would rise from the present level of fewer than 100,000 per year to more than 800,000 per year. In the same survey it was estimated that adult HIV infections would rise to 13 million worldwide (Chin, Sato, and Mann 1989).

In addition to the morbidity directly caused by HIV infection, one should also consider the excess morbidity from other diseases as a result of HIV infection. This has already been documented for tuberculosis in the United States and several African countries, where the incidence of tuberculosis is rising as a result of the HIV epidemic (CDC 1989; Colebunders and others 1989; Standaert and others 1989).

Socioeconomic Correlates of HIV Infection

Information on the correlation, or lack of correlation, of STD incidence rates with socioeconomic indicators would be epidemiologically useful in several ways. First, such information could help in the effort to target interventions. Second, it could help us to understand the practices which spread the disease. And, finally, it could tell us more about the diseases' effects on society.

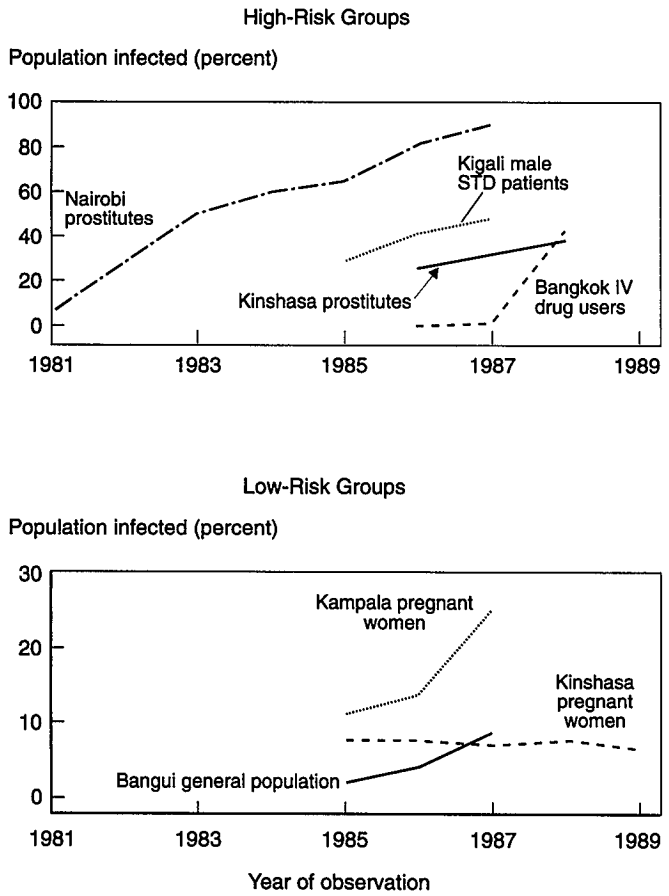
Unfortunately very little information has been available on STDs. Because individuals have incentives to hide an STD infection—and because the rich can hide these infections more successfully—any data on STD incidence or prevalence by social class were known to be suspect. With HIV infection, however, the situation has reversed itself. Because HIV/AIDS is

Table 20-5. Reported and Estimated Cases of AIDS, by Region and Stage of Development, 1990

Region	Reported cases		Estimated cases	
	Number	*Per million population*	*Number*	*Per million population*
Industrial countries				
United States and Canada	159,194	577.9	175,000	635.3
Europe	43,441	71.2	48,000	78.7
Australia	2,347	140.2	3,000	179.2
South Africa	650	17.8	1,000	27.4
Japan	294	2.4	300	2.4
New Zealand	207	61.7	200	59.6
Total	206,133	193.4	227,500	213.5
Developing countries				
Sub-Saharan Africa	81,833	173.0	648,000	1,369.7
Latin America and the Caribbean	31,943	71.7	275,000	617.3
Europe	2,462	13.9	52,000	293.7
North Africa and Mediterranean	686	1.5	1,000	2.2
Western Pacific	180	0.1	2,500	1.9
Southeast Asia	141	0.1	5,000	3.7
Total	117,245	27.7	983,500	232.8
Total	323,378	61.1	1,211,000	228.9

Source: Reported cases from World Health Organization 1991a; Chin, Global Programme on AIDS, WHO; Zachariah and Vu 1988.

Figure 20-3. Evolution of HIV Seroprevalence in Selected Populations of Developing Countries



Source: Piot and others, 1990.

known to be fatal, wealthy people are alleged to have identified themselves in the hope of getting treatment. Thus, some have argued that estimated HIV infection rates by class are biased toward a higher infection rate for higher classes.

The data on this question are still scarce; we are aware of no data outside Africa. In table 20-6, however, we present information from three studies in three different African countries, all of which confirm the hypothesis of higher prevalence rates at higher income levels. These patterns might be explained by the relatively greater access of the rich to foreign travel or, alternatively, by greater rates of sexual partner change among higher-income adults. In either case, the pattern may dissolve as the epidemic spreads in a given population. Additional work is needed not only on prevalence rates but also, and especially, on incidence rates by social class so that public health officials can determine how best to target their control efforts.

It has been asserted, but not demonstrated, that the correlation between infection rates and higher social status is positive for men but negative for women.[7] Larson (1989) and Caldwell, Caldwell, and Quiggin (1989) advance an image of the sociosexual role of the African woman that predicts just such a possibility. In Larson's words:

> Independence has not altered the ambivalence and outright hostility towards urban women generated during the colonial era. . . . Most East and Central African countries have taken actions to restrict urban women's activities. These range from the banning of miniskirts and other provocative clothing to more threatening actions such as attempts to bus unmarried women out of town or arresting unescorted women found on the streets or in bars hotels and cinemas at night (Larson 1989, p. 4).

As a result of these powerful negative incentives, there are many fewer young women than young men in the sexually most active age range in the urban centers of countries such as Côte d'Ivoire, Kenya, Rwanda, Burundi, and South Africa. It is natural to hypothesize that in these situations the demand by the young men for prostitution services is very high. In contrast, in cities which are relatively hospitable to young women, such as those of Zaire, Senegal, and Mali, the demand for sexual services can be expected to be smaller.

But the quantity of commercially supplied sexual services is determined by the supply as well as the demand. The supply will be high only if the potential suppliers have relatively few remunerative alternatives. We hypothesize that the number of women enrolled in secondary school per 100 men enrolled is a good indicator of the opportunity cost of the time of urban women.[8] In cities in which women are relatively well educated, we expect that, other things being equal, fewer women will become prostitutes and the HIV virus will spread more slowly.

More empirical evidence for the proposition that women's education and a high ratio of females to males might both contribute to reducing the prevalence of STDs is presented in figure 20-4. The upper-left panel of the figure displays a scatter plot of 1987 HIV prevalence rates against the urban ratio of females to males.[9] Note that the higher prevalence rates are associated with urban areas in which there are many fewer young adult women than men. The upper-right panel of figure 20-4 shows, for the same countries, the association between HIV prevalence and the ratio of female to male secondary education enrollment.[10] Here, the relationship is even more marked, with the highest seroprevalence rates observed in those countries with the poorest record on female education. For the smaller number of countries for which the infection rate of female prostitutes was known in 1987, the left lower panel of figure 20-4 demonstrates even more strongly the hypothesized effect of small female-to-male ratios—a high prevalence rate of HIV infection among prostitutes.

A multivariate regression of urban adult HIV seroprevalence rate on these two indicators of the status of women explains 48 percent of the variation in prevalence rates and is statistically significant at the 1 percent significance level. In this sample, each of the two variables, urban adult sex ratio and female education, contributes independently and significantly to explain variation in the seroprevalence level.[11]

Because this regression equation was estimated on a cross-section of cities, in some of which the HIV prevalence rates may still be rising, the relationship is likely to shift over time. Still,

Table 20-6. Relationship of Socioeconomic Status with Higher Rates of HIV Infection in Sub-Saharan Africa

Country	Date	Sample: Population	Sample: Size	Socioeconomic indicator	HIV infection rate (percent)
Rwanda	1987	National sample of urban adults	1,255	*Education*	
				Primary or less	20.8
				More than primary	29.6
Zaire	1987	Employees of urban textile factory	5,951	*Job*	
				Worker	2.8
				Foreman	4.6
				Executive	5.3
Zambia	1985	Patients, blood donors, personnel of urban hospital	1,078	*Years of education completed*	
				0–4	8.0
				5–9	14.7
				10–14	24.1
				15 or more	33.3

Source: Melbye, Nselesani, and Bayley 1986; Bugingo and others 1988; Ndilu and others 1988.

the strong estimated effects of these two indicators of low female status on the prevalence of HIV infection are likely to persist. An implication is that one of the most promising ways to fight STDs over the longer run is to improve the education and increase the number of urban women.[12]

Public Health Significance of STDs

This section presents estimates of the burden of STDs and of the benefit of averting a case of CSTD and HIV infection.

Health Lost and Saved

Many other categories of diseases, as well as CSTDs and HIV, have substantial public health significance. In order to attach a priority ranking to STD interventions in a specific country, it is necessary to attempt to quantify the public health effect of STDs in comparison with other diseases in that country. Two broad methods are relevant. First, one can compute any of a variety of measures of the good health that is *lost* as a result of these diseases in comparison with others. Second, one can estimate the good health that would be *saved* by interventions on each category of disease.

The computation of the amount of good health lost due to each prevalent disease in a developing country was pioneered by the Ghana Health Assessment Project Team, hereafter referred to as GHAP (1981). The method the investigators used was to multiply a measure of the disability-adjusted life-years lost (DALYs) from a case of each disease by the annual incidence of that disease to obtain an estimate of the average annual burden of each disease on a typical member of the population.[13] Expressed as a formula, the equation for each disease is:

$$\text{DALYs} = \text{Cases/capita/year} \times \text{DALY/case}$$

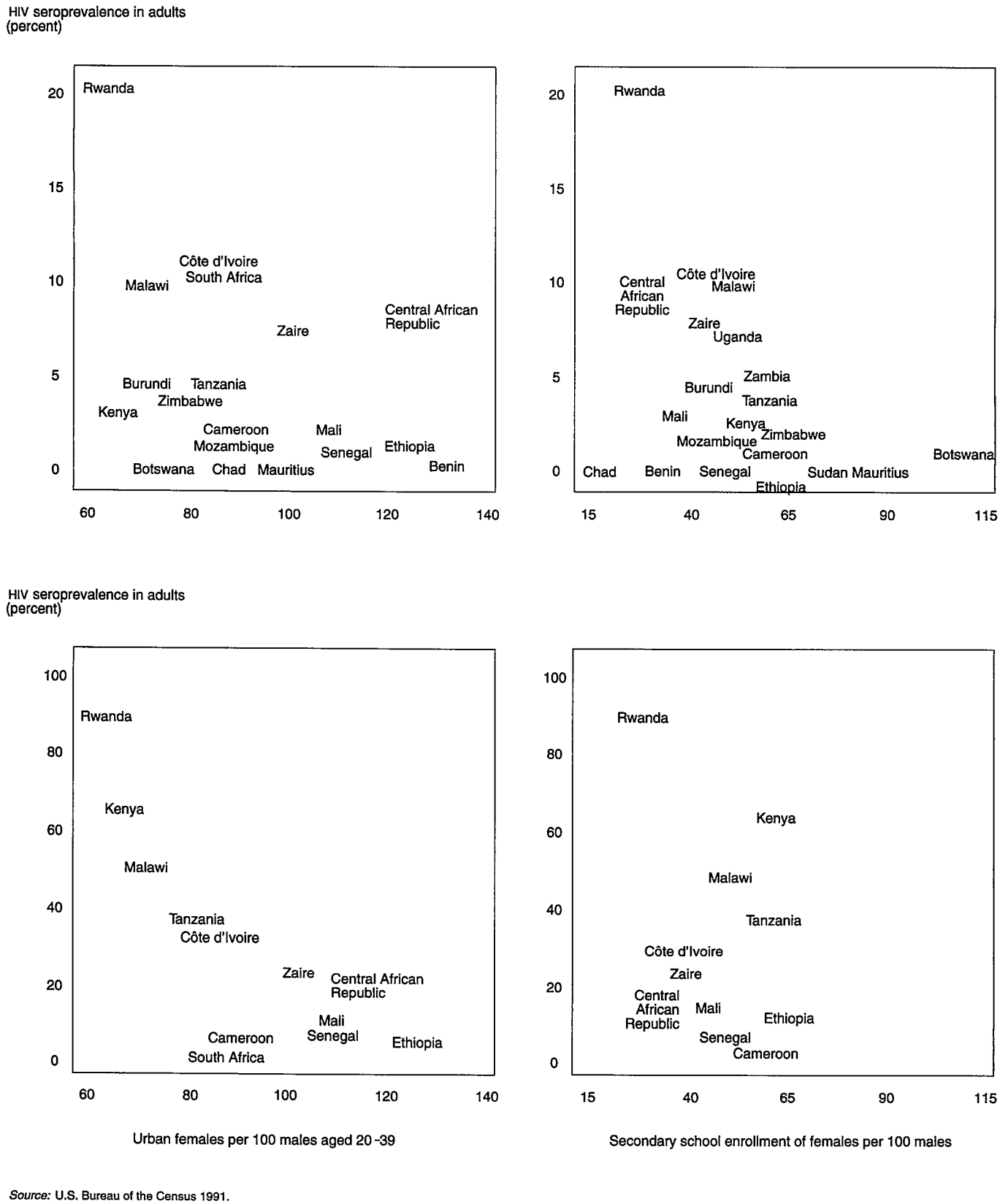
By comparing estimates of DALYs per capita per year across diseases, one arrives at an estimate of the relative contribution of each disease to the total burden of ill health borne by a given population. Furthermore, these estimates indicate the total health benefit that would accrue from eradicating one of the diseases.

The example of smallpox notwithstanding, eradication is unfortunately not usually an option available to public health decisionmakers. Instead they are asked to make decisions at the margin, allocating 10 percent more of their resources to this prevention effort, perhaps by cutting resources on another effort. As GHAP recognized (1981), estimates of total burden are not useful for these marginal decisions. Instead decisionmakers need to know (a) how many disability-adjusted life-years could be saved for every case of the disease prevented or cured and (b) the relative costs of preventing or curing a case of each disease. In this section we present and interpret the burden measures, from both the static and the dynamic perspective. Then in the next two sections we turn to the second and perhaps more important issue, the estimate of the health effect of averting a case of an STD, again from both a static and a dynamic perspective.

The Static Burden of STDs

Analyses of the public health importance of sexually transmitted diseases have not typically accorded them great importance either in absolute terms or in relation to other infectious and parasitic diseases. For example, GHAP ranked "venereal disease" number 53 in order of the burden it imposed on the population of Ghana in the 1970s. Partly because of AIDS and partly because of a new understanding of how widespread the CSTDs are, especially in Africa, and how damaging their sequelae, opinion has begun to shift toward a more serious appreciation of the harm done by these diseases—and of the potential benefits of their alleviation. (See, for example, Curran 1980; Brown, Zacarias, and Aral 1985; Grimes 1986; Washington, Arno, and Brooks 1986; Washington, Johnson, and Sanders 1987; Wasserheit 1989).

Figure 20-4. Correlation of Urban HIV Infection with Gender and Schooling in African Countries, 1987



Source: U.S. Bureau of the Census 1991.

In view of the heterogeneity of the epidemiological picture and the gaps in available information, it is difficult to discuss in detail the public health effect of STDs on any specific country. Instead we define a typology of countries according to the estimated prevalence rates of CSTD and HIV infection in the sexually active populations of their main urban centers. In table 20-7 we define nine patterns of STD prevalence and tentatively classify representative countries from Africa, Latin America, and Asia.

In order to compute estimates of the "burden" of each of the various diseases in model countries, we apply the method originally developed by GHAP (1981) and extended by Barnum (1987) and Over, Bertozzi, and Chin (1989), which is based on the above simple equation. In appendix 20A we present calculations of the number of disability-adjusted life-years lost per case for the STDs and other important diseases, which is one of the two pieces of the formula. The other necessary component is the estimated incidence rate for each disease. Because incidence rates of STDs are largely unknown, we "guesstimate" the age structure of incidence for each STD in each of the two extreme urban settings described in table 20-7, a high-prevalence urban setting and a lowprevalence one. Our guesstimates appear in table 20-8, together with estimates for the other diseases which have been derived from the GHAP study of Ghana. The estimated STD incidence rates might apply anywhere in the world that an urban area can be characterized as in table 20-7. The estimated incidence rates for the other diseases, however, are specific to Ghana in the late 1970s and can only indicate the rough orders of magnitude of the burdens of these diseases in other times and places.

Table 20-7. *Urban Prevalence of* HIV *and* CSTD, *by Region*

CSTD Prevalence[a]	Prevalence of HIV infection[b]		
	Low or unknown	*Intermediate*	*High*
Low or unknown	Cambodia	Angola	None
	Cape Verde	Botswana	
	China	Burkina Faso	
	Eastern Europe	Namibia	
	Middle East	Sierra Leone	
	Niger		
	Togo		
	Viet Nam		
Intermediate	India	Congo	None
	Senegal	Mali	
		Zaire	
		Zimbabwe	
High	Brazil	Cameroon	Burundi
	Colombia	Caribbean Nations	Côte d'Ivoire
	Lesotho	Central African Republic	Malawi
	Madagascar	Ethiopia	Rwanda
	Mauritania	Gabon	Uganda
	Mexico	Ghana	Zambia
	Nigeria	Kenya	
	Philippines	Mozambique	
	Swaziland	Tanzania	
		Thailand	

a. High: rates of gonorrhea among sexually active adults exceed 5 percent or prevalence of serological markers for syphilis exceed 10 percent in pregnant women. Intermediate: prevalence below these levels but at least 1 percent for both of these diseases. Other countries are categorized as "low or unknown."

b. Low or unknown: less than 1 percent. Intermediate: between 1 and 10 percent. High: more than 10 percent.

Source: Authors.

Multiplying the age-specific incidence rate of a disease (from table 20-8) by the disability-adjusted life-years lost per case from that disease at that age group (a calculation intermediate to obtaining the figures in table 20A-3), converting the result to days (by multiplying by 365), and, finally, computing the weighted average of these products across all age groups, with the age-group size as the weight, yields the estimated number of healthy life-days lost per capita per year from a given disease. In table 20-9 we present the results of this calculation, and in figures 20-5 and 20-6 we portray them.

The rather surprising feature in table 20-9 is that *the burden of STDs in a high-prevalence urban area is a substantial fraction of the entire disease burden of that population.* By itself, HIV ranks second on the discounted disability-adjusted life-days (DALD) criterion and moves up to first when lost days are weighted by their relative productivities. Furthermore, the sum of the burdens of HIV, syphilis, and chlamydia equals 85 DALDs and 63 productivity-weighted discounted disability-adjusted life-days (PDALDs) per capita, enough to place these STDs in aggregate at the top of the list in importance in an urban high-prevalence area. The eleventh ranking disease in table 20-9 and figures 20-5 and 20-6 is chlamydia, which attains its rank because of an extremely high incidence rate in ages fifteen to fifty and an assumption that 5 percent of cases are permanently disabled to the extent of 30 percent incapacity for women (crippling pelvic inflammatory disease) and 50 percent for men (severe urethral strictures). Only chancroid appears in these calculations to have an effect as small as that attributed by GHAP to all STDs together, but new information on the likely links between genital ulcers and the probability of transmission of HIV infection may promote chancroid far above its place here. (See the discussion below of the effect of genital ulcers on the transmission of STDs.) In contrast, in low-prevalence urban areas, syphilis is the most burdensome STD, and its burden is less than that of any of the top fifteen Ghanaian diseases.

The Short-Term Dynamic Burden of an STD Epidemic

In order to illustrate the essential features of dynamic STD epidemiology and to characterize the differences among epidemics of the different STDs, it is useful to experiment with two simple models of an STD epidemic. In this section of the chapter, these models extend our estimates of the burden of STDs by incorporating the fact that each case causes additional

Table 20-8. Incidence of STDs and Other Important Diseases, by Age
(per 1,000 people)

Disease	Prevalence[a]	Sex	Age (years) 0–1	1–4	5–14	15–49	50–64	65+
Sexually transmitted disease								
Chancroid	High	Both	0	0	0	12.5	9	0
	Low	Both	0	0	0	1.25	0.9	0
Chlamydia	High	Male	50	0	0	50	5	0
	High	Female	50	0	0	37.5	0	0
	Low	Male	5	0	0	5	2.5	0
	Low	Female	5	0	0	3.75	0	0
Gonorrhea	High	Male	25	0	0	45	4.5	0
	High	Female	25	0	0	30	0	0
	Low	Male	2.5	0	0	5	0.45	0
	Low	Female	2.5	0	0	3	0	0
HIV	High	Both	20	0.5	2.5	15	2.5	0
	Low	Both	0.1	0	0	0.3	0	0
Syphilis	High	Male	25	0	0	20	2.5	0
	High	Female	25	0	0	20	2.5	0
	Low	Male	2.5	0	0.5	2	0.25	0
	Low	Female	2.5	0	0.5	2	0.25	0
Other diseases								
Birth injury	n.a.	Both	36	0	0	0	0	0
Cerebrovascular disease	n.a.	Both	0	0	0	3	9	12
Cirrhosis	n.a.	Both	0	0	0	1.2	1.2	1.2
Congenital malformations	n.a.	Both	21	0	0	0	0	0
Gastroenteritis	n.a.	Both	800	200	5	5	5	5
Injuries[b]	n.a.	Both	5	6	7.7	9	5	5
Malaria	n.a.	Both	600	100	0	0	0	0
Measles	n.a.	Both	375	150	0	0	0	0
Pneumonia, adult	n.a.	Both	0	0	0	12	13	15
Pneumonia, child	n.a.	Both	7	9	3	0	0	0
Prematurity	n.a.	Both	213	0	0	0	0	0
Severe malnutrition	n.a.	Both	8	6	0.5	0.1	0.1	0.1
Sickle cell	n.a.	Both	28	0	0	0	0	0
Tetanus (neonatal)	n.a.	Both	11.2	0	0	0	0	0
Tuberculosis	n.a.	Both	0.5	0.5	1	3	3	3

n.a. Not applicable.
a. For STD, urban areas of high or low prevalence in pattern II countries, defined by table 20-7.
b. Such as accidents.
Source: Authors; diseases not related to STDs, Ghana Health Assessment Project Team 1981.

future cases. In the next section these same models will be useful in estimating the effect of alternative interventions on the course of an epidemic of each STD.

The model presented first is a short-run model of the course of an STD epidemic within the confines of an enclosed stable population. Although this model reveals some features of an HIV epidemic, its focus is too short-term to represent fully the important effects of such a slow-acting disease. Thus, after exploring the implications of a short-term model, we turn to a presentation of a longer-term demographic model, which incorporates the interactions between an AIDS epidemic and the demographic features of a population.

The short-run model posits just two groups of individuals, a core and a noncore group, which have different sizes and different rates of sexual activity. To predict the pattern of an epidemic from the starting prevalence rates of infection in these two groups, it is sufficient to specify only two sets of parameters, one set to describe the sexual behavior of the two groups and one to describe the medical characteristics of the disease to be modeled.

We characterize the sexual behavior of the two groups by making the following assumptions:

- The core group of highly sexually active people increases (both men and women) includes 1,000 individuals, only 2 percent of the 50,000 in the noncore group.
- Individuals in the core group are ten times as sexually active as those in the noncore group, with the former having a new sexual partner every five days and the latter every fifty days.[14]
- In choosing new sexual partners, individuals exercise no preference according to group but instead select randomly among all individuals who are choosing new partners during that time period.[15]

Table 20-9. Per Capita Annual Disease Burden of STDs and Other Diseases in Sub-Saharan Africa

Disease	Discounted disability-adjusted life-days lost		Discounted productive disability-adjusted life-days lost	
	Value	Rank	Value	Rank
Measles	68.9	1	45.1	2
HIV[a]	60.6	2	48.3	1
Malaria	55.1	3	35.2	3
Gastroenteritis	35.7	4	22.4	4
Syphilis[a]	15.9	5	9.3	5
Birth injury	12.4	6	7.7	6
Sickle cell	11.3	7	6.5	9
Prematurity	10.1	8	6.4	10
Pneumonia, child	9.7	9	7.1	7
Severe malnutrition	8.6	10	5.7	13
Chlamydia[a]	8.6	11	5.8	12
Cerebrovascular disease	7.9	12	6.6	8
Injuries (i.e., accidents)	7.5	13	6.0	11
Tuberculosis	5.2	14	4.1	14
Pneumonia, adult	4.8	15	4.0	15
Tetanus (neonatal)	4.2	16	2.6	17
Cirrhosis	3.7	17	3.0	16
Congenital malformation	3.6	18	2.2	18
Gonorrhea[a]	1.9	19	1.2	19
Syphilis[b]	1.3	20	0.7	21
HIV[b]	1.0	21	0.8	20
Chlamydia[b]	0.8	22	0.5	22
Gonorrhea[b]	0.6	23	0.4	23
Chancroid[a]	0.5	24	0.3	24
Chancroid[b]	0.05	25	0.03	25
Total non-STDs[c]	303		204	
Total STDs[a]	88		65	
Total STDs[b]	3.6		2.5	

Note: Burdens are summed over the entire population of both genders.

a. Sexually transmitted disease; high-prevalence urban area.

b. Sexually transmitted disease; low-prevalence urban area.

c. In addition to the listed non-STDs, this total includes forty-one other diseases, all with values of discounted DALDs and productivity-weighted discounted DALDs lost per capita less than 4.0.

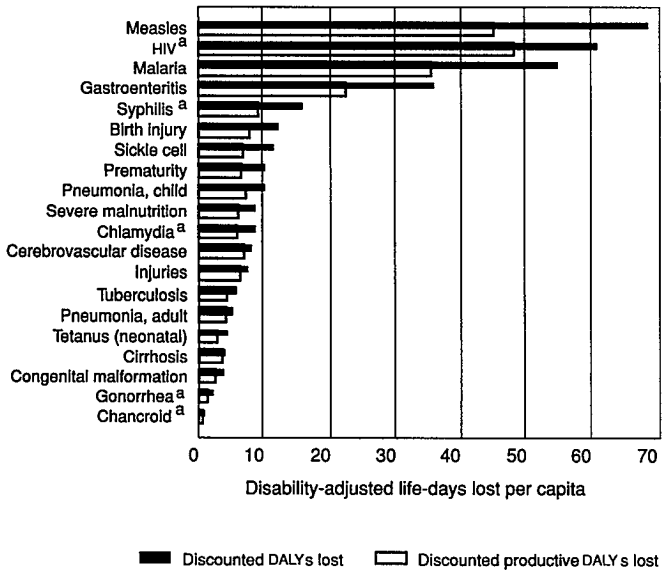
Source: Ghana Health Assessment Prject Team 1981; authors.

These specific values were used by Hethcote and Yorke (1984, p. 38) in their gonorrhea model. For ease of reference, they are presented together with some other derivative parameters in table 20-10. It must be emphasized that these parameters are not considered to be representative of African populations. Although they were originally chosen by Hethcote and Yorke to characterize a North American gonorrhea epidemic, sexual behavior varies enormously in the United States just as it does in Africa, and these parameters are not known to be typical of a specific North American population either. The intention here is not to predict accurately every detail of an STD epidemic in Africa with a single model, a hopeless and senseless task. Rather, by presenting the results of simulations with this model, we intend to develop an analytical technique for approximating the public health effect of these diseases, *assuming the parameters of sexual behavior were known*. Because a great deal of effort is currently being expended to determine these quantities, before long it may be possible to substitute for the assumptions in table 20-10 some numbers based on empirical data.[16]

For the purpose of this modeling exercise, only two aspects of each disease are required, the probability of transmission per new sexual partner and the number of days that an infected person remains infective before recovering or dying.[17] In the first four rows of table 20-11 we summarize this information for six distinct STD epidemics to be modeled. In contrast to table 20-10, which is not intended to be particularly representative of a specific part of the world, the estimates in table 20-11 have been adjusted to approximate as closely as possible the medical characteristics of these diseases in Sub-Saharan Africa. Note that the probability of transmission of HIV infection on a single encounter is assumed to increase by a factor of three to five in the presence of genital ulcers. For this reason, we distinguish HIV in the absence of genital ulcers as a separately analyzed epidemic from HIV infection in their presence.

The parameters which represent the average duration of infectivity should be thought of as determined by the interplay of demand and supply for medical care. Factors which influence demand include the discomfort caused by the disease and socioeconomic characteristics of the infected individual. Dis-

Figure 20-5. Static Burden of STDs in Relation to Other Diseases in a High-Prevalence African City



a. Sexually transmitted disease.
Source: Authors' estimates; Ghana Health Assessment Project Team 1981.

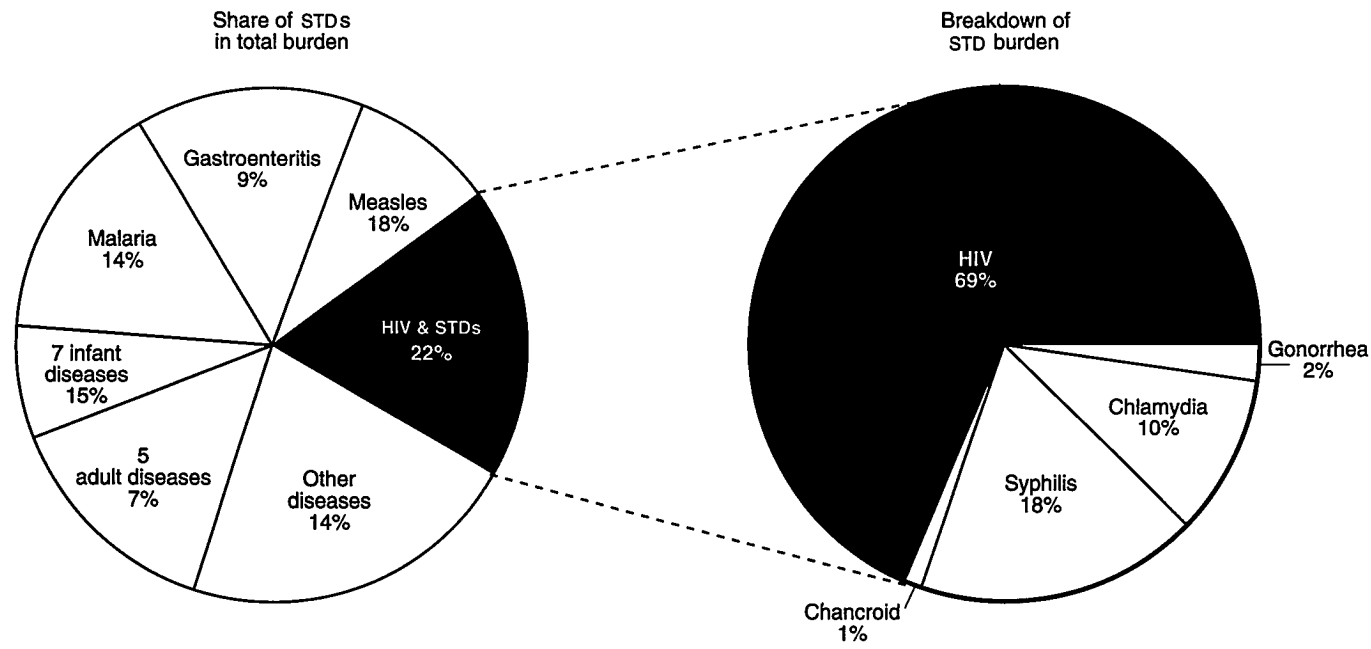
comfort is known to vary by disease, by sex, and randomly across individuals. Socioeconomic factors which affect demand for medical care of an STD will include the income, education, geographical location, attitude toward STDs, and access to household resources of the infected individual. Supply considerations, such as the availability and quality of medical services, will also affect the duration of infectivity. Because we believe that the demand factors conspire with the supply factors in lengthening the duration of the average STD infection in many developing countries, we adopt assumed periods of infectivity which are roughly twice the durations typically found in industrial countries.

Because our model does not distinguish between the sexes, we must choose single values of the transmission probability and the duration of infectivity for each disease. Rows three and six of table 20-11 present these parameters, which are the averages of the parameters for the separate sexes.

A full statement of the model requires the specification of the equations of motion that determine the flows of individuals from the pool of susceptibles in a group (that is, the healthy, uninfected, nonimmune individuals) into the pool of infected in that group (that is, those individuals who suffer the consequences of the disease and are capable of transmitting it). In appendix 20B we present these equations and the derivations of the assertions made in the next few paragraphs.

Suppose the noncore group were isolated from the core. Under this assumption, row eight of table 20-11 shows the value of the reproduction rate in the noncore group for each simulated epidemic. Recall that a reproduction rate less than unity implies that the disease will fail to reproduce itself, dying out over time. Gonorrhea and chancroid would behave this way in the noncore group, because the reproduction rates in this group, in the absence of interaction with the core, would be 0.825 and 0.293, respectively. In contrast, note the particularly high value of 4.32 for the reproduction rate of HIV with ulcers in the noncore group. Also, note from row seven that

Figure 20-6. Share of STDs in Total Disease Burden in a High-Prevalence African City, and Proportion of STDs



Source: Authors' estimates.

Table 20-10. Assumptions for Base Run of Core and Noncore Groups

Parameter	Symbol[a]	Sexual activity risk groups: Core	Noncore
Group size	N	1,000	50,000
New sexual partners per day	a	0.2	0.02
Total encounters per day per group	aN	200	1,000
Ratio of group encounters to total	b	0.167	0.833
Selectivity	G	0	0
Mixing coefficients	M_{1i}	0.167	0.833
	M_{2i}	0.167	0.833
Starting prevalence by group	I_0	0.2	0.01

a. See appendix 20B for the definitions of parameters not defined in the text. All these parameters are group specific except G, which is constant across groups.
Source: Authors' construction.

all the diseases can sustain themselves independently in the core.

Another important consequence derivable from the reproduction rate is the equilibrium level of prevalence of a disease in a single isolated group. Because infected individuals remain infected only D days, it is possible for an equilibrium to be established between the flows of individuals into and out of the infected pool. In appendix 20B we show that the equilibrium prevalence rate for an epidemic confined to a single group with reproduction rate R greater than one is simply expressed as $(R - 1)/R$. The fourteenth and fifteenth rows of table 20-11 present these rates, which would be approached asymptotically as the epidemic becomes endemic within a single group. Note the marked difference in equilibrium prevalence rates between the core and noncore groups for each disease, which is caused by the assumed tenfold difference in the rate of partner change of the two groups. The only exception to this pattern is the epidemic of HIV with ulcers, which, as distinct from HIV without ulcers, eventually becomes prevalent within more than 75 percent of the noncore as well as the core groups. This result derives from the extremely high value of the reproduction rate for this disease, which itself is due to the high probability of transmission combined with the long duration of infectivity for HIV—ten years.[18]

Table 20-11. Medical Parameters and Simulation Results for STDs

Parameter	Gonorrhea	Syphilis	Chlamydia	Chancroid	HIV without ulcers	HIV with ulcers
Transmission probabilities						
Male to female	0.6	0.250	0.4	0.350	0.03	0.1
Female to male	0.4	0.200	0.3	0.300	0.01	0.05
Q[a]	0.5	0.225	0.35	0.325	0.02	0.075
Duration of infectivity (days)						
Male	45	180	90	45	2,880	2,880
Female	120	270	240	45	2,880	2,880
D[b]	82.5	225	165	45	2,880	2,880
Reproductive rates[c]						
R (core)	8.25	10.1	11.55	2.93	11.5	43.2
R (noncore)	0.825	1.01	1.155	0.293	1.15	4.32
Contact number[d]	2.063	2.5	2.887	0.731	2.88	10.8
Parameters of equation of motion when selectivity, G, is set at 0[c]						
C_{11}	0.0167	0.0075	0.0117	0.0108	0.0007	0.0025
C_{12}	0.0833	0.0375	0.0583	0.0542	0.0033	0.0125
C_{22}	0.0083	0.0037	0.0058	0.0054	0.0003	0.0013
C_{21}	0.0017	0.0007	0.0012	0.0011	0.0001	0.0003
Equilibrium prevalence rates: isolated groups[e]						
Core	0.879	0.901	0.913	0.658	0.913	0.977
Noncore	0	0.012	0.134	0	0.132	0.769
Equilibrium prevalence rates: interacting groups[e]						
Core	0.684	0.778	0.822	0	0.822	0.972
Noncore	0.178	0.259	0.316	0	0.315	0.778

a. Average of male-to-female and female-to-male transmission probability per sexual partner.
b. Average of male and female durations of infectivity.
c. See appendix 20B for definitions.
d. Weighted average of R (core) and R (noncore).
e. Multiply by 1,000 for prevalence per 1,000.
Source: Rows 1, 2, 4, and 5 present results of a Delphi survey conducted by the authors. Other figures are authors' calculations; Hooper and others 1978.

As was pointed out earlier, the interesting feature of STD epidemiology is that the core and noncore groups do not remain isolated from each other but instead choose sex partners from the other group. Assuming that partners are selected from the two groups without prejudice in proportion to their availability (that is, the selectivity coefficient is 0 percent), Hethcote and Yorke (1984) show that the reproduction rate for the core-noncore model is simply the weighted average of the two individual rates.[19] This joint rate is called the "contact number" by Hethcote and Yorke and in table 20-11. If it is less than unity, as it is for chancroid, the disease will die out, not only in the noncore group, in which the reproduction rate is less than one, but also in the core group, in which it is greater than one. This occurs because the disease in the core is diluted by interaction between the core and noncore, making the disease unsustainable in either group. To produce the endemic levels of chancroid infection observed in African cities today, this simple model would require modified parameters, perhaps more active sexual behavior, a higher rate of transmission, or a longer duration of infectivity than we have assumed.

To explore the differences among the six different diseases, while holding constant the assumptions about sexual behavior, we simulate an epidemic of each disease from the same initial conditions. We start each epidemic at a prevalence rate of 1 percent among the 50,000 noncore and a prevalence rate of 20 percent among the 1,000 members of the core. The time paths of all six epidemics over a ten-year period are displayed in figure 20-7. In the graph in the left part of figure 20-7, only the core groups in the six epidemics are compared, whereas in the graph on the right side the results for the noncore groups are presented. In comparing the two graphs, keep in mind that 100 percent of the core is only 1,000 people, whereas 10 percent of the noncore, the upper limit of the vertical axis, represents 5,000 people. Because 2 percent of the noncore equals the entire population of the core, the data in figure 20-7 reveal that the size of any growing epidemic in the noncore quickly exceeds the total size of the core group.

When the model is simulated for ten years, five of the six epidemics closely approach their equilibrium levels in the core (chancroid at zero), whereas three do so in the noncore. Note that instead of disappearing entirely, as gonorrhea would have done in the absence of the core group, the prevalence of this disease rises to an equilibrium level of about 3 percent in the noncore. Similarly the prevalence of syphilis, which would have leveled off at the endemic level of 7.4 percent, instead reaches 28 percent at the end of the ten-year period. Although HIV spreads rapidly in the core even in the absence of ulcers, the large increase in its rate of spread in the noncore as a result of the ulcers is interesting indeed. Of course the simulated rate of spread assumes that the entire noncore (and core) populations suffer from genital ulcers. Because such ulcers are caused by syphilis, herpes simplex, and chancroid, a more realistic simulation for HIV might lie between the ulcers and no ulcers scenarios presented here. The dramatic difference between the ulcer and the no ulcer scenarios lends credence to the hypothesis that a putative greater prevalence of genital ulcers in Africa than in Asia or Latin America accounts for the apparently more rapid heterosexual spread of AIDS in Africa.[20]

How "realistic" are the simulations presented here? The equilibrium prevalence rates of gonorrhea, syphilis, and chlamydia in the noncore are similar to prevalence rates estimated in some African capitals (see table 20-2). The estimated prevalence rate increase for HIV infection in the noncore group, from 1 percent to 10 percent in ten years, is remarkably similar to the epidemic's trend in some of the worst-hit African capitals (see figure 20-3).

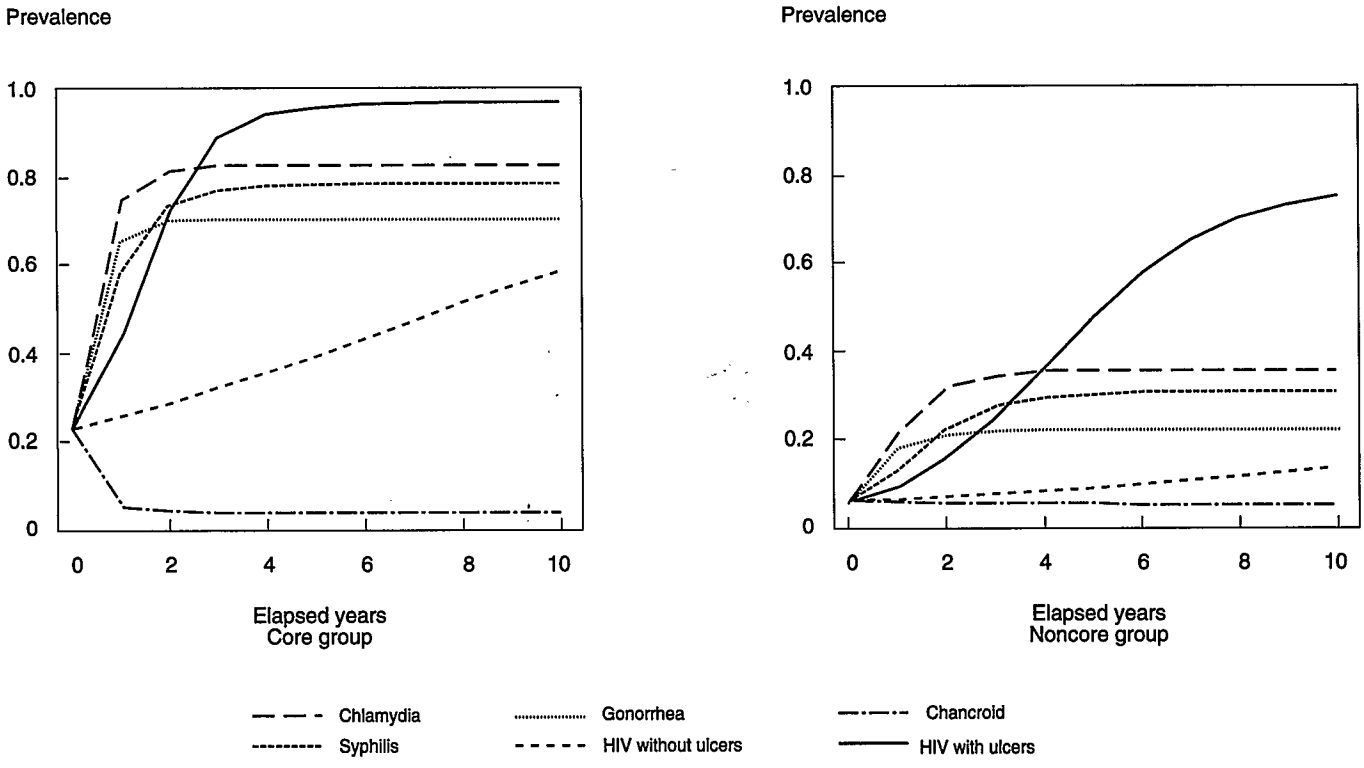
How do the results of this modeling exercise change our understanding of the relative burden of STDs as presented above? One observation stands out. The total burden of an STD is likely to be unequally distributed between the core and the noncore groups, with the core group bearing a much larger per capita burden. The observation by Rothenberg (1983) regarding the relatively greater risk of STDs of inhabitants of urban as opposed to adjoining rural New York State communities is directly applicable to African countries. Table 20-4 and figure 20-2 both display the dramatic differences that have been found between the prevalence levels of HIV infection in urban and rural African communities. The World Health Organization's Global Programme on AIDS adopts the assumption that rural prevalence levels are about one-tenth those of urban areas (James Chin, in a 1988 article cited by Bongaarts and Way 1989).[21]

Although the model-generated values on the estimated trajectories of these epidemics cannot be used to predict actual prevalence rates, the behavior of the various epidemics depicted in figure 20-7 does capture some features of their real-world counterparts. In particular the modeled gonorrhea and syphilis epidemics demonstrate the lesson learned by STD modelers a decade ago, that the core group plays an important role in maintaining the prevalence rate of an epidemic in the noncore at levels substantially above those that would obtain without interaction with the core. In the next section of this chapter, we will use the simulations presented in figure 20-7 as a base against which to compare the effects of interventions. The results in this section suggest that policies which target interventions at the core group may be particularly promising candidates.

The Demographic Effect of AIDS Epidemic

Because the model used in the last section does not incorporate demographic changes, it is not suitable for modeling the long-run demographic burden of the HIV epidemic. Still, several models in the literature do incorporate an explicit model of heterosexually transmitted HIV infection into a demographic model of population growth. One of the first of these, by Bongaarts (1988, 1989), simulates the spread of the infection over twenty-five years in a population structured to resemble that of many African countries. Without the epidemic, the model country's population would continue to grow at 3 per-

Figure 20-7. Simulated STD Epidemics in Core and Noncore Groups



Source: Authors' estimates.

cent per year, birth and death rates would continue to fall, and life expectancy would continue to rise from its current level of forty-six by 0.3 years per annum.

Choosing hypothetical sexual behavior parameters and plausible epidemiological parameters, Bongaarts finds that, once introduced, the HIV epidemic reaches a stable dynamic equilibrium after about twenty-five years. By that time, the model predicts, the proportion of HIV-infected adults will stabilize at less than 30 percent, although approximately 55 percent of core-group females will be infected. Because Bongaarts's model assumes a latency period of 9.3 years, infected women have almost as many children as they would have had in the absence of AIDS. As a result the birth rate is unaffected by the epidemic and the increased perinatal and adult mortality offset one another, producing no change in the dependency ratio as a result of the epidemic.

What does change, of course, is the death rate. If the HIV prevalence rate in a given adult population is 10 percent and about 5 percent of those infected die each year, then the AIDS-related mortality in this population will be 5 per 1,000 more than it otherwise would have been. Each additional 10 percent in the infection rate similarly adds about 5 per 1,000 to the mortality rate. Because the baseline mortality rate for adults fifteen through forty-nine in Sub-Saharan Africa is 5 or 6 per 1,000, infection rates of 10 percent, 20 percent, and 30 percent will double, triple, and quadruple the adult mortality rates, respectively.

Bongaarts's model projects these increased mortality rates onto an entire national population in which the baseline mortality is currently about 19 per 1,000. Instead of declining from 19 to 13 per 1,000, as Bongaarts assumed would occur without AIDS, the death rate is predicted to rise to 26 per 1,000—twice what it would otherwise have been. With the birth rate's downward trend unchanged but the death rate increasing, Bongaarts's model projects the population growth rate to slow from 3 percent to 1.9 percent per year by the end of the twenty-five-year period.

This conclusion is remarkably robust to changes in two principal assumptions: the initial population growth rate and the severity of the epidemic. If the population growth rate were only 2.5 percent per year (lower than in any Sub-Saharan African country except Chad and the Central African Republic), the population growth rate would remain positive unless the seroprevalence rate attains the extremely high level of 45 percent among all adults (Bongaarts 1989, figure 7). With population growth rates at a more typical level of 3.0 percent or 3.5 percent, the epidemic severity required to shrink the population would be even higher—55 percent or 60 percent.

A second model combining epidemiologic and demographic features is by Anderson and others (1986). It predicts that population growth rates could eventually become negative if the initial incidence rate of HIV infection in the susceptible population exceeds the population growth rate. However, the incidence rates estimated from a few Central African cities

exceed national population growth rates. For this reason, in this and later papers, Anderson and co-authors conclude that HIV infection could cause populations to stop growing within 30 to 100 years from the beginning of the epidemic. In their words, "[a] wide range of parameter values, all within the bounds suggested by current empirical studies, predicted asymptotically negative population growth rates" (Anderson and McLean 1988, p. 231).

These predictions of population shrinkage in African countries have received a great deal of attention. The incidence rates of HIV infection cited by the authors to support the plausibility of their assumptions, however, are all from studies of sexually active urban adults, some of whom were prostitutes. In fact, African populations are typically only 15 percent urban, and the unknown portion of women who are prostitutes is unlikely to exceed a few percentage points. Even an extraordinarily high incidence rate among all urban adults of 20 percent per year results in only a 3 percent incidence rate in the entire population if the rural 85 percent population remains uninfected, and this would be too low to result in negative population growth rates in most countries. If the incidence rate among urban adult susceptibles is instead under 2 percent per year, as it was estimated to be among the employees of the main hospital in Kinshasa, then negative population growth would require implausibly high rates of growth of infection in the rural population.

The Anderson-May-McLean models are parsimonious in portraying the interactions among demographic and epidemiologic variables. The models predict negative population growth, but only for implausible assumptions regarding the initial incidence rates of HIV infection in national populations.[22]

Recently the work of a team of modelers sponsored by the U.S. Department of State's Interagency Working Group on AIDS Models and Methods has come to fruition with the release of a model called the iwgAIDS model (Stanley and others 1989). Embodied in a user-friendly computer software package, the iwgAIDS model addresses such issues as transmission between prostitutes, their clients, and the wives of their clients and choice of sexual partners by age and location (that is, urban or rural), as well as transmission by blood transfusion, needle-sharing, and the vertical route from mother to infant. Although sufficiently flexible to project negative population growth, given sufficiently pessimistic, "worst case" assumptions, the intermediate scenario predicted by early runs of this model is a growth rate of 1.1 percent per year (Stanley and others 1989). More recently a careful attempt by the U.S. Bureau of the Census to characterize a "typical" African HIV epidemic over twenty-five years with this model predicts dramatic increases in adult mortality comparable to those predicted by the Bongaarts model and a fall in urban life-expectancy by nineteen years compared with the base case. At the end of twenty-five years, the national population growth rate is still growing at 2.2 percent per year, compared with 2.8 percent projected without the AIDS epidemic (Way and Stanecki 1991). Future work with this model will characterize the likely epidemics in the harder-hit African countries and on Latin American and Asian countries, in which transmission patterns and the underlying population dynamics differ substantially from Africa.

For similar choices of parameters, all three models produce similar results regarding several key indicators of the long-term burden of the epidemic. First, both models agree that the dependency ratio, measured by

$$\textit{Dependency ratio} = \frac{\textit{Number of people} < 15 \textit{ or} > 64}{\textit{Number of people } 15 \textit{ through } 64}$$

would not be greatly affected by the epidemic. This result at first seems surprising, in view of the anecdotal evidence from heavily affected areas of Tanzania and Uganda that AIDS is the "grandmother disease," because it kills adults, leaving orphaned children in the care of the grandparents. The explanation for this apparent contradiction lies in the distribution of the deaths. Because parental deaths precede child deaths in some households and follow them in others, the overall dependency ratio can remain relatively constant despite large increases in the number of orphans from the former households.

Still, the authors of all these models emphasize that any reductions in population growth rate caused by the HIV epidemic will be due to increased deaths primarily among young adults. Far from benefiting the population by reducing its growth rate, the consequent doubling or quadrupling of the mortality rate in individuals age fifteen through forty-four would have "disastrous effects on the health care system, the economy and the fabric of society" (Bongaarts 1988, p. 36). In the absence of a vaccine or effective treatment, these consequences can be prevented only by a concerted educational campaign designed to change sexual behavior. We will consider the possible design of such a campaign below.

The Gender-Specific Burdens of STDs

Do sexually transmitted diseases burden one sex more than another in developing countries? There are tentative answers to this question from both the static and the dynamic perspective.

Appendix 20A and table 20-8 include separate estimates for men and women of the STD mortality and morbidity rates in both high-incidence and low-incidence urban settings. Because the static burden calculations summarized in table 20-9 and figures 20-5 and 20-6 are intended to compare the effects of individual diseases, the effects on the two sexes are combined there. To the extent that appendix 20A and table 20-8 differentiate between the genders, we can return to them to estimate the ratio of the burden borne by women to that borne by men for each disease.

Because the statistics are based on pattern II urban areas, they ignore homosexual and IV drug transmission routes for HIV

infection. In these pattern II countries, the ratio of male to female cases is close to unity for HIV transmission (see table 20-3). Therefore the data in appendix 20A and tables 20-8 and 20-9 are not able to discriminate between the effects of HIV transmission on men and on women. The effects of chancroid on the two sexes are also difficult to distinguish. For the remaining three diseases, however, the burden borne by each of the two sexes is presented in columns 4 and 5 of table 20-12, and a comparison of the per capita burden on women with that on men for each of the five STDs is shown in figure 20-8.

According to the data in table 20-12 and figure 20-8, women in a high-prevalence urban setting bear a total STD illness burden of 44.4 disability-adjusted life-days per capita per year, about 3 percent more than the burden borne by men. If human papilloma virus and its sequela, cervical cancer, had been included, and if our methodology permitted us to capture the earlier onset of HIV infection in women than in men (Ryder and Piot 1988), the excess burden on women over that on men would be greater.[23]

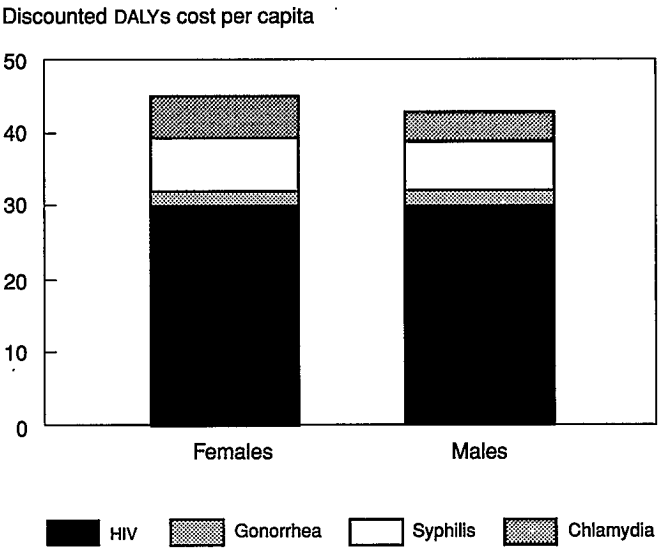
But these static calculations ignore the interactions between the presence of this disease and the socioeconomic positions of women in a population. Three types of such interactions are of concern. First, what are the effects of infertility caused by STDs on the future welfare of the affected individual—and how do such effects differ between men and women? Second, what have been the cultural adaptations to high prevalence of STDs and how have those adaptations affected the welfare of the two genders? Third, what has been the effect of these cultural adaptations, if any, on the spread of STDs and on consequent levels of infertility?

To do justice to any of these questions across all human cultures would require an extensive ethnographic survey, which space limitations do not permit. With respect to the first question, however, it is well established that a woman's value in a poor culture often hinges crucially on her presumed or demonstrated fertility. Although infertility clearly harms men as well, some cultures in which infertility is common have customs which protect an infertile man—but not an infertile woman—from its consequences. For example, in northwestern Tanzania, an infertile man may acquire an heir by being the first man to have intercourse with a woman after she gives birth. In this same culture, a husband may return an infertile wife to her parents and request the return of her bride-price (Reining 1972).

Whether a given cultural practice has developed in response to the high prevalence of STD-caused infertility would be extremely difficult to establish, even with an extensive ethnographic survey, because it would require longitudinal information specific to a given culture on both STD prevalence rates and the frequency of various cultural practices.[24] In the case of the practices just mentioned, however, it is hard to resist the interpretation that the practices have become more entrenched as a result of the high prevalence of STDs. Whatever their cause, it is clear that these cultural adaptations have resulted in an unequal sharing of the burden of infertility—imposing it more on the women than on the men.

The next link in the chain of causation is between such gender-biased adaptations to the prevalence of STDs and the

Figure 20-8. Annual Gender-Specific Burden of STDs



Source: Table 20-12.

Table 20-12. Burden of STDs in High-Prevalence Urban Areas, by Gender

Disease	Average incidence (per thousand)		Discounted disability-adjusted life-days lost (per capita per year)			Discounted disability-adjusted life-years saved	
	Women	Men	Total	Women	Men	Women	Men
Chancroid	6.2	6.2	0.5	0.25	0.25	0.2	0.2
Chlamydia	9.5	12.4	8.6	4.8	3.8	1.3	0.8
Gonorrhea	7.3	10.8	1.9	0.9	0.9	1.0	0.7
HIV	8.5	8.5	60.6	30.3	30.3	19.5	19.5
Syphilis	5.8	5.8	15.9	8.2	7.7	3.9	3.7
Total	n.a.	n.a.	87.5	44.4	43.1	n.a.	n.a.
Average DALY saved per case selected	n.a.	n.a.	n.a.	n.a.	n.a.	5.6	4.7

n.a. Not applicable.
Source: Authors' calculations.

further spread of these diseases. In an exhaustive study of infertility in Sub-Saharan Africa, Odile Frank writes:

> Marital instability caused by infertility and the spread of venereal disease caused by marital instability and sexual mobility can form a vicious cycle. The movement of abandoned or rejected barren women to urban prostitution has been noted in Niger, Uganda, and the Central African Republic. Similarly, in many of these societies, marital and sexual mobility on the part of the women is interpreted as a desperate attempt to become pregnant, and tolerance on the part of society as a means to maximize their chances of doing so.... Once venereal disease was introduced into a community with some degree of sexual or marital mobility, its diffusion might have been assured by the existing customs. [Subsequently] the mobility itself [may have been] intensified to overcome the fertility effects (Frank 1983, pp. 22 and 26).

The existence of such a vicious cycle has recently been argued by Judith Wasserheit (1989), whose depiction of the causal links is reproduced as figure 20-9. To Wasserheit and Frank's argument, we add the intervening link of low status of women to their low education and their small numbers in urban areas, factors which the earlier discussion suggests cause, or create the preconditions for, urban prostitution. Furthermore, Wasserheit and Frank both argue that the resulting high level of infertility, far from damping the African population growth, exacerbates it by preventing individuals from confidently postponing conception. In Frank's words, "[a]s long as infertility remains prominent in Africa, large numbers of individuals and some entire populations will remain thwarted in their ambitions to bear and raise children, and even larger numbers may resist both intrinsic and extrinsic pressures for fertility limitation in the face of the risk to which they see others exposed" (Frank 1983, p. 40).

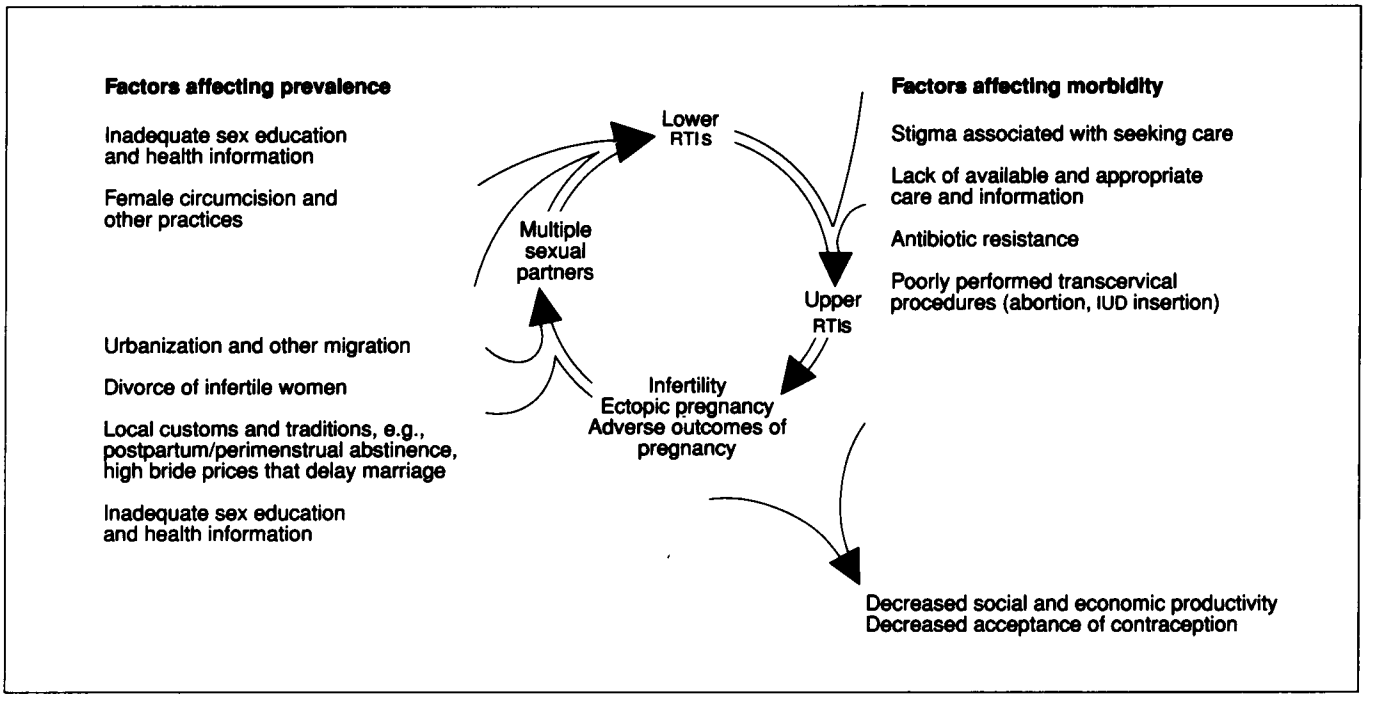
Wasserheit draws an additional and more direct link between STDs and the success of family planning programs: "In the absence of accurate diagnosis and effective education and therapy [for STDs], it is far easier for a woman to blame her vaginal discharge on her contraceptive method than to entertain and address [other possibilities]. The net result is often that the woman drops her contraceptive method under the misimpression that the method caused an unrelated infection" (Wasserheit 1989, p. 10).

If the cost of a large population growth rate is borne disproportionately by women, then these arguments that STDs exacerbate the population growth rate reinforce the case that STDs affect women more than men. We leave as a challenge to others the quantification of these interaction effects.

Lowering or Postponing the Incidence of STDs

This section will discuss the principles and benefits involved in preventing STDs.

Figure 20-9. Interaction between Sociocultural and Physiological Factors in Reproductive Tract Infections in Developing Countries



Source: Wasserheit 1989.

Principles of Primary Prevention of STDs

Principles of primary prevention follow, grouped by the form of transmission targeted.

TYPES OF PRIMARY PREVENTIVE STRATEGY. The four different modes of transmission of the HIV virus are sexual intercourse, mother-to-child (that is, "vertical"), transfusion of blood or blood products, and needles and other skin-piercing instruments. Each of these transmission modes applies to at least one CSTD as well as to HIV. Primary prevention strategies are designed to disrupt these modes of transmission, but a large number of different policies could contribute to this goal.

In table 20-13 we classify primary prevention strategies according to whether the indicated behavioral change is voluntary, mandatory, or only a passive response to environmental changes. This classification scheme, which has been borrowed from the field of injury prevention, directs our attention to the degree of coercion required to implement a policy and thus to the probable cost of the intervention.

Each of these three strategy categories corresponds to a distinctly different type of government policy. Voluntary behavior modification can be encouraged only by information, education, and communication (IEC) campaigns and by individual counseling. Mandatory behavior modification requires the enactment and enforcement of government laws and regulations. Passive responses are the least intrusive of the three types of strategies, depending on government policies which change either the inherent likelihood of the risky behaviors or the risk attached to them.

In the rest of this subsection, available information on the effectiveness of interventions will be described for each transmission mode. By reference to table 20-13, each intervention can be associated with a voluntary, mandatory, or passive means of behavior modification.

PREVENTION OF SEXUAL TRANSMISSION: TARGETING. According to Hethcote and Yorke (1984, p. 32), "[i]n the early 1970s, the prevalent idea was . . . that everyone who was sexually active could get gonorrhea and, consequently, . . . that 'gonorrhea is everybody's problem.'" Then in the late 1970s public health opinion changed markedly in the United States, to the extent that the change was described by a WHO scientific working group in the following words: "This assumption is no longer in

Table 20-13. Interventions for Primary Prevention of STDs and HIV Infection, by Mode of Transmission and Form of Behavior Modification

	Mode of Transmission			
Behavior modification	*Sexual intercourse*	*Mother-to-infant (vertical)*	*Transfusion of blood and blood products*	*Needles and other skin-piercing instruments*
Voluntary (change demand by changing information or preferences)	*Encourage* Use of condoms or virucide Fewer sex partners Partner selection Partner notification by patient referral Sex education in schools Early treatment of STDs	*Offer* Voluntary screening of pregnant women Eye prophylaxis at birth, on request	*Encourage* Test of donated blood Recipient choice of donors Donor deferral Public information on low benefits and high risk of transfusion	*Encourage* Providers to sterilize reusable needles and to discard disposable ones Consumers to request sterile needles Providers to exercise caution with blood Needle exchange by IVDA
Mandatory (change external incentive structure by imposing quantity restrictions	*Enforce* Regulation or prohibition of prostitution Quarantine of infected individuals Partner notification by provider referral	*Enforce* Screening of pregnant women Pregnancy counseling of infected women Contraceptive counseling	*Enforce* Provider compliance with transfusion criteria Blood screening and blood banking Eye prophylaxis	*Enforce* Destruction of disposable needles Regulation of handling of blood by HIV-positive patients Laws against IV drug abuse
Passive response to environmental changes (change external incentive structure through price restrictions)	*Increase* Subsidies for condoms and for STD treatment Tax or regulation of night clubs and alcohol Ratio of women to men in urban areas Jobs for single women Education for women	*Increase* Subsidies for condoms and for STD treatment Tax or regulation of night clubs and alcohol Ratio of women to men in urban areas Jobs for single women Education for women	*Prevent* Malaria, especially among children Anemia *Increase* Price of transfusions	*Provide* Needles that self-destruct after one use

Source: Authors' construction.

vogue in [the United States], and decisions for control are now based on the concept of the core of transmitters of disease which postulates that a relatively small proportion of the population is contributing to the maintenance of the epidemic and that it is precisely this group of transmitters that is particularly important [for disease control]" (WHO 1978, p. 116, as quoted in Hethcote and Yorke 1984)

Motivated to a remarkable degree by quasi-cost-effectiveness arguments derived from mathematical simulations, public health strategies against gonorrhea in the United States turned away from broad screening programs of the general population to focus on "targeted" control programs. Targeting strategies included partner notification in an attempt to identify and treat both the infector and the infectee(s) of the index case, rescreening of treated cases several months later to check for reinfection, and outreach activities to high-risk groups. Some examples of the arguments marshaled by mathematical models for such targeted activities include the following:

- Because diagnosed and treated cases are likely to be in the core group at high risk of reinfection, rescreening these cases several months after treatment is "approximately four times as effective per number of individuals tested as [would be the] screening [of randomly selected individuals from the general population] in reducing total incidence" (Hethcote and Yorke 1984, p. 32).
- Because the infectors of an identified case are more likely to have belonged to the core group than are infectees of that case, contact tracing, screening, and treatment lower disease prevalence more per discovered case if targeted at the former than the latter (Hethcote and Yorke 1984, p. 85).
- Under the hypothesis that a vaccination is developed which provides immunity to gonorrhea, but only for a short time, "post-treatment vaccination is about five times as effective per number of persons immunized as random vaccination in the population" (Hethcote and Yorke 1984, p. 33).

Empirical confirmation of the concept of the core group was presented by Rothenberg (1983):

> The pattern of reported gonorrhea in upstate New York (exclusive of New York City) in the years 1975–80 is one of intense urban concentration, with concentric circles of diminishing incidence. The relative risk for gonorrhea in these central core areas, compared to background state rates, is 19.8 for men and 15.9 for women, but as high as 40 in selected census tracts.... Contact investigation data suggest that sexual contact tends to exhibit geographic clustering as well. These observations provide support for narrow focusing of epidemiologic resources as a major disease control strategy.

There are interesting parallels and contrasts between the history of public health thought regarding CSTDs and AIDS. It is natural to suppose that public health thinking about control strategies for HIV infection would build on the insights described above, taking maximum advantage of every available opportunity to target control activities. Instead the possibility of such targeting has been resisted with language which is reminiscent of the decades-old description of gonorrhea as "everybody's problem."[25]

The core is an epidemiological concept, rather than a precisely defined social group, and so identifying the core in a given population and reaching its members with education or treatment may be extremely difficult and costly. Because some prostitutes are relatively easy to identify, they are often the only part of the core that is reached. Countries like Ghana and Rwanda are conducting an AIDS-prevention program among their military personnel, demonstrating that targeting this part of the core group is sometimes politically feasible (Lamptey and Potts 1990). Clients of prostitutes are more difficult to reach, but some of them acquire a symptomatic STD and present themselves for treatment at a clinic. In general, men and women with an STD are by definition at risk, and they are a reasonably accessible group for HIV/STD prevention activities. Finally, sexually active adolescents can be reached through the school system and through formal and informal youth organizations and activities, such as sports clubs and popular concerts.

By selecting some groups for special attention, a targeting policy runs two risks: those targeted may be—or feel—stigmatized, and those not targeted may react with a false sense of security. Because, in contrast to CSTDs, HIV infection is incurable, policies to target prevention efforts at core groups or at infected individuals, for example, through contact tracing, can assume ominous political overtones. HIV-infected persons (HIPs) will lack confidence in the ability of a publicly operated contact-tracing program to maintain the confidentiality of its records. This fear is particularly well founded in developing countries, where the staff of the public health system is known by, and accessible to, most of the population, and traditions of bureaucratic anonymity and confidentiality are unknown. Once publicly identified, HIPs may lose substantial proportions of their civil rights, as either official or unofficial pressures attempt to isolate them from society. The problem is exacerbated in communities in which people continue to believe that AIDS might be transmitted by shaking hands, by eating out of a common bowl, or by other mundane, nonsexual social acts (Wilson and Mehryar 1991).

One strategy that has been effective in combating stigmatization has also appeared to contribute substantially to program success: peer counseling. Peers have been successful counselors in pilot projects with prostitutes in Kenya, Ghana, and Cameroon (Ngugi and others 1988; Lamptey and Potts 1990), with truck drivers in Tanzania, and with youth in Zaire.[26] Peers are not only better at communicating messages about safe sex; they are also better at finding other core group members in the first place. Thus their use can bring the otherwise prohibitive costs of finding core group members down to quite modest proportions. The section below elaborates on the cost of targeted and untargeted programs.

PREVENTION OF SEXUAL TRANSMISSION: INTERVENTIONS. Avoidance of sexual exposure to pathogenic microorganisms can be achieved in three ways: (a) avoidance of potentially infected sex partners (through sexual abstinence or mutual monogamy); (b) protection with a barrier method during sexual intercourse (condom use); (c) practicing only nonpenetrative sex ("safer sex"). All three methods depend entirely on individual behavior, which may be modified by various kinds of health education, targeted or not. Because of the strong effects of culture and religion on attitudes toward sex, the effects of health education on sexual behavior necessarily differ across societies or even across subgroups of a society. Methods as different as mass campaigns, school programs, and face-to-face counseling are being used in the primary prevention of STDs and HIV infection, implying widely varying personnel and recurrent cost requirements.

Although the incidence of HIV infection dropped spectacularly in selected groups of homosexual men in North America and Europe (Coutinho, van Griensven, and Moss 1989), how much of this decline can be attributed to health education programs is unclear. In the developing world, the effectiveness of health education on sexual behavior is even less understood. Targeted education programs in several African cities resulted in dramatically increased condom use among clients of female prostitutes, although this was not always associated with a decrease in the incidence of HIV (Lamptey and others 1988; Ngugi and others 1988; Laga and others 1989). The protection offered by a condom during intercourse with a person with an STD is unknown, but probably approaches 100 percent if properly used and if no breakage occurs.

Because spermicides and viricides can be controlled by the female partner, there has been substantial interest in the few studies to evaluate their in vitro activity against gonorrhea and chlamydial and HIV infection. There is some evidence that they protect against gonorrhea and chlamydia, especially when used in conjunction with a condom or diaphragm (Cole and others 1980; Austin, Louv, and Alexander 1984; Rosenberg, Schultz, and Burton 1986; Louv and others 1988). The authors of one study found no effect of contraceptive sponges on HIV acquisition in highly exposed prostitutes in Nairobi (Kreiss and others 1986). Therefore, it is premature to recommend them in the STD/HIV prevention program. Because of their potential importance in the primary prevention of STD and HIV, further research on this issue is a top priority.

Partner notification, also known as contact tracing, is an important element of CSTD programs. First vigorously promoted in the United States in the 1930s, tracing the sexual contacts of syphilis patients only began "in earnest [in] the 1940s when effective treatment for syphilis became available" (Bayer 1990, p. 125). Subsequently it became accepted in the United States as an essential component of the public health strategies against syphilis in the 1960s, gonorrhea in the 1970s, and chlamydia in the 1980s.

Partner notification acts to prevent the spread of a CSTD epidemic in two ways. First, the uninfected sexual contacts become aware of their risk and can protect themselves. Second, the infected contacts can be offered a cure. In addition, as argued earlier, sexual contacts of an index case are more likely than is the average CSTD patient to be members of the core group of transmitters.

The distinction between "mandatory" and voluntary partner notification is somewhat artificial because it is impossible to verify that an individual has named all sexual contacts. Partner notification programs can be more or less aggressive by varying the intensity of the interview and by offering the choice between (a) provider referral, in which the provider notifies the contact without revealing the identity of the index case; and (b) patient referral, in which the patient notifies the contact and advises the contact to seek counseling, testing, and, if necessary, treatment.

Policy prescriptions for HIV infection require a different perspective. Until recently, public health departments have not been able to offer any treatment or other incentive which might persuade exposed individuals to run the (real or perceived) risk of being identified and stigmatized as seropositive for HIV. Early experiments in Colorado showed that, in the United States, aggressive partner notification at a public health laboratory reduced the number of people asking to be tested. This finding supported worries that tying partner notification to testing would "drive the epidemic underground."

Now that zidovudine (AZT) has been found to retard the progression from HIV infection to AIDS, public health facilities able to offer AZT will for the first time be able to offer an incentive which will help to offset the fear of stigmatization. Furthermore, if distribution of AZT can be channeled through public health facilities with active partner notification programs, its availability will substantially improve the ability of these programs to trace contacts. In countries in which AZT can be afforded by the public health system, we expect the effectiveness of partner notification programs to rise dramatically. Even in the absence of a cure for HIV infection, the availability of AZT at public health facilities in a country may stimulate a movement of the AIDS control effort along the same path previously followed by CSTD control programs: that is, toward tightly targeted screening, rescreening, and partner notification programs and away from general public education (Clumeck and others 1989; Toomey and Cates, 1989).

Unfortunately for the application of such a strategy in developing countries, the price of AZT is extremely high. The current cost of $8,000 per patient-year may drop to $4,000 as a result of recent findings that a smaller dose gives the same effect as a larger one. That annual cost, however, exceeds the annual per capita gross national product (GNP) of almost all developing countries.

A remaining quandary is whether the individual who learns that he or she is seropositive for HIV will reduce high-risk sexual behavior. In American and European studies, knowledge of HIV infection has sometimes marginally decreased and sometimes actually increased high-risk behavior (Office of Technology Assessment 1988, p. 14; Van Griensven and others 1989). Until a medical treatment is available to reduce the infectivity

of HIV-infected persons, the principal effect of partner notification programs on transmission may be to alert uninfected partners of their exposure and thereby motivate them to adopt safe sex practices. There is a pressing need for operational research on partner notification programs in diverse pattern II countries.

PREVENTION OF VERTICAL TRANSMISSION. For over a century, eye prophylaxis at birth has been the method of choice for the prevention of gonococcal conjunctivitis in the neonate. The method is simple and its effectiveness is 93 to 97 percent (Laga and others 1988; Laga and others 1989). It is officially recommended as a routine practice in most developing countries, although it is not always implemented (Laga and others 1986a and 1986b). Ocular prophylaxis at birth is not effective against chlamydial conjunctivitis, which is not a sight-threatening disease (Datta and others 1988; Hammerschlag and others 1989).

Detection and treatment of gonococcal and chlamydial infections in pregnant women may be the optimal strategy in controlling these diseases in mother and child, because it prevents transmission to the neonate as well as complications and sequelae in the mother. As discussed in appendix 20C, however, diagnosis of gonorrhea and chlamydial infection in women is technically demanding and as yet rarely available in the developing world. Such screening is more effective if targeted at women with higher prevalence rates for these infections, though this advantage may not outweigh the stigmatizing potential and lower social acceptability of selective screening. Moreover, attempts to delineate high-prevalence groups of pregnant women have met with variable success (Laga and others 1986a and 1986b; Braddick and others 1990). The prevention of neonatal chlamydial conjunctivitis and pneumonia is based on treatment of infected women, but, again, this is rarely practiced because of technical and fiscal reasons. Targeting screening activities for C. *trachomatis* infection (that is, to women below twenty years of age) has been recommended for the United States (Arnal and Holmes 1991).

Screening of pregnant women for evidence of syphilis is recommended in most countries of the world to prevent congenital syphilis. Although such screening is irregularly implemented, innovative programs involving primary health care workers using a simple and rapid assay for syphilis antibody (rapid plasma reagin test), have recently been initiated in Africa (Hira, Kamanga, and Bhat 1989).

Finally, screening pregnant women for HIV infection is increasingly used as a means of preventing perinatal HIV infection, although its application remains controversial in many countries and its effectiveness is unclear when the pregnancy is not interrupted (Braddick and Kreiss 1988).

PREVENTION OF TRANSFUSION-ACQUIRED HIV. Wherever possible, blood donations are being screened for syphilis and hepatitis B virus markers throughout the world—though the cost-effectiveness of screening blood donors for hepatitis B virus infection in hepatitis B endemic areas has been questioned (Ryder and others 1989). Storage of blood at 4 degrees centigrade for more than four days eliminates treponemes and could theoretically be used in countries in which no laboratory testing for syphilis is available. Areas without facilities for syphilis screening, however, do not usually have facilities for storing blood (Meheus and Deschryver 1989).

The prevention of transfusion-acquired HIV infection relies on four methods: (a) testing of all blood donations for HIV antibodies before transfusion and discarding donations that are HIV positive; (b) donor selection and recruitment (also known as donor "deferral") aiming at excluding donors presumably at high risk for HIV infection or at recruiting low-risk voluntary donors; (c) rational use of blood transfusion by the health service; (d) prevention of conditions which call for transfusion, especially severe anemia and childhood malaria. Improvement of prenatal care and the "safe motherhood" initiatives can reduce the need for peripartum transfusions, which are one of the main indications for blood transfusion in the developing world.

PREVENTION OF HIV TRANSMISSION BY SKIN-PIERCING TOOLS. Outbreaks of HIV infection in the Soviet Union suggest that intravenous injections may play an important role in the spread of HIV infection in some hospitalized populations (Pokrovski and others 1990). In general, the risk of infection from contaminated equipment is larger when prevalence among patients and staff is larger (Berkley 1991). Still, in contrast to other modes of transmission, the contribution of contaminated needles and syringes to the spread of HIV in pattern II countries is probably very small. Proper sterilization of reusable needles and syringes and use of disposable materials have been recommended to prevent the transmission of various microorganisms by injection.

Those who inject drugs are at increased risk for HIV infection through needle sharing and may be a source of infection for other population groups through sexual transmission. Prevention strategies for IV drug users are still largely experimental but mainly include prevention of IV drug use itself by health education, treatment of drug dependency, needle exchange programs, promotion of use of sterile or disinfected "works," and promotion of safer sex practices.

DEVELOPMENTS IN PRIMARY PREVENTION IN THE NEXT DECADE. A tremendous effort is being undertaken to develop a vaccine against HIV infection, though with little obvious success thus far. It is possible that such a vaccine will become available by the year 2000. Attempts to develop vaccines against gonorrhea and chlamydial infection have failed so far, and it is not expected that they will become available in the near future. A vaccine against syphilis seems even less likely.

Virucidal products for local genital prophylactic use will probably become available, but assessing their effectiveness will be difficult. Methods for barrier protection of women, such as the female condom, may become increasingly popular. As knowledge of people's sexual behavior and motivations increases, health education interventions may become more effective.

The Benefit of Averting a Case: Static Analysis

As explained earlier, unless a decisionmaker is considering the eradication of a disease, knowledge of the total burden of that disease is of less use to him or her than would be an estimate of the benefit of averting a single case. Coupled with information on the cost of averting a single case, this benefit measure would assist the decisionmaker to allocate resources. In the absence of interactions among different disease programs, the most cost-effective health resource allocation could be obtained by equating the health gained per dollar across all diseases.[27] The existence of these interactions prevents a straightforward application of this simple principle. Information on potential savings of disability-adjusted life-years from each averted case can still be a useful guide, which, together with ancillary information, can improve the effectiveness of health services in developing countries.

Earlier we defined the disability-adjusted life-years lost per capita per year from a given disease as a function of the discounted (productivity-weighted) number of disability-adjusted life-years lost per case of that disease; table 20A-3 provided these intermediate calculations which enabled the calculation of disease burdens for table 20-9. But the number of DALYs lost per case is also the estimated benefit of preventing, or of quickly curing, a single case of that disease. Thus, in order to estimate the health gain from averting a case of a disease, we need only turn back to table 20A-3 and reinterpret its content from this slightly different perspective. Figure 20-10 displays the results from table 20A-3 with diseases ranked in order of the disability-adjusted life-years (DALYs) saved per case averted.

Because the difference between the burden calculations done earlier and the benefit calculations in this section is to remove the effect of incidence rates, it is not surprising that conditions like sickle cell anemia, neonatal tetanus, and birth injury are favored by this change.[28] Each of these has a relatively low incidence compared with measles or malaria, for example, but each robs (an African) society of a great many life-years per case because its victims are so young. Discounting at 3 percent is not sufficient to offset this effect, so these diseases appear at the top of the list of benefits per case averted. Because of the high fourth-place ranking of HIV, however, STDs continue to hold a surprisingly high rank. Furthermore, note from figure 20-10 that adjustment for the relative productivity of the lost years raises HIV infection to first place among all the considered diseases.

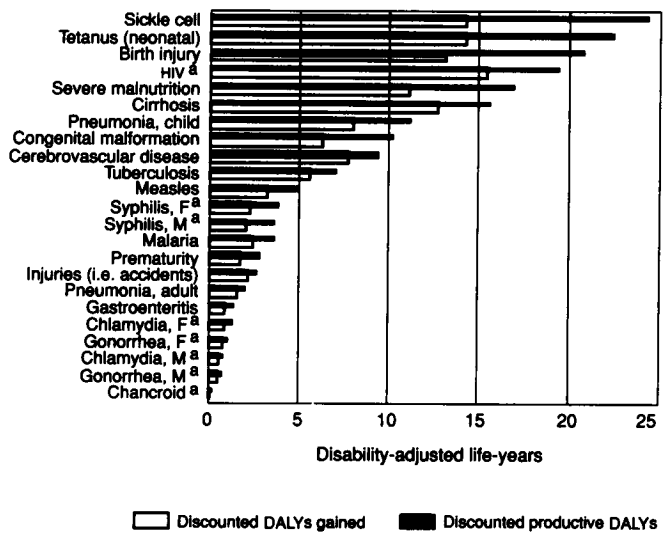
Syphilis has been displaced by cirrhosis, cerebrovascular disease, tuberculosis, and several other diseases from its fifth-place ranking in figure 20-5. Although the other STDs rank much lower on the scale of benefits per case averted in this static analysis, the same caveat applies as was mentioned above: to the extent that chlamydia, gonorrhea, and chancroid predispose individuals to HIV infection, a portion of the benefit of averting a case of HIV should be attributed to the interventions which prevent the seemingly less important diseases.

Table 20-12 and figure 20-8 support the case that the static burden of STDs is slightly greater on women than on men in a typical high-prevalence urban setting. Another way to compare the genders is to ask how many disability-adjusted life-years would be saved on average by averting a case of STDs in each gender. According to the last columns of table 20-12, the static benefit is slightly higher when a case of chlamydia, gonorrhea, or syphilis is prevented or cured in a woman than if a similar case is prevented or cured in a man. Averaging these potential benefits with the equal benefits from preventing HIV or chancroid in a man or a woman yields an average static benefit of 5.6 disability-adjusted life-years for every case prevented in a woman, which is 19 percent more than the benefit of 4.7 DALYs of averting an STD in a man. Comparing either of these figures with the non-STDs in table 20A-3 or figure 20-10 shows that the benefit from curing an average STD ranks below tuberculosis and just above measles and malaria. When the unquantified interactions of STDs with a woman's socioeconomic status are added, STDs would rise even higher in importance.

The Benefit of Averting a Case: Dynamic Analysis

The above static analysis ignores the fact that each case of an STD prevented will, because of the contagiousness of the disease, prevent additional cases.[29] From the dynamic perspective, a health care intervention could achieve health benefits in two distinct ways. The simplest intervention is one that cures or prevents the infection of some people once. Such a "one-time" program might be implemented by a mobile clinic that visits a town once, never to return.[30] By changing the infection status of some people, a one-time program would

Figure 20-10. Static Benefit of Preventing a Case of STD and Other Diseases in Sub-Saharan Africa



a. Sexually transmitted disease.
Source: Authors; Ghana Health Assessment Project Team 1981.

postpone ill health but would not prevent the epidemic from resuming its dynamic path toward equilibrium. The health benefits of a one-time program are due to the value of postponing an episode of ill health or a death. Because ultimately death can only be postponed, the benefits of such a one-time program should not be disparaged. Although temporary, they may nevertheless be considerable.

The second type of intervention is a sustained one that alters either the sexual behavior of the population or the disease-specific parameters. If maintained indefinitely, such changes will affect not only the epidemic's path toward equilibrium but the ultimate equilibrium prevalence rates themselves and therefore will have a permanent effect on the burden of the disease. Of course, a sustained intervention will typically require sustained budget support.

A CORE AS AGAINST A NONCORE STRATEGY. In order to examine the potential effect of a one-time intervention, we simulate an epidemic of each of the STDs in a population composed of two sexually active groups, the noncore and the core. We assume that the core comprises only 2 percent of the population but is five times more sexually active than the noncore and has a starting prevalence rate of 20 percent infection for each STD, compared with only 1 percent infection in the noncore.[31] Having simulated the course of each epidemic in the absence of intervention, we then simulate, for each STD, two different possible "one-time" interventions. In one of these we cure 100 individuals in the core and in the other we cure 100 individuals in the noncore. Then, by comparing each of these two alternative simulations with the base run, we compute which postpones more ill health and thereby best improves the health of the population.

Figures 20-11 and 20-12 portray the dynamic effect of preventing 100 cases of gonorrhea (figure 20-11) and of HIV (figure 20-12). Each figure contrasts the effect of preventing 100 cases in the core to preventing those cases in the noncore. For example, in figure 20-11 the top curve is calculated as the difference between the number of new cases of gonorrhea each month with no intervention and the smaller number if there is an intervention, which is applied only to the core group. In the sixth month after 100 core individuals are cured of gonorrhea, there are approximately 380 fewer new cases of gonorrhea, in the core and the noncore together, than if the intervention had not occurred. In contrast, if the 100 cures were effected in the noncore group, the number of cases averted during the sixth month in both groups would only be about 40. In table 20-14 we compare the simulated effects of the two types of prevention programs for all six epidemics.

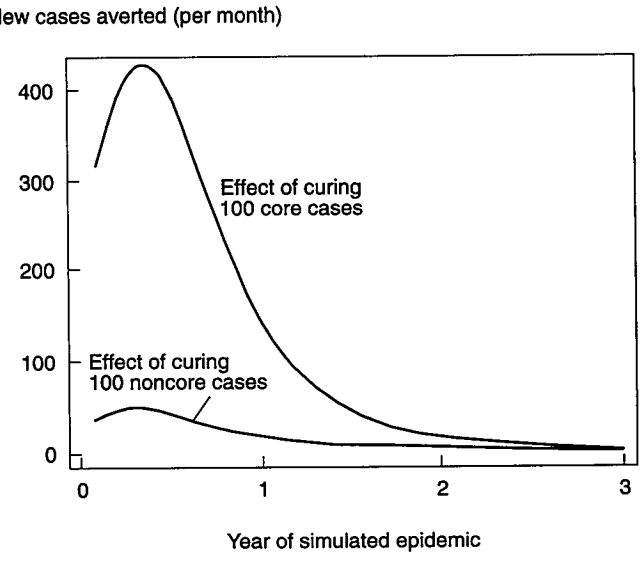
The results of this dynamic simulation reveal several things about preventing cases of an STD that are hidden by the static analysis. First, note from figure 20-11 that the one-time cure of 100 gonorrhea cases, whether in the core or the noncore, has virtually no effect on the number of cases three years later. The beneficial effect of a one-time intervention is transitory, because of the speed with which this epidemic approaches its equilibrium in the population. Similar patterns are displayed by the chlamydia, syphilis, and chancroid epidemics.

In contrast to the classic STDs, HIV has a much smaller probability of transmission per sexual contact (0.01 to 0.03 in contrast to 0.4 to 0.6 for gonorrhea) and a much longer duration of infectivity (eight years in contrast to up to one year for syphilis). These differences make an HIV epidemic much slower to reach equilibrium than any of the CSTD epidemics. As a result, as can be seen in figure 20-12, the beneficial effect on an HIV epidemic of an intervention is still apparent ten years after the intervention.

The pattern changes if the HIV epidemic occurs in a population that is saturated by genital ulcer disease (GUD). Assuming that GUD increases the transmission probability by a factor of four, the effect is greatly to speed the epidemic and therefore to speed the return of the epidemic's path to equilibrium after any one-time intervention. For this accelerated HIV epidemic, a one-time intervention results in fewer new cases each month for a period of about five years than would have occurred without the intervention. After about five years, however, the number of new cases each month would have begun to slow even without intervention, because so few uninfected people would have remained to be infected. As a result of the intervention, there are more uninfected people in the population after five years, so that the number of new cases can be slightly larger during the sixth and subsequent years than it would have been without intervention. Figure 20-13 shows that this pattern holds whether the intervention is in the core or the noncore group.[32]

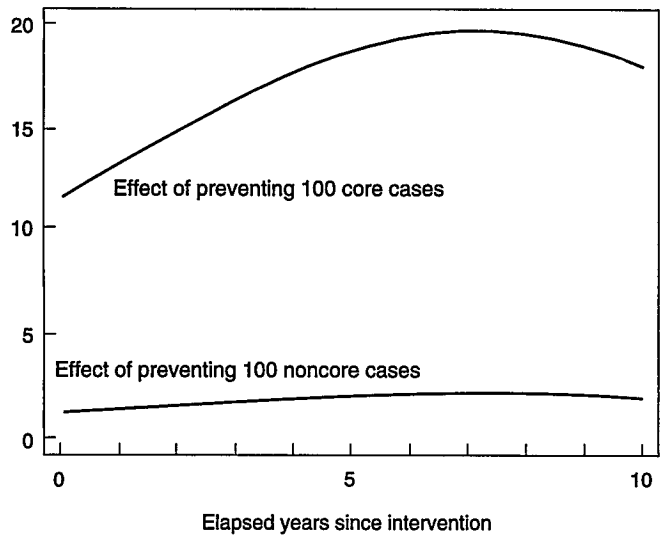
THE ADVANTAGE OF TARGETING THE CORE. In order to measure the aggregate of all the ill health averted by the act of

Figure 20-11. Dynamic Benefit of Curing or Preventing 100 Cases of Gonorrhea in the Core and the Noncore Groups



a. Cure in the initial intervention thereby preventing more infection.
Source: Authors.

Figure 20-12. Dynamic Benefit of Preventing 100 Cases of HIV in the Core and Noncore Groups when No Classic STDs Are Seen in the Population



Source: Authors.

preventing 100 cases today, we subtract in each month the number of new cases despite the intervention from the number predicted in the base run to have occurred in the absence of the intervention. Then we discount each of these averted future new cases back to the time of the intervention (at 3 percent per annum) and sum their discounted values to express the result as discounted new cases averted. Table 20-14 includes these figures for each disease and for each of the two interventions.

Consider again the disease gonorrhea. Despite the absence of any long-run effect on prevalence rate of either the core or the noncore one-time intervention, each of them does save a substantial number of case-years. Curing (or preventing) 100 initial cases in the noncore averts a total of 426 discounted future cases of gonorrhea (composed of 402 in the noncore and 24 in the core). Suppose, however, that the 100 cases prevented are instead extracted from the core group. In this case the total number of cases averted rises to 4,278, or ten times as many (of which only 231 are in the core). A policy of targeting the one-time intervention at the core averts ten times as many cases as would have been averted by a policy directed at the noncore. Furthermore, examination of the rest of table 20-14 shows that this result is robust across all the analyzed diseases.

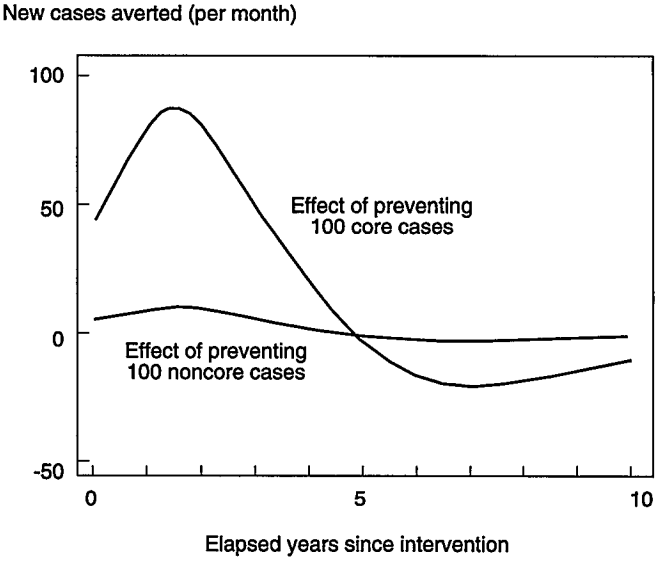
The absolute number of discounted future cases averted by the one-time intervention is roughly similar for gonorrhea, chlamydia, and syphilis but is much smaller for chancroid (because it is less infective) and somewhat smaller for the slower epidemics of HIV with and without the exacerbation of genital ulcer disease. Note that preventing 100 cases of HIV has only slightly more effect when the HIV epidemic is exacerbated by GUD than when it is not. This is because the initially greater effect in the presence of GUD is subsequently offset after year five as the epidemic accelerates back to its original path.

SENSITIVITY OF CORE STRATEGY TO ALTERNATIVE ASSUMPTIONS. The advantage of targeting the core highlighted in the above subsection is a significant result with potentially important policy ramifications. Because it is derived from a simulation based on specific parameter values, the question arises as to whether the result would hold under alternative assumptions. The exercise already varies the disease-specific assumptions across the six different simulated epidemics. We now examine the sensitivity of these results to changed assumptions about sexual behavior. We focus on two parameters from table 20-10, the selectivity coefficient (G) and the rate of sexual partner change (a).

As described above, the selectivity coefficient is the parameter which captures the degree of mixing between the core and noncore. The extreme values of 0 and 100 percent represent proportionate and zero mixing, respectively. The assumption of proportionate mixing ($G = 0$) used to this point in the chapter obviously does not represent the epidemiology of pattern I countries, in which homosexuals tend to be exclusively homosexual and IV drug users also represent a relatively (not entirely) isolated community. Proportionate mixing, however, may be a much more realistic representation of behavior patterns in pattern II countries.

Recall that the assumption of proportionate mixing implies that an individual chooses indiscriminately among core and noncore partners according to their availability for sexual contact. As table 20-10 shows, there are 1,000 noncore individuals available with whom to change partners each day and only 200 core individuals. Thus the assumption of proportion-

Figure 20-13. Dynamic Benefit of Preventing 100 Cases of HIV in the Core and Noncore when Transmission is Increased by Genital Ulcer Disease



Source: Authors.

Table 20-14. Dynamic Effects of Preventing 100 STD Cases in Core Rather than Noncore Group

Disease	Discounted new cases averted over ten years[a]: Targeting core group	Targeting noncore group	Ratio of core to noncore
Chancroid	810	83	9.8
Chlamydia	4,096	423	9.7
Gonorrhea	4,278	426	10.0
HIV without ulcers	1,744	180	9.7
HIV with ulcers	2,106	201	10.5
Syphilis	4,132	422	9.8

a. Sum of the savings in both the core and noncore group of an initial preventive or curative policy applied to only one group. The streams of saved cases are discounted at an annual rate of 3 percent.
Source: Authors' calculations.

ate mixing in this model implies that any individual in the core or the noncore has a five times greater chance of contacting a noncore than a core person. Among the sexually active groups in highly affected Sub-Saharan African cities described in Larson (1989) and Caldwell, Caldwell and Quiggin (1989), this scenario may indeed be quite realistic.

Still, what would happen if selectivity were greater than zero or if sexual behavior were less active? Repeated in the upper-left panel of table 20-15 are the effectiveness ratios from the right column of table 20-14. In the other three panels of table 20-15 are displayed the effects on these ratios of varying either the selectivity or the rate of partner change in the core. Note that none of the three alternative sets of sexual behavior parameters casts doubts on the greater effectiveness of a policy aimed at the core group. Indeed in no case does the ratio of the core to noncore effectiveness fall below 8.5, and in one case it rises to 55.5.[33]

COMBINING THE STATIC AND DYNAMIC BENEFITS. In the absence of an intervention, an epidemic causes a loss equal to the discounted sum of the losses from all future cases of the disease. If an intervention is effective, its benefit is to reduce the magnitude of this loss by reducing or postponing future cases. In the case of a one-time intervention like the one simulated here, prevalence rates of the STD epidemics ultimately reach the same levels as they would have reached without the intervention, only later. Thus the beneficial effect of the one-time intervention is to postpone these cases.[34]

In table 20-16 we combine the static estimates (from table 20A-3) of benefits from preventing or treating a case of each STD with the dynamic estimates (from table 20-14) of the discounted sum of averted future cases. Because the dynamic estimates are based on a ten-year simulation, they somewhat understate the estimated future effect of an intervention on an extremely slow epidemic, such as HIV in the absence of GUD. These estimates nevertheless show dramatically the substantial health benefits from the prevention or cure of the more serious STDs, such as syphilis and HIV infection, in contrast to the less serious, such as chlamydia and even gonorrhea. Recall, however, that these estimates do not yet include the additional benefits of preventing or curing one of the CSTDs because of the consequent reduction of HIV transmission. The next subsection addresses this issue.

HEALTH BENEFITS WHEN STDs AFFECT HIV TRANSMISSION. The hypothesis that CSTDs affect the efficiency of HIV transmission is both biologically and epidemiologically appealing. When sexual contact occurs between an HIV-infected individual and a susceptible person, the presence of genital ulcer disease in either partner could plausibly increase the probability of HIV transmission by allowing the virus easier exit from the infected person or easier entry to the susceptible one. If STDs do increase the efficiency of HIV transmission, the higher STD prevalence rates in Sub-Saharan Africa would provide a partial epidemiological explanation for the faster increase in prevalence rates among heterosexuals in Africa than has been observed among heterosexuals in North America and Europe.

Whether STDs actually do increase the efficiency of HIV transmission is inherently difficult to demonstrate, because of the need to control properly for the frequency of sexual partner change. Without such control, an observed correlation between HIV infection and a past history of STDs could actually be due to the correlation of both variables with the degree of sexual activity. The researchers in several independent studies in both East and West Africa, however, have found large and statistically significant effects of STDs on the efficiency of HIV transmission, even after controlling for past sexual activity (Cameron and others 1989; Ryder and others 1990). Furthermore, investigators in a recent study in Zaire have found that even nonulcerative cases of gonorrhea and chlamydia increase the transmission probability (Laga and others 1990).

The simulations of an HIV epidemic both with and without ulcers in figures 20-12 and 20-13 demonstrate that, when an HIV epidemic is accelerated by STDs, the benefits of an inter-

Table 20-15. Sensitivity Analysis: Advantage of Preventing or Curing STD in the Core Group, Based on Selectivity and Rate of Partner Change

Rate of partner change	Disease	Selectivity (G): 0.0[a]	0.30
0.02[a]	Chancroid	9.8	20.5
	Chlamydia	9.7	9.0
	Gonorrhea	10.0	10.5
	HIV without ulcers	9.7	10.3
	HIV with ulcers	10.5	8.5
	Syphilis	9.8	9.5
0.04	Chancroid	20.1	22.6
	Chlamydia	17.1	11.2
	Gonorrhea	17.1	12.4
	HIV without ulcers	17.4	12.5
	HIV with ulcers	55.5	22.0
	Syphilis	17.0	11.5

a. Base value.
Source: Authors' calculations.

Table 20-16. Discounted Disability-Adjusted Life-Years Saved per Case Prevented or Cured When Epidemics Independent: Core vs. Noncore

Disease	Static benefit[a]	Dynamic benefit[b]		Total benefit[c]	
		Core	Noncore	Core	Noncore
Chancroid	0.2	1.6	0.2	1.8	0.4
Chlamydia	1.05	43.0	4.4	44.1	5.5
Gonorrhea	0.85	36.4	3.6	37.3	4.5
HIV without ulcers	19.5	340.1	35.1	359.6	54.6
HIV with ulcers	19.5	410.7	39.2	430.2	58.7
Syphilis	3.8	157.0	16.0	160.8	19.8

a. Benefit to only the cured or protected individual from curing or preventing a case of STD. Because the dynamic model does not distinguish the genders, the static benefits of averting a case in the two genders are averaged.

b. Benefit to people other than the cured or protected individual from curing or preventing a single case of STD. Computed by dividing the figures from table 20-14 by 100 and multiplying by the static benefit per case averted.

c. Benefit of a single cure or prevention to both the individual and to the people he or she would have infected. Computed by adding the static benefit to the dynamic benefit.

Source: Authors' calculations.

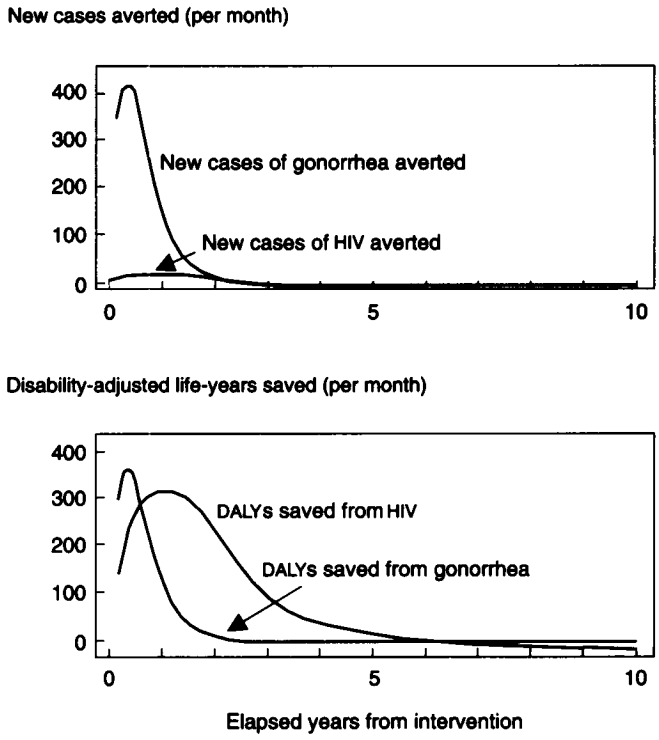
vention occur sooner and also decay more quickly. If the CSTDs could be somehow removed from a population in which they have been endemic, the rate of growth of HIV prevalence would slow dramatically, taking more than twice as long to reach its ceiling. But STDs cannot be magically removed; they must either be prevented or cured one at a time.

When STDs affect HIV transmission, the health benefits of curing or preventing a case of a CSTD should be larger than in the absence of such an interaction. To estimate the increased health benefit of curing or preventing a case of a CSTD in the presence of an HIV epidemic, we modify the simulation model used above to include an interaction between the STD being modeled and HIV. Because chancroid and syphilis cause genital ulcer disease, we assume that the probability of HIV infection when one partner has either of these diseases is five times larger than if neither is so infected. The nonulcerating diseases, gonorrhea and chlamydia, are assumed to increase infectivity by three and two times, respectively.[35]

Figure 20-14 illustrates the effects on the gonorrhea epidemic and also on a simultaneous HIV epidemic of an intervention which cures or prevents 100 cases of gonorrhea in the core group. In the top panel, the top curve charts the number of cases of gonorrhea averted each subsequent month as a result of this intervention, which totals 4,278, just as it does in table 20-14 as depicted in figure 20-11 above. The bottom curve in the top panel, although barely distinguishable from the horizontal axis, captures the indirect effect of curing gonorrhea cases on the HIV epidemic. The discounted sum of averted future cases of HIV infection is 425.1 over the ten-year span of the simulation.

The bottom panel of figure 20-14 graphs the same two epidemic paths as the top panel with one difference: each is multiplied by the static benefit per averted case to yield the flow of saved disability-adjusted life-years that result from curing 100 cases of gonorrhea. Because, according to figure 20-10 and table 20A-3, the static benefit per case of gonorrhea is only 0.85 disability-adjusted life-years (average of 0.7 for men and 1.0 for women) and is 19.5 disability-adjusted life-years per case of HIV infection, the flow of health resulting from the intervention's indirect effect on the HIV epidemic outweighs that resulting from its effect on the gonorrhea epidemic. The transformation from cases averted to disability-adjusted life-years saved thus reverses the apparent importance of the two effects. The discounted sum of these health benefits are 3,646 disability-adjusted life-years from averted gonorrhea cases and 8,289 from averted HIV.[36] The total dynamic effect of averting 100 cases of gonorrhea in the core group is the sum

Figure 20-14. Effect of Curing 100 Core Cases of Gonorrhea When Gonorrhea Increases HIV Transmission



Source: Authors.

Table 20-17. Dynamic Effects of an HIV Epidemic from Preventing 100 STD Cases in Core and Noncore Groups

Disease	Discounted new cases of HIV averted over ten years[a]: Targeting core group	Targeting noncore group	Ratio of core to noncore
Chancroid	275.9	17.4	15.9
Chlamydia	355.8	30.3	11.7
Gonorrhea	425.1	36.2	11.7
Syphilis	1,207.8	109.1	11.1

a. Sum of the averted cases of HIV infection in both the core and noncore groups from an initial prevention or cure of 100 cases of classic STD in only one of these groups. In addition to these health benefits, saving 100 cases of classic STD also reduces future cases of that STD.

Source: Authors' calculations.

of these two figures, or 11,935 disability-adjusted life-years. Adding this to the 85 disability-adjusted life-years gained for the lives of the individuals whose cases of gonorrhea were directly treated or prevented gives a total of 12,020 disability-adjusted life-years saved, or 120.2 disability-adjusted life-years saved per case of gonorrhea averted.

In table 20-17 we show the total cases of HIV averted when 100 cases of one of the CSTDs are cured or prevented in the core or the noncore group. These benefits are in addition to the benefits given in table 20-14. As might be expected, the indirect effects on averting cases of HIV, like the direct effects in table 20-14, are much greater when the intervention is targeted at the core group.

In table 20-18 we gather together the components to give the total health benefit, measured in disability-adjusted life-years saved, per case of each CSTD prevented or cured. The figures in table 20-18 are shown graphically in figure 20-15. Note the extraordinarily large health effect of preventing or curing a case of syphilis in the core group. By saving almost 400 disability-adjusted life-years per case cured or prevented, this intervention has an even greater effect on health than would the direct prevention of a case of HIV infection. The beneficial effects of interventions against all the other CSTDs are also greatly increased in the presence of an HIV epidemic. These health benefits presented in table 20-18 and figure 20-15 are used later for the cost-effectiveness calculations.

BENEFITS OF A SUSTAINED INTERVENTION. Each STD is characterized in table 20-11 by a probability of transmission on a given sexual contact and by a duration of infectivity. Interventions which reduce either of these parameters for an STD in a given population will slow the epidemic and, if the intervention is permanent, will reduce the equilibrium incidence and prevalence rates in the population. Interventions which reduce the risk of transmission include circumcision (Bongaarts, Reining, and Conant, 1989; Moses and others 1989), the use of nonpenetrative sex, and, most important, the use of condoms.

Our method is analogous to that used above to model the effect of 100 cures. We use the same base runs for each epidemic to represent the situation without an intervention. Then we model two alternative interventions, one in the core and one in the noncore. The intervention consists of assuming that 100 people randomly drawn from the chosen (core or noncore) group are protected for one year from either becoming infected or from infecting others. In this way the probability that a susceptible person will acquire the transmission through contact with a person of a given group is reduced by the probability that at least one of the two partners is thus "protected."[37] The result is that, for a year, the rate of growth of the epidemics is slower than it would be in the absence of this intervention. At the end of the year the epidemic resumes its normal pace and the prevalence rate converges to the same equilibrium that it attains in the base scenario.

By protecting 100 people of the 1,000 in the core, we reduce the effective danger of sex with a core person by 10 percent. In contrast, protecting 100 people of the 50,000 in the noncore only reduces the danger of having sex with a noncore person by 0.2 percent. This difference is responsible for the dramatic difference in the effectiveness of the two interventions. Notice that a person-year of protection of a core individual in the presence of an HIV epidemic alone saves 56.6 DALYs, almost three times more than are saved by protecting a noncore person

Table 20-18. Discounted Disability-Adjusted Life-Years Saved per Case Prevented or Cured When STDs Affect HIV Transmission: Core vs. Noncore

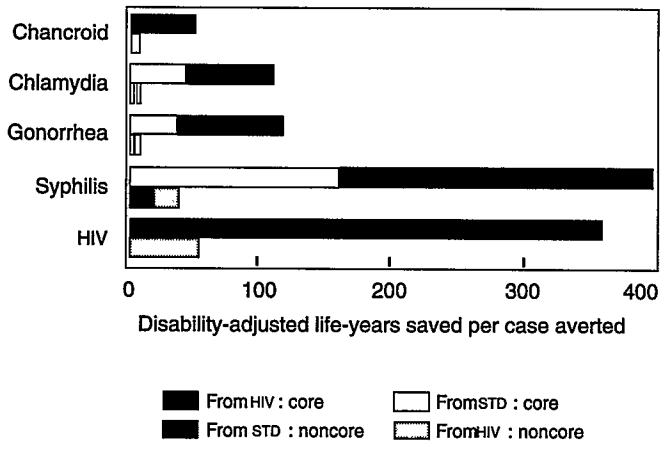
Disease	Static and dynamic DALYs per case from classic STD only: Core	Noncore	Dynamic DALYs per case from averted HIV only[a]: Core	Noncore	Total DALYs saved per case of classic STD: Core	Noncore
Chancroid	1.8	0.4	53.8	3.4	55.6	3.8
Chlamydia	44.1	5.5	69.4	5.9	113.5	11.4
Gonorrhea	37.3	4.5	82.9	7.1	120.2	11.6
HIV without ulcers	359.6	54.6	n.a.	n.a.	359.6	54.6
HIV with ulcers	430.2	58.7	n.a.	n.a.	430.2	58.7
Syphilis	160.8	19.8	235.5	21.3	396.3	41.1

n.a. Not applicable.

a. Additional benefits of preventing or curing a case of a classic STD resulting from indirect prevention of HIV infection. Calculated by dividing the cases of HIV averted (table 20-16) by 100 and multiplying by 19.5, the static benefit of each case averted.

Source: Authors' calculations.

Figure 20-15. Total Health Benefit of Averting a Case of Classic STD When STD Exacerbates HIV Transmission: Core vs. Noncore Strategy



Source: Table 20-18.

for a year. If the only STD epidemic is syphilis, which is much more infectious, protecting a core person for a year saves 141.7 DALYs, about twenty times more than would protecting a noncore person for a year. If the syphilis and HIV epidemics are both in the population simultaneously, however, protecting a core person saves a total of 384.6 DALYs, forty times more than would protecting a noncore person. Of the 384.6 DALYs saved, 141.7 are from syphilis, 56.6 are from HIV in the absence of any interaction with syphilis, and 186.3 are from HIV, because the slower syphilis epidemic has a smaller effect on HIV transmission.

The model estimates of a one-time intervention curing 100 people showed in table 20-18 that the intervention would have roughly ten times greater effect when targeted to the core than to the noncore. In table 20-19 it is shown that a sustained intervention which lowers transmission probabilities also has a larger effect when targeted at the core. But this time the advantage ranges from a multiple of forty for syphilis to a multiple of seventy-four for chancroid. Unless the cost of targeting such a sustained intervention at the core is as much as forty times larger per person-year of protection than targeting it to the noncore, the data in table 20-19 lead us to predict that targeting to the core will be the more cost-effective strategy.

The modeling method used to generate the numbers in table 20-19 allows only one or two epidemics to be present simultaneously in the population. When there are more than two simultaneous epidemics, reducing transmission probabilities by protecting individuals, with condoms or otherwise, would have an even larger health benefit. Because the most important interaction is with HIV and because averted HIV infection provides most of the benefits of the sustained intervention, the effect of considering only two diseases at a time will be a minor understatement of the benefits of this intervention.

Costs of and Expenditure on Primary Prevention Programs

It would be useful to present cost and expenditure information on all forty-three of the interventions categorized in table 20-13 by the mode of transmission they are designed to interrupt. Unfortunately there is almost no information on either the cost of or the current expenditure on primary prevention of STDs in developing countries. In this section we present the fragmentary available information on the cost of a few of these interventions designed to interrupt three of the four modes of transmission: sexual intercourse, mother-to-infant, and blood transfusion. For lack of information on expenditure, we conclude the section by analyzing the budgeted expenditures in the Sub-Saharan countries' medium-term plans by 1988.

COST OF PREVENTING SEXUAL TRANSMISSION. Of the fourteen interventions listed in the first column of table 20-13, we focus our cost-effectiveness analysis on only one: the encouragement of condom use through social marketing. Both the costs and the effects of the other interventions are insufficiently well known to permit quantitative estimates.

Table 20-19. Discounted Disability-Adjusted Life-Years Saved per Person-Year of Protection when STDs Affect HIV Transmission: Core vs. Noncore

	Static and dynamic DALYs per case from classic STD only		*Dynamic DALYs per case from averted HIV only*[a]		*Total DALYs saved per case of classic STD*	
Disease	*Core*	*Noncore*	*Core*	*Noncore*	*Core*	*Noncore*
Chancroid	1.4	0.2	79.5	0.9	80.9	1.1
Chlamydia	52.3	2.3	144.4	1.9	196.6	4.2
Gonorrhea	64.9	2.4	210.3	2.8	275.2	5.2
HIV without ulcers	56.6	19.9	n.a.	n.a.	56.6	19.9
HIV with ulcers	156.0	21.5	n.a.	n.a.	156.0	21.5
Syphilis	141.7	6.5	242.9	3.3	384.6	9.7

n.a. Not applicable.

a. Obtained by multiplying the discounted sum of future cases averted over ten years as a result of the intervention, times the static benefit of each case averted, averaging the male and female values where they differ.

b. Additional benefits of a person-year of protection due to both the direct protection against HIV and the indirect prevention of HIV infection. The portion of this benefit due to the indirect effect through the reduced prevalence of the CSTD can be calculated by subtracting the numbers for HIV without ulcers in columns 1 and 2 from the numbers in columns 3 and 4.

Source: Authors' calculations.

Table 20-20. Two Condom Social Marketing Programs in Sub-Saharan Africa

Feature	Zaire	Tanzania
Location	Kinshasa	Six truck stops and two trucking companies
Start date	1989	1989
Baseline condom use	200,000 condoms sold privately per year at cost of $1 per condom.	Half of drivers had had more than fifty sexual partners in their lifetime. Condoms used consistently with casual partners by 42 percent of bar girls and commercial sex workers (CSW) and by 37 percent of drivers.
Accomplishments	13,000,000 condoms sold in two years at 6 cents per condom. Expect to sell 8,000,000 more in third year. Condoms now present in 7,000 of 9,000 targeted outlets.	Each truck stop is serviced by an average of 200 CSWs who use 20,000 condoms per month, or an average of 100 per CSW per month or four per night.
Total cost per year	About $2 million	$100,000 budget plus free condoms provided by National AIDS Control Program. Amortization of vehicles provided free by African Medical and Research Foundation (AMREF). Perhaps $750,000.
Total condom sales per year	About 8 million	2 million
Price per condom	6 cents in 1990, falling to 0.6 cents in 1991 as result of domestic inflation and devaluation.	No charge to customer
Cost per couple-year of protection		
Core[a]	$300	$456
Noncore[b]	$30	$45.60
Contractor	Population Services International	Family Health International/AIDSTECH

Note: All money in U.S. dollars.

a. Assumes four contacts per night, twenty-five nights per month. Cost per condom 25 cents in Zaire, 38 cents in Tanzania.

b. Assumes ten contacts per month. Cost per condom 25 cents in Zaire, 38 cents in Tanzania.

Source: Personal communications from Linda Cole, Family Health International, March 1991 (Tanzania) and from Richard Frenk, Population Services International, February, 1991.

The use of condoms by sexually active individuals with multiple sexual partners affects the STD epidemics by reducing the probability of sexual transmission on a given sexual contact. This probability, Q, is one of the four key behavioral parameters in the dynamic epidemiological model presented earlier.[38] The government-sponsored programs in several Sub-Saharan African countries have focused only on frequency of partner change, thereby failing to help and sometimes stigmatizing individuals who find it impossible to remain monogamous.

In many of these same countries, private organizations have informed prostitutes and others of means to reduce the danger of each sexual contact through the proper use of a condom. The cost of such programs is poorly understood. Sketchy information on programs funded by the United States Agency for International Development through AIDSTECH, Family Health International, is summarized in table 20-20. The subsidy costs of these condom social marketing programs for AIDS control range from $30 to $45 per year of protection for a noncore person in 1990 U.S. dollars, not including any money from cost-recovery efforts which remunerates the distribution network.

For comparison, the estimated cost of a couple-year of protection by condoms distributed by social marketing in family planning programs in Honduras and Bangladesh was recently estimated to be $14.77 and $6.55, respectively, in 1988 U.S. dollars, of which $4.59 and $ 5.90, respectively, were the net subsidy cost to the government (Bulatao 1985; Janowitz, Bratt, and Fried 1990). Because family planning programs presume that couples are monogamous, the cost of the condoms to protect a couple from conception for a year is roughly comparable to the cost of the condoms to protect one of these individuals from STDs for a year, assuming that person is in the noncore group. The difference of a factor of five to ten in average subsidy costs between the condom marketing programs aimed at STD prevention in Africa and the family planning programs in Latin America and Asia is partly due to the high overhead and substantial input of expatriate personnel during the start-up phase of the former. Perhaps as the STD prevention social marketing programs mature, the average annual subsidy per noncore person-year of protection will fall closer to the levels observed for the family planning programs. Still, the fact that AIDS prevention social marketing programs target high-risk groups may keep their average costs higher than the values attainable by family planning programs that target the noncore. We hypothesize that the budgetary (or subsidy) cost of a condom social marketing program targeted to the noncore will lie between the value of $5.00 per protected individual observed in the family planning programs and the value of $45.00 observed in the Tanzanian experiment in peer education. Whatever the cost per individual user in the noncore, we further hypothesize that the cost

per protected individual will be ten times larger in the core group.

COST OF PREVENTING MOTHER-TO-INFANT TRANSMISSION. A major sequela of gonorrhea is gonococcal ophthalmia neonatorum, which can be inexpensively prevented by the application of an antibiotic to the eyes of the newborn immediately after birth. Because 3.5 percent of all live births in some African populations suffer from this potentially blinding disease, there is reason to consider a prophylactic application of antibiotic to the eyes of all neonates as part of a standard maternal and child health package. Laga, Meheus, and Piot (1989) have estimated the cost of applying an antibiotic (either silver nitrate or tetracycline) to the eyes of all newborn infants to be approximately $0.10 per newborn for silver nitrate and approximately $0.05 per newborn for tetracycline. On the basis of clinical trials of these alternatives in Nairobi, they estimate that silver nitrate prevents 40 of the 47 cases that would occur among 100 babies born of women with a gonococcal infection, whereas tetracycline would prevent 44 of the 47 cases. The calculation of the dollars per case of gonococcal ophthalmia neonatorum at different prevalence rates in the population is presented in table 20-21.

With respect to HIV infection, from 30 percent to 50 percent of the children born to HIV-infected women will be infected with HIV at birth. If those women could be counseled to prevent pregnancy or abort their fetus, one HIV-infected child would be prevented for every one to two uninfected children born. Unfortunately, anecdotal evidence suggests that many poor women, when informed that they are HIV-infected and of the probable consequences, prefer to continue bearing children. Our general position regarding mandatory programs—that they are unethical and counterproductive—seems particularly apt in the case of hypothetical programs to enforce or strongly encourage abortion of the fetuses of HIV-infected women. Thus we conclude that the only cost-effective way to prevent vertical transmission of HIV is to prevent the infection of the mother in the first place.

COST OF PREVENTING TRANSMISSION BY BLOOD TRANSFUSION. The average variable cost of an enzyme-linked immunosorbent assay (ELISA test) for the presence of HIV antibodies in the blood can be as low as $1 in a well-run laboratory in a developing country which performs large numbers of such tests. Assuming another $1 per test for management overhead, the average total cost of such a test could be as low as $2. To obtain this low a cost in a developing country, however, requires good management, well-trained and well-managed technicians, and large volume. In rural areas of developing countries where none of these conditions obtain, an alternative test not requiring refrigeration is a rapid serologic test for HIV for which the average variable cost is as much as $4 per test, which becomes $5 with the addition of the same dollar for management overhead. Finally, a laboratory expert in Sub-Saharan Africa has informed the first author in confidence that the average total cost of blood screening in some Sub-Saharan African capitals can be as large as $10 per test.

Suppose that a perfect test to determine whether a unit of donated blood is infected with HIV costs $2 per blood sample tested. If 5 percent of donors are known to be infected, then it would require an average of twenty tests to find a single infected unit of blood. By eliminating this unit of blood and replacing it at no cost with an uninfected unit, a transfusion service has avoided transfusing a patient with HIV-infected blood at twenty times the cost of a blood test. In addition, suppose that three-quarters of the people to receive blood transfusions are HIV-negative before the medical emergency and subsequently survive the medical problem that caused them to need the blood. Then the cost of averting an HIV infection through blood screening is 4/3 of 20 times the cost of a single test, or $53 per HIV infection prevented. The general equation is:

$$\textit{Cost per HIV infection averted} = \frac{\left(\dfrac{\textit{Cost per test}}{\textit{Prevalence rate}}\right)}{\textit{Survival rate of transmission recipients}}$$

A more complete model of the cost-effectiveness of blood screening would relax many of the assumptions made in the above analysis. For example, the tests currently available are not perfect, especially under field conditions. They generate false positives and false negatives. Furthermore, infected units of blood cannot be replaced at no cost but cost as much as $5 each to replace. Elaboration of these more complete models with plausible values for the complicating parameters, however, raises the estimated cost per averted case of HIV infection by only a few percentage points. Therefore, for ease of exposition, we present here only the results of this extremely simple model.[39]

Shown in figure 20-16 on a logarithmic scale is the relation between the cost per averted case of HIV infection and the prevalence rate graphed for two different values of the cost per test, $2 and $10. At a prevalence rate of 5 percent and a test cost of $2, the cost of averting a case of HIV infection is $53 as in the above example. Note the dramatic effect of prevalence rate on cost. At one extreme, when the prevalence rate among donors is as high as 40 percent, as it might be for the donors that an urban prostitute would recruit from among her coworkers in a high-prevalence African city, screening can avert a

Table 20-21. Cost per Case Averted of Eye Infection from Gonorrhea, by Prevalence of Gonorrhea among Pregnant Women
(1989 U.S. dollars)

			Prevalence of gonorrhea among pregnant women			
Therapy	*Cost*	*Effectiveness*	*0.001*	*0.01*	*0.10*	*0.25*
Silver nitrate	0.10	0.85	111.11	11.76	1.18	0.47
Tetracycline	0.05	0.94	55.56	5.32	0.53	0.21

Source: Laga, Meheus, and Piot 1989.

case of HIV infection for only $7. At the other extreme, in areas of low prevalence, blood screening is a very expensive way to avert HIV infection, costing more than $6,000 per case averted. The left-most data point on the graph is at a seroprevalence rate of 4 per 10,000, or 0.04 percent.[40] All these costs are multiplied by five if the cost per test is $10 rather than $2. These higher costs are related to prevalence rates in the upper line in figure 20-16.

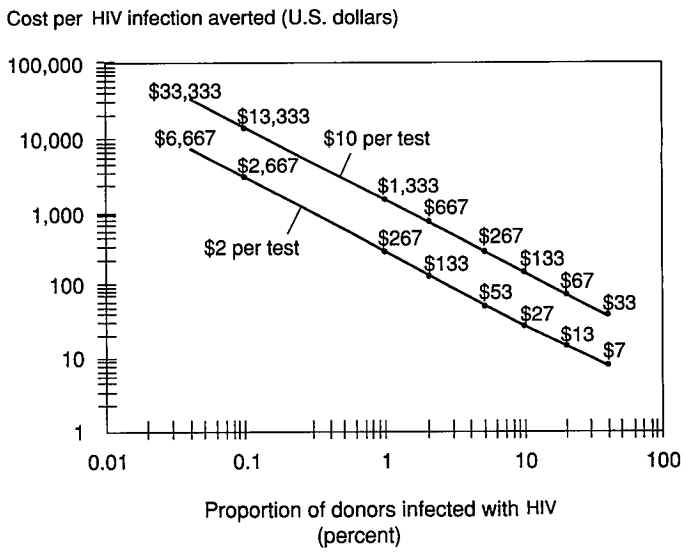
In any given country the possible sites for blood transfusion all have different prevalence rates among their donors and different laboratory conditions leading to different test costs. The lesson of figure 20-16 is that the cost-effectiveness of blood screening for averting cases of HIV infection will vary a great deal from one of these sites to another. Screening should begin at those sites where screening is most cost-effective and only be developed in the least cost-effective sites if the country is unable to avert cases of HIV or to save disability-adjusted life-years more cheaply in other ways.

BUDGET FOR PRIMARY PREVENTION OF HIV INFECTION. In table 20-22 we present the first-year budget of the sixteen Sub-Saharan African countries which were first to adopt such medium-term plans for AIDS prevention and control. With only partial minor exceptions, the first-year proposed expenditure has been fully funded, typically out of grants from bilateral donors, both directly and through the World Health Organization's Global Programme on AIDS (WHO/GPA).

In the third column of table 20-22 is the total (recurrent plus capital) central government health expenditure for those countries from which figures are available. The figures in the fifth column show that, in the average country, the medium-term plan (MTP) will augment central government health expenditure by 6 percent. In Zaire and Rwanda the MTP represents a 20 percent increment to central government health expenditure, and in Uganda, Zambia, Tanzania, and Burundi the increment is about 10 percent.

One way to gauge the magnitude of these MTP budgets is to relate them to the estimated number of HIV-infected persons.

Figure 20-16. Cost per HIV Infection Averted by Blood Screening, as a Function of Prevalence and Test Cost



Source: Authors.

Table 20-22. Donor-Funded AIDS Prevention and Control Budgets in African Countries

Country	Year of MTP	First-year MTP budget[a]	Central government health expenditures	MTP as percent of government health expenditures	Estimated persons HIV positive	MTP budget per HIV-positive person
Uganda	1987	1,508	14,695	10.3	894.3	1.69
Zambia	1988	3,101	34,094	9.1	205.2	15
Zaire	1988	4,363	22,269	19.6	281.8	15
Central African Republic	1987–88	1,599	—	—	54.3	29
Rwanda	1987	2,922	13,680	21.4	81.5	36
Congo	1988	1,727	—	—	45.5	38
Tanzania	1987	3,945	51,250	7.7	96.6	41
Mozambique	1988	1,788	—	—	43.5	41
Cameroon	1988	1,841	86,593	2.1	33.2	55
Kenya	1987	2,940	120,335	2.4	44.5	66
Burundi	1988	1,719	14,925	11.5	15.0	115
Zimbabwe	1988–89	3,799	128,323	3.0	30.9	123
Botswana	1987	150	32,369	0.5	0.9	167
Senegal	1988	1,443	—	—	2.9	498
Mauritius	1988	242	26,045	0.9	0.1	2,420
Ethiopia	1988	3,137	45,480	6.9	0.1	31,370
Mean		2,264	36,879	6.0	114.4	20

Note: Budget and expenditures in thousands of 1987 U.S. dollars.
— Not available.
a. From first medium-term planning documents prepared by individual countries with WHO/GPA assistance.
Source: Bongaarts and Way 1989; World Bank 1989. See also note a, above.

The fifth column of the table contains the estimated number of HIPs in each country in 1987–88. From the data in the second and fifth columns, we arrive at that in the sixth column, the MTP budget per HIP, which ranges from less than $2 in Uganda to more than $31,000 in Ethiopia.

The appropriate budget allocation to a national AIDS control program depends on the cost of preventing a case of HIV infection in that country and on the alternative possible uses for the same budget resources. For an international agency such as WHO/GPA, the alternative expenditure for grant resources not spent in country X is expenditure on preventing HIV infection in country Y. Such an agency's goal might reasonably be to minimize the number of cases of HIV infection worldwide by maximizing the number of prevented cases each year. With a fixed global grant budget, this goal could be achieved only by equalizing the number of cases prevented per grant dollar across countries.

The cost per case of HIV prevented will vary across countries and within a country across interventions. As long as HIV prevalence rates are increasing, however, the number of people at risk of new infection will be roughly proportional to the number of people capable of infecting others in that country, that is, the number of HIPs. Thus a rational allocation of a global grant budget for AIDS control should approximately equate the MTP dollars per HIP across countries. Some variation in budget per HIP would remain because of the different institutional structures—and, therefore, the different costs of interventions—across countries. Still, the large variations in MTP budget per HIP revealed by the sixth column of table 20-22 demonstrate that the allocation of resources across these Sub-Saharan African countries is quite different from the prevention-maximizing allocation. Even ignoring the two extreme countries, Uganda and Ethiopia, the MTP budget per HIP is more than thirty times larger in Mauritius and Senegal than in Zambia and Zaire, a multiple too large to explain by differences in absorptive capacity. It is hard to escape the conclusion that the MTP budgeting process was driven by random political and other factors which bore little relation to a rational allocation of resources across countries.

There is a prior question, however—whether these large incremental expenditures can be effectively absorbed by the countries in question. Because the health expenditure of central governments rarely fluctuates by more than 2 or 3 percentage points in any given year, and then the fluctuation is usually spread over all the many preventive and curative programs in the ministry, it is not surprising that governments have had substantial difficulty launching such large incremental expenditure programs, amounting to as much as 10 to 20 percent of their health budgets, for a single disease. Although the key resource constraint over the short run has proved to be trained manpower, an additional limit to the absorptive capacity of national AIDS programs has been a lack of clear guidance on prioritizing interventions. The medium-term plan has typically enumerated a long list of desirable activities, including most of those listed in table 20-13, without ranking them by effectiveness or urgency. The result is that the small numbers of trained staff have been spread too thinly trying to do all these activities at once. We hope that analyses such as the present one will help guide the prioritization of activities and expenditure so that national AIDS programs can achieve greater health benefits (that is, save more disability-adjusted life-years) for their allotted budget.

Cost-Effective STD Prevention Strategies

Primary prevention of STDs requires the interruption of one or more of the modes of STD transmission displayed as column headings in table 20-13. Resources are not so plentiful, however, that countries can afford to press forward on all possible interventions simultaneously.[41] Instead, choices are required. In this section, we review the available primary prevention interventions and recommend some as likely to be more cost-effective than others. We retain from previous sections of this chapter the lesson that preventing a case of STD in the core will save many more subsequent cases than would preventing a case in the noncore.

In the first row of table 20-13, we present the voluntary behavioral changes, which can be stimulated by appropriately targeted information, education, and communication programs. These IEC programs typically affect the individual demand for a protective voluntary behavior, such as use of a condom or avoidance of a transfusion. They do so either by providing information or by changing preferences; sometimes they do both.

In contrast to voluntary behavior modification through IEC, mandatory and passive behavior modification typically occur through changes in the availability or price of a protective behavior or product, that is, on the supply side of a market. For example, either an enforced prohibition of prostitution or the provision of training and jobs for urban single women would reduce the supply, raise the price, and therefore reduce the frequency of commercial sex.

Although both mandatory and passive behavioral changes typically operate on the supply side, their mechanisms and effects are clearly distinct. Mandatory programs (such as the prohibition of prostitution) involve the enactment of laws and regulations which require the health-promoting behavior on penalty of fine or imprisonment. Examples outside the area of STD prevention include laws on speed limits and regulations concerning pollution control. To be effective, such laws and regulations must be enforced, which requires expenditure on government regulators. Furthermore, the regulators must be well paid and closely supervised to the point that their suborning is more costly to the would-be transgressor than is compliance with the laws. All these difficulties imply that mandatory behavior modification is best suited for short-term emergency control of easily observed, politically unpopular behavior.

Passive programs, in contrast, are typically slow to start but can be profound in their long-run influence on private decisions. If the government policies which support the passive program (such as improved job opportunities for women) are perceived to be permanent, they can induce individuals to

choose different residential locations, careers, and family sizes and thus can profoundly affect the details of their lives.

The choice of a cost-effective package of primary prevention interventions must be conducted in two dimensions: choices are required both within modes of transmission (the columns of table 20-13) and between modes of transmission (the rows of the table). We begin with the sexual transmission mode, which is the sole mode of transmission for most CSTDs and accounts for more than 90 percent of all adult cases of HIV infection in pattern II countries.[42]

SEXUAL TRANSMISSION AND MANDATORY PROGRAMS. The privacy of sexual practices and the primacy of the sex drive make sexual behavior one of the least-suited activities for mandatory behavior modification. During World War II the United States conducted an excellent example of a failed mandatory policy when it attempted to enforce the prohibition against prostitution in order to halt the spread of STDs.

> [After] thousands of women were institutionalized or detained [and] jails became overcrowded, Ness arranged for the creation of some 30 "civilian conservation camps" for young women as a means of relieving some of the pressure on existing facilities.[43] [But] despite the incarceration of thousands of prostitutes, it soon became clear that this could not in itself solve the venereal disease problem. Indeed, the effect of closing the red-light districts was sometimes disappointing to military officials. Increasingly, army physicians reported that prostitutes constituted only a minority of the soldiers' sexual contacts. In the Third Service Command, for example, only 19 percent of the infections could be attributed to prostitutes; in other communities even fewer infections could be so traced (Brandt 1987, p. 167).[44]

Thus, on practical grounds alone, we recommend against mandatory programs which rely on legal prohibitions. Furthermore, the consequences of such programs for civil liberties are likely to be unacceptable to democratic societies.[45]

SEXUAL TRANSMISSION AND CHANGED "PRICES." Setting aside mandatory programs as unlikely to be effective, we turn to policy choices categorized as either voluntary or passive. We believe that too little attention has been given to passive methods of modifying behavior in relation to that given to voluntary and mandatory ones. Among those listed in table 20-13, the potential effectiveness of subsidies to condom distribution through private channels has been demonstrated by a social marketing effort in Kinshasa, Zaire, which increased the sales of condoms in 110 pharmacies from 19,000 per month to 300,000 per month in only ten months (Lamptey and Goodridge 1991). Still, to our knowledge, the possibility of taxing alcohol served in public places in order to increase the cost of sexual partner change has not been studied.

More promising still are longer-run programs to improve the marriage, education, and job opportunities for women. It was demonstrated earlier that African cities with low female-to-male secondary enrollment ratios also had high rates of STD infection. To the extent that primary infertility caused by STDs prevents women from marrying or remaining married, programs to prevent or quickly cure STDs will help women avoid the stigmatization and rejection caused by infertility—and thus avoid recourse to prostitution. Education is a long-run strategy that will increase the woman's contribution to the development process, induce her to have fewer, healthier children, and improve her bargaining position in sexual relationships. Such a policy is an appropriate one to counter a slow, long-run epidemic like HIV infection that is exacerbated by low female education.

A somewhat shorter-run policy that has so far received little or no attention in national AIDS control programs is the creation of jobs for urban women. In a sampling of prostitutes in one Nigerian town, 67 of them reported that they would cease prostitution (an average of 4.4 paying clients per day) if they could find a job paying the equivalent of $15 a month (Williams, Hearst, and Udofia 1989). A possible example of an inadvertently beneficial effect on STD transmission of job creation for women is the "enterprise zones" of northern Mexico, where many of the young female employees are said to be grateful for these low-wage jobs as a welcome alternative to their former lives as prostitutes (personal communication from Sally Stansfield 1989).

Although the immediate effect of alternative female employment in urban areas of pattern II countries would be to reduce the supply and thereby raise the price of commercial sex for men, the longer-run effect would be to attract additional women to these urban centers. Still, on the basis of the statistical evidence presented earlier, we believe that this, too, would contribute to the control of STDs.

SEXUAL TRANSMISSION AND VOLUNTARY PARTNER NOTIFICATION. Although passive behavioral change seems to us the most promising long-run strategy by which to control sexual transmission, certain voluntary strategies, when tightly targeted at the core group, may also be cost-effective. As the first among these we designate voluntary partner notification, by both patient and provider referral. This method has proven increasingly effective in the control of CSTDs, especially after the availability first of salvarsan (in 1909) and then of penicillin (in 1943) made it possible to offer a cure to the sexual contacts of the index case. Some European countries, however, oppose partner notification programs for the CSTDs on the ground that, even when voluntary, they invade privacy.

Recently, some American states have been experimenting with partner notification in cases of HIV infection. Toomey and Cates' concise overview of U.S. practices points out that partner notification is far more effective than HIV screening of a population of STD patients in identifying new cases of HIV infection (1989). For example, compared with seroprevalence rates for HIV of 2.7 percent and 6.4 percent among STD patients in Virginia and Florida, seroprevalence rates among notified partners were 13.5 percent and 25.1 percent, respectively. The

cost per index case in Virginia was $50 if the patient was asked to refer, and $64 if the public health staff conducted provider referral. In Colorado, researchers in a similar study using different methods found costs of $50 per index case without provider referral and $33 for each partner notified by the providers.[46] Because these figures, $33 to $65 per index case, consist largely of the cost of labor, they can be deflated to figures that would apply in poor pattern II countries by expressing them as 0.5 percent of GNP per capita.[47] If partner notification programs could be operated in pattern II countries at even 1 or 2 percent of local GNP per capita for each index case, the resources currently available for AIDS control could mount significant partner notification programs.

These American successes with partner notification were achieved before it was possible to offer any treatment for nonsymptomatic HIV infection. Now that AZT has been found to retard the development of the disease, these American programs will achieve even greater success. Although the high price of AZT will prevent its immediate wholesale provision to asymptomatic infected people of the pattern II countries, this technological advance nevertheless holds out hope for improved partner notification programs in either of two distinct scenarios.

First, suppose that the annual cost of a temporarily effective antiviral medication remains as high as it is now, several thousand dollars per year. In this case, a public health program in a poor developing country could afford to buy only a few such treatments next year. If the program could convince the public that these few treatments are to be allocated fairly to a few of those who are actively cooperating with prevention efforts, then the availability of even a small chance for a temporarily effective treatment could serve as a powerful inducement for behavioral change.[48]

But the price of antivirals is unlikely to remain constant. If it falls in price as fast as penicillin did after its discovery, antivirals will be 100 times cheaper by the mid-1990s (Brandt 1987, p. 170). At $40 per annual treatment, antivirals cannot be denied to the poor, severely affected pattern II countries. If they are tightly controlled by the government so that access to them is only through a public health clinic which aggressively pursues partner notification, then antivirals can substantially increase the effectiveness of partner notification efforts. The incidence of all STDs, including HIV, may be strikingly reduced.

Because partner notification may have significant ethical and practical problems and undesirable social and biological side effects, it may not be a feasible or recommendable approach to HIV control in many societies. Some issues which have to be resolved before initiating such a program include possible stigmatization of those notified, violation of privacy, potential for misuse by index cases, rejection of notified women by their partners (sometimes leading to prostitution), the need for a large corps of counselors and for medical facilities capable of monitoring the biological side effects of antiretroviral therapy, and an assurance of long-term sustainability and continuity. Preliminary results from counseling and partner notification efforts with HIV-infected pregnant women in Africa are rather disappointing (Temmerman and others 1990). For all these reasons, we do not recommend partner notification as a primary strategy for HIV control at the moment, but we believe that pilot projects should be supported to address the issues discussed.

SEXUAL TRANSMISSION AND IEC PROGRAMS. The most cost-effective IEC program to inform the general public about STDs is targeted not at individuals at risk but at journalists. Using STDs as an excuse to sell newspapers by openly discussing sexual behavior, journalists and their editors have become willing collaborators with the public health authorities in STD control at least since President Franklin D. Roosevelt's surgeon general, Thomas Parran, broke taboos in the United States by publishing an explicit article on STDs in the *Reader's Digest* in 1936. More than 125 newspapers, many other magazines, and even the staid monthly the *Ladies' Home Journal* picked up the campaign, providing a wealth of free IEC (Brandt 1987, p. 141). In 1988 the British campaign against AIDS obtained 8 million pounds of free publicity in one month alone while spending only 3 million on its own campaign (United Kingdom, National Health Service 1988).

Any visitor to or resident of a developing country with an HIV epidemic is aware of how enthusiastically journalists there have picked up and reported any information about HIV infection, whether it is true or false. With respect to the media, the challenge for the national AIDS control programs in these countries is threefold: to prevent the publication of misinformation; to continue to provide new, interesting press releases expressed in lay language and accompanied by vivid graphics; and to broaden the discussion beyond HIV and AIDS to other STDs.

In our opinion, efforts to address publicly financed IEC campaigns to the entire population or even to all sexually active people are likely to be markedly less cost-effective in slowing STD epidemics than would the passive and voluntary programs described above. Evidence from a variety of national settings confirms that such IEC campaigns may improve knowledge and change attitudes but usually produce little if any behavioral change (Warner 1983; Hornik 1988). The IEC programs that are targeted at a specific subset of the core group may be a useful addition to the efforts described above.

For discussion of IEC campaigns, it is useful to cross-classify the population in two dimensions by "target group" and "access group." We define target groups as groups of individuals with homogeneous risk behavior, whose behavior change is the object of some STD intervention listed in table 20-13. Access groups are defined according to the means or channel by which we can gain access to them for the communication of IEC and training messages. In table 20-23 we present a classification of target groups as rows and access groups as columns.

The target group for behavioral change can be either the group at risk of infection or the group that controls the risk of infection. Information, education, and communication programs would be addressed to the former and training to the latter. In the rows of table 20-23, we identify three subgroups among those at risk: sexually active persons, health care con-

sumers (at risk from transfusion or contaminated needles), and health care providers (at risk from accidental sticking by contaminated needles, and so on). In other rows of the table, we classify those controlling the risk of infection as health care providers or government officials. These latter groups administer and enforce mandatory or passive interventions. The target groups are, of course, of very different sizes. Although the relative sizes of the groups will vary from one urban setting to another, it is useful to note typical or "notional" relative sizes for the groups in table 20-23.[49]

In order to change the behavior of either the group at risk or the group controlling the risk, an IEC or training intervention must communicate, either through the mass media or face-to-face. The columns of table 20-23 identify subsets of the population reached by each of a selected set of access routes. Like the target groups, the access groups differ in size. Because the size of a specific access group can be varied, however (that is, by calling a meeting of unmarried workers in a given factory, or by targeting a media campaign to adolescents), it is not useful to associate even a national relative magnitude to each access group at this level of aggregation.

An IEC or training program aimed at a given access group will typically reach only some of the members of any target group but will also reach other individuals outside the target group. Define the "coverage" of a specific target group by an intervention as the proportion of the target group reached. Clearly, an intervention is to be preferred, other things being equal, if it reaches a large rather than a small proportion of the target group.[50] It is possible roughly to rank the coverage that messages aimed at each access group would achieve for each target group. For example, IEC efforts at bars or STD clinics may achieve relatively high coverage of female prostitutes, whereas IEC efforts at barracks, schools, and offices would do much less well on this measure.

Still, even if a message covers all of a target group, its effect on that group will be reduced if it also reaches large numbers outside the target. For example, a message on the desirability of using condoms with multiple sexual partners, when routed through the mass media, will lose credibility and plausibility to the prostitute, because she and her peers are a small percentage of those receiving the message. Define the "concentration" of a message on a target group as the percentage of all message recipients who are in the given target group.[51] Again, the concentration of a message routed through a given access group at a given target group can be roughly ranked. In the above example of a mass media campaign, we argue that the small concentration makes the campaign less effective, other things being equal. By focusing a message aimed at prostitutes via an access group defined by the clients of an STD clinic or by a red-light residential neighborhood, however, the message's concentration can be substantially increased. Thus concentration must be added to coverage as a desirable attribute of an IEC or training program.[52]

In the cells of table 20-23 we have tentatively classified the use of each access group to reach each target group as having a coverage and a concentration which are "high," "medium," or "low." As an example of how to read the table, consider an IEC program which attempts to change the behavior of prostitutes (the target group) by addressing all the clients of bars (the access group). Because such a program is likely to reach a high proportion of all prostitutes, it scores an "H" for "high" on coverage in the appropriate cell of table 20-23. A program addressed to the access group "saloon clients," however, will necessarily be diluted in its effect on prostitutes because of their small share in the population of such clients. Therefore this program scores an "L" for "low" on concentration in the same cell. If the goal of a program is to change the behavior of prostitutes, consideration should be given to reaching them through an STD clinic, especially one which might have a higher-than-average concentration of prostitutes, or in their residential neighborhood, in which we estimate both the coverage and the concentration to be "medium." If we assume that the goal of the IEC program is to slow the epidemics, preventing as many case-years of illness as possible per dollar of the IEC budget, the candidates for programs which hold the most promise are those which are targeted at part of the core group, have high coverage of and concentration on the targeted group, and provide a message which can be expected to interest and persuade many in the target group.

Consider, first, prostitutes who are part of the core. If we have guessed correctly on the entries in the first row of table 20-23, none of the access groups listed will provide both high coverage of and high concentration on this group. Furthermore, experience with female prostitutes in Nairobi, Kenya (Ngugi and others 1988); male bar workers in Bangkok, Thailand (Sittitrai 1990); and other groups has shown that even face-to-face contact fails to change the frequency of safe sex enough to slow the spread of the HIV virus. The most promising results from prostitutes came instead from peer training programs, in which trusted fellow prostitutes are the source of the persuasive message. A program like this in Cameroon increased the reported use of condoms (at least half the time) from 28 percent to 72 percent over a twelve-month period (Monny-Lobe and others 1989). Previous similar successes had been reported in Ghana (Lamptey and others 1988) and Mexico. The medium concentration that may be achieved in some red-light districts argues that these residential neighborhoods be the venue for these meetings.

The data in table 20-23 indicate that the clients of prostitutes are also likely to be hard to reach with high concentration, because they do not form a large percentage of any of these access groups. Because clients are a largely clandestine group in many countries, peer training programs are also likely to fail. Hence, we recommend against targeting them.

Like prostitutes, sexually active adolescents may respond relatively well to peer counseling and might otherwise be hard to reach. Because that portion of adolescents who are attending secondary school or a university are a particular critical national resource in pattern II countries, we recommend that they be targeted with particular vigor.

In contrast to the above groups, a message aimed at bar patrons is predicted to cover a large proportion of adults with

Table 20-23. Coverage and Concentration of IEC and Training Programs, by Target and Access Group

Target group		Access group					
Group	*Size*	*Audience of mass media*	*Prisoners, soldiers, students, or workers in prisons, barracks, schools, or work sites*	*Sexually active adults at bars*	*Patients at general health care clinics*	*Clients and workers at family planning and STD clinics*	*Residents of a neighborhood*
Groups at risk							
From sex							
Prostitutes	20	Low/low	Low/low	High/low	Medium/low	High/low	Medium/medium
Clients of prostitutes	100	Medium/low	High/low	High/low	Medium/low	High/low	Low/low
Sexually active adolescents	2,000	Low/low	Medium/low	Low/low	Medium/low	Medium/low	Low/low
Adults with multiple partners	2,000	High/medium	High/medium	High/high	Medium/low	Medium/high	High/low
From transfusions	10,000	Medium/high	Medium/high	Low/medium	High/high	Low/medium	High/high
From needles	5	High/low	Low/low	Medium/low	High/medium	High/high	Low/low
Group controlling risk							
Health care providers	5	High/low	Low/low	Medium/low	High/medium	High/high	Low/low
Government officials	5	High/low	High/medium	Medium/low	Low/low	Low/low	Medium/low

Note: Coverage is defined as the proportion of the target group reached by a message. Concentration is the proportion of those reached who are in the target group. "High" is defined as greater than two-thirds; "medium" is defined as one-third to two-thirds; "low" is defined as less than one-third. The estimated coverage precedes the estimated concentration; thus, the notation "high/low" means that using the indicated access group to target the indicated target group will have a high coverage but a low concentration.

Source: Authors' development of Hornik 1989a and 1989b.

multiple partners and to do so with high concentration. We recommend targeted IEC at this core group.

We explicitly assign a low priority to publicly financed IEC campaigns designed to change the sexual behavior of noncore groups, such as the health care consumers of table 20-23. Although some people in these other, lower-risk, populations may become infected with HIV through sexual intercourse, public programs are unlikely to deliver more effective messages than the privately financed media, and each public dollar spent here could be spent with greater effect on any of the programs discussed above.

It is extremely difficult to quantify all the above considerations. Still, the epidemiological model presented earlier can be used to arrive at a rough estimate of the relative cost-effectiveness of a particular kind of IEC program, one that is designed to increase the frequency of condom use. We assume that condoms are distributed with the assistance of a condom social marketing campaign which subsidizes IEC efforts that vary, depending on the campaign's target group.[53] For the noncore, the social marketing resources would be spent on the public media. To target the core, the campaign would employ peer counselors from among the high-risk population. In table 20-24 we present the estimated cost per disability-adjusted life-year saved by such an intervention depending on which STDs are present in the population, on the cost per person-year of the social marketing campaign, and on whether the program is targeted at the core or the noncore.

As predicted in the discussion of table 20-19, the immense increase in effectiveness attained by protecting core individuals rather than noncore is large enough to offset our assumption that the cost per person-year of protection will be ten times larger in the core. In table 20-24 we show costs per disability-adjusted life-year below $1 for interventions targeted to the core group in the presence of certain epidemics. These costs compare favorably with those of other interventions.

PREVENTION OF TRANSMISSION FROM MOTHER TO INFANT. The World Health Organization estimates mother-to-infant transmission as the second most important transmission mode for HIV infection in pattern II countries, accounting for up to 11 percent of all cases. Obviously, prevention of HIV-infection in women also prevents these women from infecting their infants at no additional program cost. The question is whether additional resources should be reallocated to prevent infected women from conceiving or from giving birth.

As part of the program of notifying sexual partners, we recommend that HIV-infected women, especially if they are pregnant, receive extra, gender-specific, voluntary counseling which focuses on the risks of having seropositive babies and the costs of their care.[54] Recent experience from Kenya and Zaire suggests that the fertility rate of women who know they are infected with HIV is at least as great as that of uninfected women, despite counseling about their infection status and the risk of perinatal infection (Temmerman and others 1990). In addition, the illegality of abortion in many countries is a serious impediment to such a strategy.

Table 20-24. Cost per Discounted Disability-Adjusted Life-Year Saved for a Condom Subsidy Intervention: Sensitivity to Cost per Person Year of Protection and Core versus Noncore Strategy
(1990 U.S. dollars)

Disease (group)	*Disability-adjusted life-years saved per person-year of protection*	*Cost per year of protection*	
		$50 in core group $5 in noncore group	*$450 in core group $45 in noncore group*
Chancroid			
Core group	80.9	0.62	5.56
Noncore group	1.1	4.55	40.91
Chlamydia			
Core group	196.6	0.25	2.29
Noncore group	4.2	1.19	10.71
Gonorrhea			
Core group	275.2	0.18	1.64
Noncore group	5.2	0.96	8.65
HIV without ulcers			
Noncore group	56.6	0.88	7.95
Core group	19.9	2.51	22.61
HIV with ulcers			
Core group	156.0	0.32	2.88
Noncore group	21.5	0.23	2.09
Syphilis			
Core group	384.6	0.13	1.17
Noncore group	9.7	0.52	4.64

Source: First column from table 20-19; cost per person-year of protection from table 20-20; Janowitz, Bratt, and Fried 1990.

In table 20-21 we presented calculations of the cost per case of gonococcal ophthalmia neonatorum averted through the preventive application of silver nitrate or tetracycline. When the prevalence rate of gonorrhea among pregnant women is above 1 percent, a case of gonococcal ophthalmia neonatorum can be averted for less than $6, if silver nitrate is chosen. Assuming that each averted case saves the affected child one disability-adjusted life-year, this preventive intervention buys disability-adjusted life-years for less than $6 when prevalence rates are high.[55] Therefore, we recommend universal eye prophylaxis, without prior screening of the mother, in all areas in which gonorrhea prevalence rates are above 1 percent.

Finally, to prevent congenital syphilis, we recommend universal screening of pregnant women for serological markers of syphilis, followed by effective treatment of infected women.[56]

PREVENTION OF TRANSMISSION BY BLOOD AND BLOOD PRODUCTS. Because WHO estimates that only about 6 percent of all cases of HIV infection in pattern II countries are caused by transfused blood or blood products, the case for diverting resources from other prevention programs to this one must be based on sound cost-effectiveness analysis. We consider first mandatory then

passive and voluntary policy interventions. Then we estimate the cost-effectiveness of blood screening under various circumstances.

The high incidence and severe consequences of malaria and anemia in many developing countries are discussed in other chapters of this collection. Blood transfusion has often been administered to these patients with little curative effect. Now, in pattern II countries, such patients incur the risk of HIV infection in addition to the other risks of these diseases.

In the area of blood transfusion, we depart from our aversion to mandatory policies to recommend one: a prohibition of the transfusion of unscreened blood except as a life-saving measure. According to Fleming (1988), such indications include the following:

- Profound anemia (hematocrit less than 4 grams per deciliter) with incipient cardiac failure
- Severe neonatal jaundice (serum bilirubin greater than 300 micromol/L
- Blood loss of more than 25 percent of total volume when the blood pressure and oxygen cannot be maintained by plasma expanders.

Each pattern II country should develop and enforce its own set of transfusion guidelines. Because the necessary enforcement effort is focused at secondary care institutions, it can be implemented in each such facility by a committee of senior physicians. The enforcement of this ban should be the top priority program for the prevention of infection by blood transfusion.

If additional public resources for transfusion remain after the above two programs have been implemented, the additional security which comes from a blood-screening program can be considered. When efficiently performed at a blood bank, blood tests now cost less than a dollar in Africa, which is less than 25 percent of the cost of a unit of blood in most African capitals. Furthermore, some laboratories are experimenting with the use of a single test to screen a vial of blood in which the samples of several individuals are pooled. With some of the available blood tests, a negative test result on the pool of five separate samples ensures that all individual samples are negative with a probability above .95. In areas of poor countries where blood bank facilities are unavailable or undependable and prospective donors must be screened on the spot, only the more expensive ($2.50–$4.00) rapid tests are useful for screening blood, and pooling is impractical (Laleman and others 1992). In this case, the screening will double the cost of blood. These considerations lead us to recommend that, once transfusion guidelines and donor recruitment programs are in place, a blood-screening program should be largely self-financing through patient fees, with appropriate sliding fee schedules to accommodate the indigent. Because user charges are already the de facto policy for blood screening in many African capitals, implementing such a policy will not be difficult. Both a centralized blood bank system and a decentralized strategy using simple rapid tests should be considered (Laleman and others 1992). The choice between these institutional alternatives depends on the organization and capability of the local health system.

The second priority for the prevention of HIV infection from blood transfusion is to develop a corps of low-risk, voluntary donors who repeatedly donate blood in a given community. Such a policy will be more costly to administer than the laissez-faire ad hoc policies which required the patient's family to recruit a donor, but they will still be less costly and more cost-effective than would be the universal screening of all transfused blood.

Any effort to reduce the incidence of illnesses requiring blood transfusion will in a pattern II country also reduce the incidence of HIV infection. When this benefit is added to the intrinsic merits of these other programs, some of them will assume even higher priorities in national health promotion strategies than they would on their own merits. Such health problems include trauma (especially from road accidents), malaria, anemia, and adverse birth outcomes.

A quantitative analysis of the cost-effectiveness of blood screening should consider the cost per disability-adjusted life-year saved of donor deferral, donor recruitment, and training physicians to use more conservative criteria for transfusing. Unfortunately, costs of these varied strategies are not available. It is possible, however, to calculate the cost per DALY saved by blood screening under the simple assumptions used to construct figure 20-16. From table 20-16 we know that averting a case of HIV infection saves about 359.6 DALYs if the person is in the core group and only 54.6 DALYs if the person is in the noncore. Table 20-25 is constructed to combine these figures with the costs per case of HIV averted in figure 20-16, producing costs per DALY saved. Note that the argument for HIV screening in low-prevalence populations of poor countries is weak.

PREVENTION OF TRANSMISSION BY SKIN-PIERCING INSTRUMENTS. Fewer than 3 percent of all cases of HIV infection have been attributed to needles and skin-piercing instruments in pattern II countries. Furthermore, the costs of significant reform in this area seem high. We recommend that efforts here be restricted to a modest IEC campaign designed to stimulate health care consumers to insist on brand new or properly sterilized needles. In addition, health care providers should be educated about the importance of properly sterilized needles and, for their own protection, about safe methods of discarding them.

Case Management and Secondary Prevention

By treating CSTDs, further spread of the infection is prevented, and the risk of complications and sequelae in patients with an STD is reduced.

Goals of Case Management

Treatment of STDs benefits both the infected individual and, by reducing the reservoir of infected persons, the community

Table 20-25. Cost per Discounted Disability-Adjusted Life-Years Saved of Blood Screening

Sexual activity group of proposed blood recipient	Cost of blood test	Prevalence rate of HIV infection among blood donors 0.001	0.01	0.05	0.25
Core group	$2	7.42	0.74	0.15	0.03
	$10	37.08	3.71	0.74	0.15
Noncore group	$2	48.84	4.88	0.98	0.20
	$10	244.20	24.42	4.88	0.98

Note: See figure 16 and discussion. Costs include estimated overhead cost of managing blood screening service. From Table 20-26 we assume that each case of HIV averted in the core group saves 359.6 DALYs, while each case averted in the noncore saves 54.6 DALYs.
Source: Authors' calculations.

of uninfected people. Traditionally, early diagnosis and treatment (secondary prevention) have been the cornerstones of programs for the control of bacterial STDs, including syphilis, gonorrhea, and genital chlamydial infection. As effective antiviral chemotherapy becomes available against HIV infection and genital herpes, secondary prevention may become an increasingly important aspect of the control of viral STDs. In addition, it will be possible to increase greatly the life expectancy of patients with HIV infection. The overall goals of treatment of STDs are the following:

- To cure the actual disease
- To prevent complications and sequelae
- To prevent transmission of the treated disease
- To reduce the efficiency of HIV transmission

Principles of Case Management

The STDs caused by bacterial agents are all fully treatable by specific antibiotics. Still, case management of STDs is often of poor quality and ineffective in many, if not most, countries of the world. Furthermore, even the best treatment of viral STDs remains purely symptomatic or marginally effective and very expensive (for example, herpes). Problems in case management and secondary prevention of STDs are listed below.

- Health-seeking behavior (delay of diagnosis and treatment)
- Accessibility and quality of health care facilities
- Etiological diagnosis of syndromes (inadequate laboratories, lack of simple, inexpensive diagnostic tests)
- Antimicrobial resistance (gonorrhea, chancroid)
- Partner referral

Current case management guidelines are summarized in appendix 20C.

EARLY TREATMENT. Improving health-seeking behavior is a much neglected aspect of management strategies for STDs but may be a critical element in the prevention of complications and sequelae through early diagnosis and treatment, as well as in the reduction of secondary cases of STD by the patient. Delays by men of several weeks and by women of several months before seeking treatment for an STD are not unusual. Health-seeking behavior is not only a function of attitudes toward disease and sex but also of the accessibility and quality of health care facilities dealing with STDs. These are often of poor quality, understaffed, and lacking even the most essential diagnostic tools and drugs. Whereas STDs can usually be managed at public primary health care facilities, patients often prefer to go to more expensive private physicians who for the most part are not offering a better standard of management. Training of health care workers in STD is also grossly inadequate in most medical schools.

DIAGNOSIS. A core problem in STD case management is the difficult etiological diagnosis of most syndromes, particularly in women. Thus, both gonococcal and chlamydial infection in the female are diagnosed by isolation of the bacterial agent, the simpler microscopic examinations not being adequate. Culture techniques are expensive and technically demanding and are beyond the competence or fiscal possibilities (reagents must be paid for in hard currency) of most laboratories in developing countries. Culture-independent techniques (enzyme immunoassay, immunofluorescent assays, DNA hybridization) for the diagnosis of bacterial and viral STDs have become available recently but are expensive and often still lack sensitivity and specificity. Clinical methods of diagnosing STDs by means of simple algorithms are being increasingly used (see appendix 20C). Thus far, however, these have failed effectively to diagnose gonococcal and chlamydial infections in women.

CASE FINDING AND SCREENING. Case finding and screening have traditionally been an important component of STD control programs. Their objective is to identify individuals who are infected, but are not symptomatic, in order to treat them before they develop complications and sequelae. As weapons for actively combating STDs, these two strategies must be compared with that of simply treating persons without diagnosis. In appendix 20C we analyze these two options for all the STDs considered in this chapter and find that, for cost ranges relevant to developing countries, screening is rarely more cost-effective than treating without a test. Furthermore in those cases in which screening is cost-effective, clinical diagnosis is almost always more cost-effective than laboratory tests (see appendix 20C for details.)

One use of screening not analyzed in appendix 20C is for the prevention of congenital syphilis by screening pregnant women for serological markers for syphilis. By treating infected women, congenital syphilis is prevented in the newborn. Case finding is also used for gonorrhea control in populations where the prevalence of this infection is reasonably high. It has been used with success in STD control programs in prostitutes in various parts of the world (Tuliza and others 1991).

EFFECTIVE THERAPY. Because of the development of antimicrobial resistance of *N. gonorrhoeae* strains, mainly in Southeast Asia and Sub-Saharan Africa, treatment of gonorrhea has become more complicated and more expensive. Treatment guidelines for STDs and adequate training of health care workers in STD management are not available in most developing countries.

Although not as such part of individual therapy, treatment of primary (the source contact) and secondary sexual contacts (individuals exposed to the patient) through partner notification is an essential part of case management, aiming at reducing the reinfection rate in the patient, limiting the spread of the infection in the population, and decreasing the rate of complications and sequelae in these contacts. This requires considerable resources in time and personnel and is heavily influenced by the cultural-behavioral environment. Its cost-effectiveness remains to be explored in a developing country context.

COUNSELING. Finally, because STD patients may put themselves again at risk for STD—and because a small group of core transmitters is directly and indirectly responsible for the majority of cases of STD—counseling aiming at behavioral change should also be part of the STD case management.

HIV INFECTION. Case management of patients with HIV infection includes treatment of the associated opportunistic infections in patients with AIDS, therapy for HIV infection itself, and appropriate social and psychological support. Whereas several opportunistic infections can be reasonably effectively treated (such as tuberculosis, candidiasis, herpes simplex virus infections), others are either difficult to diagnose (such as cerebral toxoplasmosis, cytomegalovirus infection), requiring sophisticated imaging or laboratory technology, or very difficult to treat (such as crytosporidiosis, infection with atypical mycobacteria). Relapses after the end of therapy are frequent for all opportunistic infections, and treatment is often purely palliative. Estimates of the costs of treating opportunistic infections in AIDS patients in Zambia are shown in appendix 20C.

Treatment of AIDS patients with AZT results in an average prolongation of life of at least two years and a considerable improvement in the quality of life. Still, side effects (mainly hematological, necessitating blood transfusions and interruption of therapy) are common. Resistant strains of HIV appear to emerge under therapy, and the drug costs as much as $750–$1,000 per month.

Costs of Case Management

This section considers issues in the cost of case management of both HIV and STD.

COSTS OF AN STD TREATMENT PROGRAM. Operation of an STD treatment program in a developing country involves both domestic and foreign resources. In most developing countries, the foreign resources include the cost of drugs and of diagnostic materials. Domestic resources include the personnel who deliver the services and the buildings in which they work. In appendix 20C we assemble the available information on the cost of STD treatment in order to arrive at an estimate of the cost per effectively treated case of STD. In table 20C-3 we present sensitivity analysis of the cost per effectively treated case with respect to two key parameters, the cost per clinic-hour and the prevalence rate of the STD in the population. The first of these parameters varies with the GNP of the country—relatively rich countries will have more highly paid medical workers and more expensive rental rates for their buildings. Contrarily, a high prevalence rate decreases the cost per effectively treated case by ensuring that few resources are wasted on people who are not really sick.

Two strategies can be defined. The first is the one usually recommended by medical experts: the health care provider applies a diagnostic procedure. He or she might take a specimen and examine it with a microscope or culture it in a laboratory in an attempt to diagnose the etiologic agent accurately. Or the provider might simply examine the patient, take a medical history, and apply a decision rule or "health care algorithm" to decide whether, and how, to treat. Each of these three diagnostic procedures has a different degree of precision and a different cost. We call a strategy that applies one of these procedures a "test-before-treatment" strategy.

The second strategy is an extreme form of presumptive treatment. In this method, the provider prescribes a broad-spectrum antibiotic to everyone in some defined population, without taking the time to do a careful examination or history. Such a method might be especially worth considering at small health posts, in which the health provider is not trained to follow accurately a diagnostic algorithm. The population treated might consist of all patients who present to the clinic complaining of STD symptoms. A more radical strategy would be to provide this broad-spectrum treatment to everyone in a community, whether or not they are currently experiencing STD symptoms or have presented for treatment. The cost-effectiveness of this "treat everyone" strategy compared with a test-before-treatment strategy will vary, depending on the cost of drugs and diagnostic tests, the prevalence rate of STDs in the reference population, and the sensitivity and specificity of the diagnostic procedure being considered.[57]

COST OF AIDS TREATMENT IN DEVELOPING COUNTRIES. Estimates of the treatment costs of persons with AIDS in developing countries have been constructed by applying use patterns (based, in the absence of data, on expert opinion) to imperfectly known inpatient and outpatient average costs (Over and others 1988). Such AIDS treatment cost estimates, therefore, should be considered preliminary. Nevertheless, the results provided in table 20-26 are indicative of the range of values to be expected in developing countries.

A principal finding of the studies which generated these estimates is that the cost per patient varies considerably, both across countries and within a country. Most cross-country

Table 20-26. Treatment Costs of AIDS in Selected Developing Countries
(U.S. dollars)

Country	GNP per capita	Treatment cost		Treatment cost as percentage of GNP per capita	
		Low	High	Low	High
Brazil	2,160	6,000	12,000	278	556
Mexico	2,080	3,286	7,344	158	353
Tanzania	290	104	631	36	218
Zaire	170	132	1,585	78	932

Note: Brazil, estimates are 1988 U.S. dollars; Mexico, 1985 U.S. dollars; Tanzania and Zaire, 1986 U.S. dollars. All estimates include both inpatient and outpatient treatment costs. The low and high estimates correspond, respectively, to the most modest and the most comprehensive health care options available in the country. The average cost will typically be closer to the low than to the high end of this range.
Source: Over and others 1988; Tapia and Martin 1990; authors' calculations.

variation in costs is caused by differences in wage rates paid to providers, which tend to vary with levels of per capita GNP. Treatment costs per case exhibit a range within a country for two principal reasons: variation in the clinical symptoms which manifest themselves and variation in the socioeconomic characteristics of the patient and the medical and institutional characteristics of the available health care options (Over and Kutzin 1990). On a percentage basis, the poorest countries tend to exhibit greater cost variation because only a small proportion of all illness episodes are treated in a relatively high-cost hospital setting (Scitovsky and Over 1988). Cost variation exists in industrial countries but to a lesser degree because widespread insurance coverage provides better access to hospital care for a greater proportion of the population and standard treatment protocols are used on a wider basis.

Cost-Effective Case Management Strategies

As various options exist for case management, it is important to examine the cost-effectiveness of each approach to optimize resource allocation.

COST-EFFECTIVE CSTD TREATMENT AND SECONDARY PREVENTION. How cost-effective is STD control in a developing country in the presence of an HIV epidemic? First, consider the cost-effectiveness of CSTD treatment in the absence of HIV. In this scenario, the measure of effectiveness would be the static and dynamic DALYs saved per case from the averted CSTD only, which are presented in the last two columns of table 20-16. Dividing the minimum cost of an effectively treated case of a CSTD from table 20C-3 by these effects yields estimates of the cost-effectiveness of CSTD treatment in the absence of HIV. These estimates are presented in table 20-27.

In the presence of an HIV epidemic, the effective treatment of a CSTD has the dynamic effect of averting cases of HIV infection. The total DALYs saved in this scenario are presented in the last two columns of table 20-18 and depicted graphically in figure 20-15. By again dividing the minimum effective treatment cost estimates by these greater effects, cost-effectiveness estimates of CSTD treatment in the presence of an HIV epidemic are generated. In table 20-28 we present these estimates, which reveal the increased cost-effectiveness of CSTD treatment where an HIV epidemic exists.

Because they are derived from the estimates in tables 20-16, 20-18, and 20C-3, the cost-effectiveness estimates in tables 20-27 and 20-28 share a sensitivity to the level of sexual activity of the treated person, the prevalence rate of the STD, and the average cost per clinic-hour. The magnitude of the difference in cost-effectiveness strongly suggests targeting treatment programs at the highly sexually active core group. In a region experiencing an HIV epidemic, for example, curing or preventing a CSTD where it has a prevalence rate of 25 percent and the cost per clinic-hour is $2.00 will buy disability-adjusted life-years for between $0.02 and $0.11 each.[58] If the cost per clinic-hour was $10.00, a disability-adjusted life-year could be saved for between $0.04 and $0.25 by curing a CSTD. After interventions targeted at the core have been successfully implemented, a country can purchase additional life-years with programs aimed at noncore groups with low prevalence rates for less than $30.00 each (assuming $2.00 per clinic-hour) to less than $87.00 each (assuming $10.00 per clinic-hour). This higher range still compares favorably with the cost of saving life-years among adults with other health care interventions.

COST-EFFECTIVE MANAGEMENT OF AIDS CASES. Case management of HIV or AIDS through the prophylactic administration of an antiviral agent like AZT is clearly not a cost-effective option for purchasing DALYs in developing countries. This situation could change dramatically, however, if the price of antiviral therapy drops dramatically. In the absence of antivirals, treatment of the opportunistic illnesses of an AIDS patient can buy disability-adjusted life-years at the substantial but feasible cost of $235 to $384 when clinic time costs $10 per hour. This sum is approximately equal to the GNP per capita of many of the heavily affected countries and is substantially less than the annual income of prime age urban adults in those countries. There is a strong argument to ensure the provision of the basic drugs required to manage these opportunistic infections in order to buy an extra year or two of life for the person with AIDS and to protect the drug supplies needed to treat other patients who are not infected with HIV.

Table 20-27. Cost per Discounted Disability-Adjusted Life-Year Saved by STD Treatment in Absence of an HIV Epidemic: Sensitivity to Prevalence Rate and Core vs. Noncore Strategy

(1990 U.S. dollars)

Disease	Disability-adjusted life-years saved per effectively treated case	$2 per clinic hour			$10 per clinic hour			$30 per clinic hour		
		1 percent prevalence	5 percent prevalence	25 percent prevalence	1 percent prevalence	5 percent prevalence	25 percent prevalence	1 percent prevalence	5 percent prevalence	25 percent prevalence
Chancroid										
Minimum treatment cost	n.a.	73	15	3	333	67	14	983	199	42
Core group	1.8	40.56	8.33	1.67	185.00	37.22	7.78	546.11	110.56	23.33
Noncore group	0.4	182.50	37.50	7.50	832.50	167.50	35.00	2,457.50	497.50	105.00
Chlamydia, female										
Minimum treatment cost	n.a.	322	64	13	544	109	22	1,100	220	44
Core group	44.1	7.30	1.45	0.29	12.34	2.47	0.50	24.94	4.99	1.00
Noncore group	5.5	58.55	11.64	2.36	98.91	19.82	4.00	200.00	40.00	8.00
Chlamydia, male										
Minimum treatment cost	n.a.	63	13	3	286	59	13	822	164	33
Core group	44.1	1.43	0.29	0.07	6.49	1.34	0.29	18.64	3.72	0.75
Noncore group	5.5	11.45	2.36	0.55	52.00	10.73	2.36	149.45	29.82	6.00
Gonorrhea, female										
Minimum treatment cost	n.a.	295	59	12	463	93	19	884	177	35
Core group	37.3	7.91	1.58	0.32	12.41	2.49	0.51	23.70	4.75	0.94
Noncore group	4.5	65.56	13.11	2.67	102.89	20.67	4.22	196.44	39.33	7.78
Gonorrhea, male										
Minimum treatment cost	n.a.	62	13	4	245	51	12	678	141	31
Core group	37.3	1.66	0.35	0.11	6.57	1.37	0.32	18.18	3.78	0.83
Noncore group	4.5	13.78	2.89	0.89	54.44	11.33	2.67	150.67	31.33	6.89
Syphilis										
Minimum treatment cost	n.a.	185	38	9	269	56	14	477	102	27
Core group	160.8	1.15	0.24	0.06	1.67	0.35	0.09	2.97	0.63	0.17
Noncore group	19.8	9.34	1.92	0.45	13.59	2.83	0.71	24.09	5.15	1.36

n.a. Not applicable.

Source: Authors.

Table 20-28. Cost per Discounted Disability-Adjusted Life-Year Saved by STD Treatment in Presence of an HIV Epidemic: Sensitivity to Prevalence Rate and Core vs. Noncore Strategy
(1990 U.S. dollars)

Disease	Disability-adjusted life-years saved per effectively treated case	$2 per clinic hour			$10 per clinic hour			$30 per clinic hour		
		1 percent prevalence	5 percent prevalence	25 percent prevalence	1 percent prevalence	5 percent prevalence	25 percent prevalence	1 percent prevalence	5 percent prevalence	25 percent prevalence
Chancroid										
Minimum treatment cost	n.a.	73	15	3	333	67	14	983	199	42
Core group	55.6	1.31	0.27	0.05	5.99	1.21	0.25	17.68	3.58	0.76
Noncore group	3.8	19.21	3.95	0.79	87.63	17.63	3.68	258.68	52.37	11.05
Chlamydia, female										
Minimum treatment cost	n.a.	322	64	13	544	109	22	1,100	220	44
Core group	113.5	2.84	0.56	0.11	4.79	0.96	0.19	9.69	1.94	0.39
Noncore group	11.4	28.25	5.61	1.14	47.72	9.56	1.93	96.49	19.30	3.86
Chlamydia, male										
Minimum treatment cost	n.a.	63	13	3	286	59	13	822	164	33
Core group	113.5	0.56	0.11	0.03	2.52	0.52	0.11	7.24	1.44	0.29
Noncore group	11.4	5.53	1.14	0.26	25.09	5.18	1.14	72.11	14.39	2.89
Gonorrhea, female										
Minimum treatment cost	n.a.	295	59	12	463	93	19	884	177	35
Core group	120.2	2.45	0.49	0.10	3.85	0.77	0.16	7.35	1.47	0.29
Noncore group	11.6	25.43	5.09	1.03	39.91	8.02	1.64	76.21	15.26	3.02
Gonorrhea, male										
Minimum treatment cost	n.a.	62	13	4	245	51	12	678	141	31
Core group	120.2	0.52	0.11	0.03	2.04	0.42	0.10	5.64	1.17	0.26
Noncore group	11.6	5.34	1.12	0.34	21.12	4.40	1.03	58.45	12.16	2.67
Syphilis										
Minimum treatment cost	n.a.	185	38	9	269	56	14	477	102	27
Core group	396.3	0.47	0.10	0.02	0.68	0.14	0.04	1.20	0.26	0.07
Noncore group	41.1	4.50	0.92	0.22	6.55	1.36	0.34	11.61	2.48	0.66

n.a. Not applicable.
Source: Authors.

Greater expenditure per AIDS case does not improve the probability of survival. Palliative care in the home and community may not be as effective at prolonging life as is the use of antivirals, but the data in table 20C-1 suggest that palliative care is almost certainly more cost-effective. Assuming that clinic time costs $10 per hour, palliative care alone (second row in the table) buys one year of healthy life, and antivirals (first row in the table) buy two years of healthy life, a disability-adjusted life-year is purchased much more inexpensively with palliative care ($235 for one year by treating AIDS without AZT) than with antiviral treatment ($1,200 for each of two years by treating AIDS with AZT). More evidence of the opportunity for considerable improvement in the cost-effectiveness of AIDS treatment is provided in table 20-26, where the ranges of estimates for each country suggest the feasibility of reducing the cost per case.

Developments in Case Management in the Next Decade

It is anticipated that major advances will be seen in case management, particularly of AIDS, in the near future.

DIAGNOSTICS. The most promising area for innovation in case management is probably the development of simple diagnostic tests for most STDs. The basic technology (mainly enzyme immunoassays) is already available, and research is currently focusing on improving test performance. This will allow on-the-spot simple and rapid specific diagnosis of CSTDs such as gonorrhea, chlamydial infection, and chancroid—an important, if not essential, element in the control of gonococcal and chlamydial infections in women. The cost of such tests is presently still high ($4 to $7), but it is expected that prices will decrease because many companies are becoming active in this field. It is not clear, however, how and if these new diagnostic tools will be used in developing countries.

DRUGS. New antibiotics are being continuously developed, including agents active against bacterial STDs. Inexpensive oral antibiotics able to cure gonorrhea caused by multiresistant strains when given as a single dose are urgently needed and may become available. Numerous antiviral compounds have recently been developed and are being or will be evaluated for their clinical effectiveness in HIV infection, both in asymptomatic carriers of HIV and in AIDS patients. It is expected that more effective and less toxic therapy for HIV infection will become available in the 1990s. It will probably consist of lifelong treatment with a combination of antiviral drugs. This would have a significant effect on the prevention of HIV infection, because secondary prevention would then become an important additional strategy for the control of HIV infection.

For these new pharmaceutical developments to be relevant to developing countries, prices must be low. Yet low prices remove the incentive for continued research and development by private firms. International political collaboration, perhaps coordinated by WHO, could help to negotiate lower prices for developing countries while keeping prices higher in the industrial countries. Care must be taken, however, on three fronts.

First, WHO must be protected from the fate that has befallen most regulatory bodies throughout the history of regulation—capture by the regulated industry. Only if mechanisms can be arranged to ensure that WHO can remain an independent, flexible regulatory body responsive to the health needs of the poorer countries, should it be mandated to play that role.

Second, there must be allowance for competition among private firms, which implies that several produce the same product. A regulatory decision to allocate the production of each drug to only one firm would remove the benefits of competition and prevent the lower prices and higher quality that competition would eventually entail.

Finally, despite the currently high prices of antivirals, developing countries should prepare now for the day when their prices will fall. We predict that, as a combined result of patent expiration, technical change, increased competition, and political pressure on pharmaceutical companies, prices for antivirals will fall rapidly—perhaps by a factor of 100 in the next three years. How much AZT should Uganda buy and how should it be distributed if a year's dose costs $700? How much if $70? How much if $7? Rather than responding to this price drop in an ad hoc manner, governments of developing countries should prepare now by developing guidelines for the purchase and equitable allocation of antivirals under every possible set of future prices.

Priorities

It is clear from the above that AIDS and STD programs have not prioritized enough, and also that rational prioritization is possible on the basis of available data and modeling exercises.

Priorities for Resource Allocation

As extensively pointed out above, STDs in general and HIV infection, chlamydial infection, and syphilis in particular are a considerable source of morbidity and mortality in many parts of the developing world, ranking them first among the top fifteen causes of disability-adjusted life-years lost in the most heavily affected urban populations. Even in low-prevalence urban populations, HIV infection and CSTDs rank eleventh among the causes of health lost, ahead of tuberculosis, adult pneumonia, and neonatal tetanus, for example. The growing urbanization and the increasing population share of young adults in most parts of the developing world can only make things worse.

Still, our analysis has shown that prevention of HIV infection, and to a lesser extent of some CSTDs, can result in considerable health gain, as compared with other common health problems in the developing world. In addition, sex education, use of condoms, and prompt treatment of STDs all contribute to reproductive health, which includes the ability to bear and raise healthy children.

It is truly remarkable that this high rank both in burden and potential health gain is not reflected in higher specific expenditure for the control of HIV infection and CSTDs. Neglected training, poor diagnostic and therapeutic capabilities, high rates of quasi-irreversible sequelae, and insufficient research and development efforts (at least for CSTDs) are all symptoms of this inadequate response. We can only guess why this situation has arisen.

Given the complex mosaic of areas of high and low prevalence, even within a single county, rational allocation of resources for care and prevention of HIV infection and CSTDs is even more difficult to plan in the developing world than in North America or Europe. This is also the case, however, for other health problems that are increasingly important in urban populations of the developing world, such as cardiovascular diseases. The continuing strong urbanization in all developing countries and the growing proportion of the population in the sexually active age range indicate that the global population potentially at risk for sexually acquired infections will continue to increase.

Priorities for the Control of STDs and HIV Infection

An argument for allocation away from other diseases and toward STD control must be based on the costs and the effects of relevant options. In this chapter we have made a strong case for the important health benefits both statically and dynamically of preventing STDs. Although we have not been able to assign costs to all the interventions that would produce these effects, alternatives for which we have quantified results in table 20-29 include three important preventive interventions and a variety of treatment options. The results reflect the sensitivity of alternative interventions to assumptions regarding targeting strategy, CSTD prevalence, the presence of an HIV epidemic, and clinic costs. Extreme assumptions are used to define the unfavorable and favorable cost-effectiveness scenarios.

An important conclusion that can be drawn from table 20-29 is that certain STD interventions are extraordinarily cost-effective under favorable assumptions. If the highly sexually active population is targeted, STD prevalence is high, and inexpensive strategies are used, blood screening, condom subsidies, and IEC interventions can save a DALY for less than $0.15. Using similar assumptions in the presence of an HIV epidemic, we find that STD treatment is also remarkably cost-effective. Even under unfavorable assumptions, however, some of the interventions, such as condom subsidies and STD treatment, remain cost-effective in relation to other adult health interventions or to the level of per capita GNP. But some interventions, such as the use of antivirals to treat persons with AIDS or blood screening of the general population in an environment of low STD prevalence, should be pursued only after other health investments are made.

TARGETING. A general finding made earlier in the chapter is that the cost-effectiveness of programs to prevent and control STDs can be extremely high when the program, whether preventive or curative, is tightly targeted. The cost per discounted disability-adjusted life-year saved can be as low as $0.15 for a blood-screening program and $0.56 for a CSTD treatment program, when such programs are aimed at a high-prevalence core group of transmitters. Blood screening or case management in the rural noncore or in a segment of the population in which

Table 20-29. Cost per Discounted Disability-Adjusted Life-Year Saved for Alternative STD Interventions

Intervention	*Parameter*	*Unfavorable assumptions*	*Favorable assumptions*
Prevention			
Condom subsidies and IEC	Cost	High	Low
	Target group	Noncore	Core
	Target disease	Chancroid and HIV	Syphilis and HIV
	Cost per DALY	$40.91	$0.13
Blood screening	Cost of test	Expensive	Inexpensive
	Target group	Noncore	Core
	Prevalence	< 0.1 percent	> 5 percent
	Cost per DALY	> $244	$0.15
Gonococcal ophthalmia neonatorum	Prevalence	< 0.1 percent	> 1 percent
	Cost per DALY	>$111	<$5.32
Treatment			
CSTDs	Hourly clinic cost	$10	$2
	Target group	Noncore	Core
	HIV epidemic	No	Yes
	Prevalence	< 1 percent	> 5 percent
	Cost per DALY	> $50	< $0.56
AIDS	Hourly clinic cost	$10	$2
	Treatment	Antivirals	Palliative and home care only
	DALYs gained	2	1
	Cost per DALY	$1,200	$75

Source: Authors' calculations.

there is no HIV epidemic, however, can be a much more expensive way to save DALYs. Blood screening can cost $300 or more per DALY saved, and treatment of chlamydia in the noncore when there is no HIV epidemic saves DALYs at a cost of $2,457 each. Hence, our main recommendation is that all national health programs should at a minimum include a few STD clinics and control programs targeted at urban core groups. Furthermore, in view of the fact that much of the benefit of these programs will accrue to individuals other than those directly contacted, the economic theory of externalities argues that these services to the core group should be highly subsidized.

The degree of extension of STD treatment and control beyond the core groups and the most cost-effective disease interventions should vary across countries according to their STD epidemiology and their access to resources to fund these programs. Assume that countries might seek to equate the cost-effectiveness of interventions on all diseases to approximately their level of per capita GNP. Then a country with a per capita GNP of $300 and a cost per clinic-hour of $10 would be guided to consider STD treatment of syphilis, gonorrhea, chlamydia, and AIDS opportunistic illnesses in the core groups. Blood-screening and safe-sex programs would also be conducted there. The only case management option which can save DALYs at less than $300 in the noncore group, however, is syphilis treatment, which would be robust even if the resource cost of the program per patient contact (the cost per clinic-hour) triples to $30 per hour.

In contrast, a middle-income country might have a GNP per capita of $4,000 and a cost per clinic-hour of $30. Such a country should implement all the programs described above. In addition, syphilis, chlamydia, and gonorrhea could be attacked in the noncore for less than $4,000 per DALY saved. Provided antiviral therapy can be obtained for as low as $2,000 per year, even AZT treatment of AIDS and HIV-infected people would be cost-effective in both the core and the noncore in such a country. Universal blood screening would be cost-effective provided the prevalence rate of infection is greater than one in 76,800 in the core or greater than one in 6,800 in the noncore.

Because our estimates of the cost-effectiveness of prevention programs are less solidly based than are our estimates of treatment costs, our recommendations regarding the allocation of resources between prevention and treatment programs are less certain. The qualitative conclusions arrived at earlier, however, point in the same direction as the more quantitative ones described above: targeted programs will typically be more cost-effective. Our estimates in table 20-24, summarized in the first row of table 20-29, suggest that focusing an IEC program on the core group will be from four to eight times more cost-effective in saving DALYs than if the program is targeted at the noncore. Of course, countries should include the costs of preventing or reducing any undesirable social and epidemiological side effects when they estimate the costs of targeted programs. Assuming such side effects can be avoided or reduced, we recommend that AIDS prevention programs first exhaust the possibilities for campaigns targeted at high-risk groups via an access group which provides both high coverage of the risk group and high concentration of the message as defined in table 20-23 and the accompanying discussion above. Only later and after thorough analysis should those campaigns be extended to noncore groups.

EMPLOYMENT OPPORTUNITIES FOR URBAN WOMEN. In view of the findings reported in earlier sections of the chapter, we are persuaded that STDs play a particularly noxious role in the lives of women in developing countries. Especially in countries with low female-to-male ratios in urban areas, STDs are both the cause and the consequence of the entrapment of women in a position of low socioeconomic status. We recommend that "women-in-development" (WID) programs join forces with STD control programs to break this vicious circle. More especially, in order to maximize this development effect in countries with small female-to-male ratios in urban areas, WID programs should request help from STD control programs in targeting job training and employment opportunity programs. Resources for WID programs targeted at women at high risk of STDs should come from both WID and STD programs, to serve both their goals.

INTEGRATION OF STD CONTROL INTO EXISTING STRUCTURE. The existing health care structure should be strengthened in its components for the diagnosis and treatment of CSTDs and AIDS and for health promotion. This requires manpower training; availability of diagnosis, drugs, and educational materials; and programmatic coordination and supervision. Improving the access of women to health services is particularly important for STD control. In areas of high or medium prevalence, STD and HIV services should be integrated into primary health care, mother and child health services, antenatal and, especially, family planning clinics.

Because of fundamentally identical strategies, STD and AIDS control programs should be developed in close coordination. National medium-term plans with clear and achievable objectives should also be formulated for STD control.

PATIENT CARE AND SUPPORT. More emphasis should be given to support activities as part of AIDS control programs. Such activities include not only etiologic and palliative therapy but also psychological and social support of the patient and his or her family. Where resources are scarce, such support should be targeted to the families of high-risk individuals so that the support efforts have the side benefit of minimizing subsequent infection. Secondary prevention of STD complications through early diagnosis and treatment remains a cornerstone in the control of bacterial STDs.

Research and Development

While writing this document, we became aware that many essential data on CSTDs and HIV infection are lacking and that both operational and basic research on STDs continue to be

neglected. This is undoubtedly a handicap for control and prevention programs.

TECHNICAL RESEARCH AND DEVELOPMENT. Simple, rapid, and inexpensive diagnostic methods are a prerequisite for the successful implementation of both individual case management and screening and case detection programs for treatable STDs. Such tests are not available, however, particularly for the detection of genital infections in women. Priority diseases include gonorrhea, chlamydial infection, congenital syphilis, and chancroid. In addition, further development of simple serological tests for HIV antibody is necessary, ideally leading to a cheap way of confirmatory testing.

The necessary technology is available, and important developments are anticipated in the near future. Special consideration should be given to make these tests affordable for developing countries and to make them available through the health care system.

Priority should be given to prevention technologies that are fully controllable by women, such as mechanical and chemical barriers. Products not traditionally used as contraceptives should be screened for both bactericidal and virucidal activity against HIV and the full range of STD agents. Innocuous and acceptable vehicles for these products should be developed and evaluated. The possibility of the production of reusable condoms should be investigated.

The availability of vaccines against CSTDs and HIV infection would obviously revolutionize the control of these diseases. For infections such as gonorrhea and genital chlamydial infection in women, even a vaccine which would not completely prevent infection but would prevent the development of complications and sequelae may be acceptable. Insufficient knowledge of the immunobiology of many STDs, complex mechanisms by microorganisms to escape the immune response in humans, and poor commercial interest (at least for the CSTDs) have all been significant obstacles to vaccine development. Guidelines and methods should be developed for phase III vaccine trials (which evaluate protective efficacy).

EPIDEMIOLOGICAL AND BEHAVIORAL RESEARCH. Epidemiological research priorities include the collection of baseline data on STDs and their complications; the development of methods for disease surveillance; further investigations on the natural history and risk factors for STDs; the effect of HIV infection on the natural history and response to treatment of other diseases; the dynamics of core groups; and factors determining diverse epidemiologic patterns. The relative and population-attributable risks for transmission of HIV should be better quantified.

Behavioral sciences have been particularly neglected in STD research, though their importance in the prevention of AIDS and in the assessment of its effect is increasingly recognized. Data on sexual, health, and substance use behaviors, with emphasis on risk behaviors, should be collected in various societies and groups to lead to a rational strategy of prevention and control. The study of societal patterns as determinants of STDs and of the social effect of STDs should be helpful to define the limitations of interventions directed only at the level of individuals' risk behaviors.

INTERVENTIONS. There is an urgent need to develop and evaluate innovative behavioral and medical interventions against HIV infection and CSTD in different societies. Such development and evaluation would include trials and feasibility studies, demonstration projects, and community-wide interventions. This research is relevant for both primary and secondary prevention. Examples of such research include the effect and sustainability of campaigns for safe sex and condom use in various groups (adolescents, prostitutes, and so on); screening of pregnant women for syphilis to prevent congenital syphilis; eye prophylaxis at birth by traditional birth attenders to prevent gonococcal ophthalmia neonatorum; evaluation of syndrome-oriented algorithms for STDs to prevent complications; evaluation of various mechanical and chemical barrier methods for the prevention of HIV infection; use of rapid tests for the screening of blood donations; evaluation of the effectiveness and cost benefit of partner notification; and different methods of counseling. The identification of appropriate target populations for interventions has traditionally been a problem and deserves more research. More attention should be given to the development and evaluation of methods for the evaluation of interventions, with emphasis on simple indicators usable in developing countries.

HEALTH SERVICES RESEARCH AND IEC. Service delivery plays an important role in CSTD and AIDS control. Yet both the costs and the effects of alternative STD prevention and case management are almost completely unknown. Crucial questions are how, whether, and at what cost STD control can be integrated into existing health systems, including primary health care structures, family planning services, mother and child programs, and drug abuse programs. This issue involves not only case detection and management, but also some of the weakest components of the health care system, such as information, counseling, and education. Possibilities of involvement of the community, for instance, through home care, should be explored and evaluated.

CASE MANAGEMENT. Because of the increasing number of patients with AIDS and AIDS-related complex, there is an urgent need to develop simple and inexpensive strategies of case management for adults and children, making use of essential drugs, home remedies, and community members. Effective antiviral therapy will probably become widely available in the near future, but it is not clear how this will affect case management in developing countries. Individual countries should commission studies to determine the recommended treatment protocols for AIDS under today's set of prices. These studies should also recommend criteria for the government to use in determining at what price it will begin to buy and allocate antiviral drugs. Clinical trials of high priority include the effectiveness of syndrome-oriented algorithms for the management of STDs; innovative treatments of resistant gonorrhea and

of acute PID to reduce postinfectious infertility; and evaluation of the validity of simple tests for the diagnosis of HIV, gonorrhea, chlamydial infection, genital ulcer disease, and PID.

ECONOMIC EFFECT ON HOUSEHOLDS. Information on the magnitude of the effect on the surviving household members of fatal illness from AIDS and other causes would serve three important purposes. First and most immediately, such information could guide the design of carefully targeted programs to assist temporarily certain surviving household members after an AIDS death. Although government-financed life-insurance policies will clearly be beyond the financial reach of the most severely affected African countries for some time, many African countries are currently considering the implementation of poverty alleviation programs. To the extent that research could discover indicators which predict which surviving households were most likely to be plunged into poverty by the AIDS death, poverty alleviation programs would be able to add these households to their beneficiaries, thereby mitigating some of the worst effects of the AIDS epidemic.

Second, information on the relative effects of STDs and other diseases would guide policy choices on the allocation of resources among alternative disease programs. By an extension of the logic of this collection, a disease is important not only for its effect on the infected individual, but also for its effect on other household members. If it is determined, for example, that an adult with an STD has a more negative effect on the health of other family members than an adult sick with other diseases, then this would strengthen the argument for reallocating resources to STDs.

Third, and finally, information on the magnitude of the economic effects of STDs on households would move the allocation of resources away from other sectors and toward the health sector.

Appendix 20A. The Medical Consequences of Sexually Transmitted Diseases

First we describe the medical consequences of each sexually transmitted disease discussed in the text, and then we summarize this information in quantitative form. We end the appendix with the presentation of estimated discounted disability-adjusted life-years lost from a single typical case of each STD and a comparison of these figures with those for other important diseases. As explained in the text, these figures can be interpreted as the benefit of averting a case of each disease: for example, of the disability-adjusted life-years saved per case prevented or cured.

Gonorrhea

Gonorrhea is caused by *Neisseria gonorrhoeae*, a fastidious gram-negative diplococcus, which displays antigenic variation. Strain type specific, temporary protective immunity has been documented. In general, however, protective immunity does not appear significantly to affect the spread of gonococcal infection, probably because of a multitude of antigenic types and because most infections may not induce protective antibody when they are limited to the genital mucosa. The risk of acquiring *N. gonorrhoeae* during heterosexual vaginal intercourse is 30 to 40 percent for the uninfected male partner and 50 to 80 percent for the uninfected female partner (Hooper and others 1978).

Gonorrhea is the main cause of urethritis among male clinic attenders in the developing world (Meheus and others 1980; Antal 1987). Urethral stricture is the most severe complication of gonococcal urethritis in males and may make up the majority of cases seen by urologists in some parts of Africa (Bewes 1973). Still, it is in women that gonococcal infection leads most often to severe complications and sequelae.

Women with gonorrhea mostly have genital manifestations, although these may be nonspecific (McCormack and others 1977). If untreated, between 5 and 10 percent of women with gonococcal infection develop salpingitis—a potentially life-threatening condition if peritonitis develops. The risk of involuntary infertility is about 15 percent after one episode of salpingitis, 30 percent after two episodes, and over 50 percent after three or more episodes (Weström 1980).

The proportion of women who are infertile because of *N. gonorrhoeae* has not been defined, but in Uganda there was an inverse correlation between the fertility rate and the incidence of gonorrhea by district (Arya, Taber, and Nsanze 1980). In addition, the risk of ectopic pregnancy—one of the leading causes of maternal death—is increased tenfold after one episode of PID (Weström 1980).

N. gonorrhoeae is also an important cause of morbidity in mother and neonate. Maternal gonococcal infection is a risk factor for premature delivery, and it may be a cause of chorioamnionitis. Furthermore, it is a significant cause of postpartum endometritis and salpingitis, a complication that occurred in up to 20 percent of all parturient women in studies in eastern Africa (Plummer, Laga, and others 1987; Temmerman and others 1988). The risk of transmission of *N. gonorrhoeae* from an infected mother to her infant's eyes is 30 to 40 percent if ophthalmic prophylaxis at birth is not used (Galega, Heyman, and Nash 1984; Laga and others 1986a and 1986b). Depending on the prevalence of gonococcal infection in pregnant women, the incidence of gonococcal ophthalmia neonatorum is up to 3.5 percent of all live births in some African populations (Laga, Meheus, and Piot 1989). Gonococcal ophthalmia is associated with keratitis in 10 to 20 percent of cases (Fransen and others 1986), and an unknown but probably small proportion of cases will become blind. *N. gonorrhoeae* is also an important cause of keratoconjunctivitis in adults in the tropics (Kesteleyn, Bogaert, and Meheus 1987).

Genital Infection with Chlamydia trachomatis

Chlamydia trachomatis is an intracellular parasitic bacterium with a complex replication cycle that takes forty-eight to seventy-two hours. It is susceptible to several groups of anti-

microbial agents, including the tetracyclines and macrolides. Fourteen serotypes have been described. Of these serotypes L1, L2, and L3, which have distinct biologic features, cause lymphogranuloma venereum, a fairly uncommon cause of inguinal and femoral lymphadenitis in the tropics. Three serotypes (A, B, C) are mainly, but not exclusively, associated with trachoma, a potentially blinding eye disease endemic in many developing countries. The remaining types cause basically the same clinical syndromes as *N. gonorrhoeae* (table 20-1). Generally, genital chlamydial infections and their complications, such as PID, are associated with milder, and even subclinical, disease—although their complications and sequelae may be equally severe. This implies that many infections go unnoticed or do not come to medical attention.

The risk of heterosexual transmission of C. *trachomatis* is probably somewhat lower than for *N. gonorrhoeae*, but the risk of developing PID for women with cervical chlamydial infection is also of the order of 5 to 10 percent (Weström 1980). The agent has been identified in 15 to 20 percent of women with acute salpingitis in Africa, and there is strong serological evidence of a role played by C. *trachomatis* in ectopic pregnancy and infertility, particularly in women with evidence of tubal disease (Meheus, Remeis, and Collet 1986; Plummer and others 1987; De Muylder and others 1990).

C. *trachomatis* is the main identifiable cause of ophthalmia neonatorum in Africa (Maybey and Whittle 1982; Meheus and others 1982; Laga and others 1986a and 1986b; Buisman and others 1988). It is also a cause of neonatal pneumonia, but it is unknown what proportion of cases in the developing world is due to C. *trachomatis*. The negative effect of C. *trachomatis* on pregnancy outcome is controversial, though it seems plausible that the agent is a significant cause of postpartum endometritis in the tropics (Gravett and others 1986; Plummer and others 1987; Temmerman and others 1989).

There is as yet no evidence for protective immunity in genital chlamydial infections. In two studies in Africa, genital chlamydial infection was found to be a risk factor for the acquisition of HIV in female prostitutes (Plummer and others 1991; Laga and others 1989).

Syphilis

Syphilis is caused by a fastidious, slowly replicating spirochete, *Treponema pallidum*, which is still not cultivable in vitro. *T. pallidum* is highly sensitive to penicillin, and no in vitro resistance to this antibiotic has as yet been reported. The risk of acquiring syphilis through heterosexual intercourse is thought to be less than 30 percent, but receptive anal intercourse significantly increases this risk (Sparling 1990).

The disease is characterized by distinct clinical phases and a long latency period between the initial manifestations (primary chancre and secondary syphilis) and the severe systemic complications of tertiary syphilis, including neurosyphilis and cardiovascular syphilis, which occur five to twenty years after infection. Primary syphilis in 20 to 40 percent of those who did not have therapy progressed to symptomatic tertiary syphilis in two cohort studies in Norway and the United States (Sparling 1990). The case-fatality rate in these studies was approximately 20 percent. Pregnant women with untreated syphilis of under two years' duration transmit the infection to their fetus in almost all cases. The proportion of affected fetuses decreases in women who have had syphilis longer than two years. Approximately 50 percent of the pregnancies in mothers with primary or secondary syphilis result in abortion, stillbirth, perinatal death, or premature delivery. Clinical manifestations usually appear between two and eight weeks in infected neonates and resemble those of secondary and tertiary syphilis (Hira and Hira 1987). Irreversible sequelae and death due to syphilis occur in 50 to 75 percent of the infants.

Genital Ulcer Disease

Genital ulcer disease has a diverse etiology, including primary syphilis, chancroid, genital herpes, donovanosis, and lymphogranuloma venereum (Piot and Meheus 1986). It is relatively more common in many parts of the developing world than in Europe or North America. There is growing evidence that genital ulcers increase both the susceptibility to HIV during sexual intercourse with an HIV-infected partner and the infectiousness of an HIV-infected person for uninfected partners (WHO 1989a; Piot and others 1988). Only chancroid will be discussed here, because it is the most common cause of GUD in the tropics. Chancroid is caused by *Haemophilus ducreyi*, a small gram-negative rod with fastidious growth requirements. There is geographic variation in antigenic properties, and protective immunity has not been reported. *H. ducreyi* strains show increasing resistance to antimicrobial agents.

The hallmark of chancroid is multiple, painful, purulent genital ulcers, accompanied in more than half of the cases by a painful inguinal lymphadenopathy. The incubation period is short, three to ten days. Unlike syphilis, chancroid yields no long-term or systemic complications. Without effective therapy, lesions last for an average of two months.

In Sub-Saharan African and Southeast Asia, *H. ducreyi* can be isolated from 20 to 60 percent of patients with genital ulcerations. In most countries, patients with GUD belong to low socioeconomic strata. Chancroid seems to be associated with prostitutes in several parts of the world, including North America, and is more common in uncircumcised men.

AIDS and HIV Infection

Human immunodeficiency virus is a retrovirus that preferentially infects CD4 bearing cells, including T lymphocytes and macrophages. Though other cell types may also become infected, there are at least two types of HIV, named HIV-1 and HIV-2, which share some antigenic properties (mainly at the level of core proteins) but which are clearly distinct in their genome. In addition, individual HIV isolates exhibit significant genetic variability (Clavel 1988). Once infected, an individual remains infected (and infectious) throughout his or her life.

At six to sixteen weeks after infection, approximately one-third of those infected develop a benign acute viral syndrome which resolves spontaneously after a few weeks. Subsequently, infected individuals go through an asymptomatic latent phase which may last for ten years or longer, after which they develop AIDS and AIDS-related complex (ARC). By definition, AIDS is characterized by the occurrence of life-threatening opportunistic infections and tumors, whereas ARC may be considered as a non-life-threatening symptomatic HIV disease. Approximately one-third of the patients suffer from subacute encephalopathy, characterized by progressive behavioral changes associated with dementia (the AIDS dementia complex). The case-fatality rate of AIDS is virtually 100 percent, with an average time of two to three years between diagnosis and death. Because of inadequate means of diagnosis and treatment, this period is probably much shorter in developing countries.

In the United States, individuals with HIV infection progress to AIDS at an average rate of 3 to 6 percent per year, and the median time from infection to progression to AIDS has been estimated at seven to ten years (Moss and Bacchetti 1989). There is evidence that the rate of progression to AIDS is related directly to age, at least among hemophiliacs residing in North America (Goedert and others 1989). In addition, HIV-seropositive persons who have not progressed to AIDS show steadily increasing impairment, with two-thirds of the subjects having some clinical problem after three years of infection. It appears that in the absence of treatment, most, if not all, infected persons will progress to AIDS. Epidemiologists hypothesize that the rate of progression to AIDS is faster in a developing country because of greater stress on the immune system due to frequent exposure to infectious diseases, but no data to test this hypothesis are yet available.

Table 20A-1. Outcome Probabilities for STD and Other Major Diseases

			Case-fatality rates, by age (per 1,000)						
Disease	*Prevalence*[a]	*Sex*	*0–1*	*1–4*	*5–14*	*15–49*	*50–64*	*65+*	*Probability of permanent disablement*
Sexually transmitted disease									
Chancroid	High	Both	...	...	...	...	...	...	0.5
	Low	Both	...	...	...	...	...	...	0.5
Chlamydia	High	Female	0.05	...	...	1	...	...	5
	High	Male	0.05	...	...	0.05	...	...	5
	Low	Female	...	...	...	...	...	...	5
	Low	Male	...	...	...	...	...	...	5
Gonorrhea	High	Female	...	...	0.1	0.2	...	...	5
	High	Male	...	...	...	...	...	...	5
	Low	Female	...	...	0.1	0.2	...	...	5
	Low	Male	...	...	...	...	...	...	5
HIV	High	Both	100	100	100	100	100	100	n.a.
	Low	Both	100	100	100	100	100	100	n.a.
Syphilis	High	Female	60	...	...	1	...	...	1.5
	High	Male	60	...	...	1	...	...	1.5
	Low	Female	25	...	...	0.35	...	...	1.5
	Low	Male	25	...	...	0.35	...	...	1.5
Other diseases									
Birth injury	n.a.	Both	67	...	...	...	...	...	33
Cerebrovascular disease	n.a.	Both	...	...	...	35	35	35	35
Cirrhosis	n.a.	Both	80	80	80	80	80	80	20
Congenital malformations	n.a.	Both	15	15	15	15	15	15	85
Gastroenteritis	n.a.	Both	7	3	0.2	0.2	0.2	0.4	...
Injuries (i.e., accidents)	n.a.	Both	10	10	10	10	10	10	5
Malaria	n.a.	Both	14	6	1	1	1	1	86
Measles	n.a.	Both	18	17	1	...	...	...	...
Pneumonia, adult	n.a.	Both	n.a.	n.a.	n.a.	10	10	10	...
Pneumonia, child	n.a.	Both	40	40	40	n.a.	n.a.	n.a.	...
Prematurity	n.a.	Both	10.2	n.a.	n.a.	n.a.	n.a.	n.a.	...
Severe malnutrition	n.a.	Both	70	65	10	10	10	20	...
Sickle cell	n.a.	Both	80	...	...	...	...	...	20
Tetanus (neonatal)	n.a.	Both	80	n.a.	n.a.	n.a.	n.a.	n.a.	...
Tuberculosis	n.a.	Both	35	35	35	35	35	35	...

n.a. Not applicable.
... Negligible.
a. Urban areas of high or low prevalence, as defined by table 20-7.
Source: Authors; Ghana Health Assessment Project Team 1981.

Quantification of the STD Sequelae for Comparison

The method introduced in the main text of this chapter for quantifying the static burden of disease requires that the sequelae be described in terms that can be roughly compared across diseases. For simplicity the method divides the possible outcomes of contracting a case of each disease into three classes: death, permanent disablement, and recovery. In table 20A-1 we summarize the assumptions made regarding the probability of each of these outcomes for each of the diseases included in the analysis. (Note that, for simplicity, only the case-fatality rate is assumed to vary across age groups.) In table 20A-2 we summarize our assumptions regarding the duration and degree of disablement due to the sequelae of the STDs and the other main diseases.

Finally, in table 20A-3 we present estimated disability-adjusted life-years lost per case, or saved per case averted, for each of these diseases, ranked in order of the discounted disability-adjusted life-years saved. We assumed that individuals would have otherwise lived to the age of sixty-five years, and we applied a discount rate of 3 percent to all future years. The second column of the table presents the results of first weighing each lost year by a productivity weight before discounting and adding the years to arrive at the discounted productivity-weighted disability-adjusted life-years saved per case averted. As in Barnum 1987; Over and others 1988; and Over, Bertozzi, and Chin 1989, productivity weights are attached to future disability-adjusted life-years before they are discounted to the time the disease is contracted. Age ranges and the weights attached to the years that would have been lived at those ages are: ages 0–1, 0; ages 1–5, 0; ages 5–15, 0.2; ages 15–50, 1.0; ages 50–65, 0.85; age 65+, 0.25. These weights roughly follow the age profile of hourly wages in a developing country (for exam-

Table 20A-2. Death and Disablement from Sequelae of STDs and Other Major Diseases

Disease	Prevalence[a]	Sex	Years until death	Disablement until death[b]	Chronic disablement[b]	Disablement until recovery[b]	Days until recovery
Sexually transmitted disease							
Chancroid	High	Both	n.a.	n.a.	20	20	73
	Low	Both	n.a.	n.a.	20	20	73
Chlamydia	High	Female	1	30	30	20	292
	High	Male	5	10	50	10	91
	Low	Female	1	30	30	20	292
	Low	Male	5	10	50	10	91
Gonorrhea	High	Female	1	50	50	20	146
	High	Male	n.a.	n.a.	50	10	55
	Low	Female	1	50	50	20	146
	Low	Male	n.a.	n.a.	50	10	55
HIV	High	Both	8	18	n.a.	n.a.	n.a.
	Low	Both	8	18	n.a.	n.a.	n.a.
Syphilis	High	Female	20	50	50	0	730
	High	Male	20	50	50	0	730
	Low	Female	20	50	50	0	730
	Low	Male	20	50	50	0	730
Other diseases							
Birth injury	n.a.	Both	0	...	20	...	...
Cerebrovascular disease	n.a.	Both	0	...	75	...	120
Cirrhosis	n.a.	Both	5	50	25	...	...
Congenital malformations	n.a.	Both	0	...	25	...	...
Gastroenteritis	n.a.	Both	0	...	n.a.	...	14
Injuries (i.e., accidents)	n.a.	Both	0	...	25	...	30
Malaria	n.a.	Both	0	...	2	...	...
Measles	n.a.	Both	0	...	...	...	21
Pneumonia, adult	n.a.	Both	0	...	...	...	30
Pneumonia, child	n.a.	Both	0	...	...	...	30
Prematurity	n.a.	Both	0	...	...	...	...
Severe malnutrition	n.a.	Both	0	...	...	...	180
Sickle cell	n.a.	Both	5	50	30	...	...
Tetanus (neonatal)	n.a.	Both	0	...	...	...	...
Tuberculosis	n.a.	Both	5	25	200	...	...

n.a. Not applicable.
... Not significant.
a. Urban areas of high or low prevalence, as defined in table 20-7.
b. Disablement expressed as a percentage of full health. A year at 100 percent disablement is weighted the same as a year lost to death.
Source: Authors; Ghana Health Assessment Project Team 1981.

Table 20A-3. Health Gains From Preventing One Case of STD or Other Diseases

Disease	Discounted disability-adjusted life-years saved		Discounted productive disability-adjusted life-years saved	
	Years	Rank	Years	Rank
Sickle cell	24.5	1	14.2	3
Tetanus (neonatal)	22.7	2	14.2	2
Birth injury	20.9	3	13.1	4
HIVa	19.5	4	15.5	1
Severe malnutrition	17.0	5	11.2	6
Cirrhosis	15.6	6	12.8	5
Pneumonia, child	11.2	7	8.1	7
Congenital malformations	10.3	8	6.4	9
Cerebrovascular disease	9.4	9	7.8	8
Tuberculosis	7.1	10	5.6	10
Measles	5.0	11	3.3	11
Syphilis,[a] female[b]	3.9	12	2.3	13
Syphilis,[a] male[c]	3.7	13	2.1	14
Malaria	3.7	14	2.4	12
Prematurity	2.9	15	1.8	16
Injuries (i.e., accidents)	2.7	16	2.1	15
Pneumonia, adult	2.0	17	1.6	17
Gastroenteritis	1.4	18	0.9	18
Chlamydia,[a] female[b]	1.3	19	0.9	19
Gonorrhea,[a] female[b]	1.0	20	0.7	20
Chlamydia,[a] male[c]	0.8	21	0.6	21
Gonorrhea,[a] male[c]	0.7	22	0.5	22
Chancroid[a]	0.2	23	0.1	23

a. Sexually transmitted disease.
b. Benefit of a program targeted at females, per case averted or prevented.
c. Benefit of a program targeted at males, per case averted or prevented.
Source: Ghana Health Assessment Project Team 1981 and authors' calculations.

ple, Lucas 1985). The results are discussed in the main part of the text.

Appendix 20B. A Simulation Model of an STD Epidemic

The basic model used here is drawn from Hethcote and Yorke 1984 (for example, their equation 3.1). It consists of two differential equations, one for the core group (group 1) and one for the noncore group (group 2). In a given group, the equation describes the net effect of two flows, one from the pool of susceptibles into the pool of infectives (the incidence of new infections) and one in the reverse direction as infectives are cured of their disease and again become susceptibles. Note that the model ignores the possibility that an individual's sexual behavior might change so that he or she moves from the core group to the noncore group, or vice versa. Such behavioral changes must be imposed on the model from the outside.

Let I_i represent the proportion of group i that is infected on a given day, where (i = 1) is the core group and (i = 2) is the noncore group. Suppose that the number of individuals in group i is N_i. Then the sizes of the pools of infectives and susceptibles on any day are, respectively, I_iN_i and $(1 - I_i)N_i$.

The basic differential equation for group i is an equation for the rate of change of I_iN_i, or, because N_i is constant, for I_i. The equation can be written as the difference between the newly infected people and the newly cured people during the day, or

$$(1)\quad \frac{d\,I_i N_i}{d\,t} = \begin{bmatrix} \text{Newly infected} \\ \text{group } i \end{bmatrix} - \begin{bmatrix} \text{Newly cured} \\ \text{group } i \end{bmatrix}.$$

The rate of new cures is simply given by the total number of infected people divided by the number of days each is infected or

$$(2)\quad \begin{bmatrix} \text{Newly cured} \\ \text{group } i \end{bmatrix} = \frac{I_i N_i}{D},$$

where D is the average duration of infectivity in days.

The rate of new infection is more complex and requires assumptions about the following: a_i = the probability of a new sexual contact on a given day by a group i person; G = selectivity of partner choice; Q = probability of infection on a single contact. From these assumptions can be computed:[59]

the reproductive rate for group i:

$$R_i = Q \cdot D \cdot a_i,$$

the proportion of new partners in group i:

the "mixing" coefficients:[60]

$$b_i = \frac{N_i a_i}{N_1 a_1 + N_2 a_2},$$

$$M_{ij} = \begin{cases} (1-G)\, b_i + G & \text{if } i = j \\ (1-G)\, b_j & \text{if } i \neq j \end{cases}$$

Finally, a set of parameters, C_{ij}, are defined as follows as functions of those defined above:

$$(3) \qquad C_{ij} = M_{ij} \cdot \frac{R_i}{D} = M_{ij} \cdot Q \cdot a_i .$$

These parameters allow us to write the expression for the rate of new infections per day as:

$$(4) \quad \begin{bmatrix} \text{Newly} \\ \text{infected} \\ \text{group } i \end{bmatrix} = \left[C_{ii} I_i + C_{ij} I_j \right] \cdot (1 - I_i) \cdot N_i \quad \forall \; i \neq j$$

Thus the two equations of motion for our simulation model are:

$$(5) \qquad \frac{d I_1}{d_t} = \left(C_{11} I_1 + C_{12} I_2 \right) \cdot (1 - I_1) - \frac{I_1}{D};$$

$$(6) \qquad \frac{d I_2}{d_t} = \left(C_{22} I_2 + C_{21} I_1 \right) \cdot (1 - I_2) - \frac{I_2}{D}.$$

Sensitivity with Respect to Selectivity

One special case of the model is worth examining. Suppose that members of each group are so selective in their choice of partner that they always choose members of their own group, so that G = 1.0. Then by the definitions of M_{ij} and C_{ij}, the two equations of motion simplify to:

$$(7) \qquad \frac{d I_i}{d_t} = I_i \cdot (1 - I_i) \cdot \frac{R_i}{D} - \frac{I_i}{D}.$$

By setting this equation to zero we solve for the equilibrium value (denoted by an asterisk) of the prevalence rate I_i:

$$(8) \qquad I_i^* = \frac{(R_i - 1)}{R_i}.$$

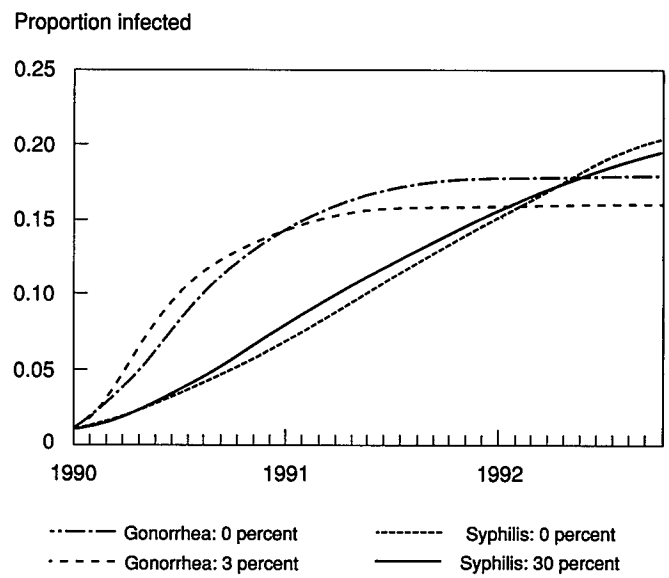
When G is not equal to 100 percent, no analytical solution exists for the two simultaneous quadratic equations in the unknowns I_1^* and I_2^*. Lajmanovich and Yorke (1976), however, have proved that the numerical solution of the two equations tends toward equilibrium values of the two prevalence rates under general conditions.

The simulations in the text constitute sensitivity analysis with respect to the disease parameters, because those vary substantially across the six simulated diseases. Also reported in the text and in table 20-15 is a sensitivity analysis of the main result on targeting with respect to two dimensions of sexual behavior, selectivity and rate of partner change. Because selectivity is a particularly interesting parameter of sexual activity, and because it could itself be the object of policy, we report here on sensitivity analysis of the main results with respect to the entire range of possible selectivity coefficients.

Consider the effects of increasing the selectivity coefficient above the value of zero assumed in the text. It is clear (and confirmed by the simulations) that there is a monotonic increasing relationship between the value of the selectivity coefficient and the speed with which the core group attains its equilibrium prevalence rate. Furthermore, the level of the core's equilibrium prevalence rate increases as G increases. By symmetry, one might expect that both the speed with which the noncore approaches equilibrium and the level of that equilibrium would decrease monotonically with increases in G. Only the second of these two expectations is confirmed.

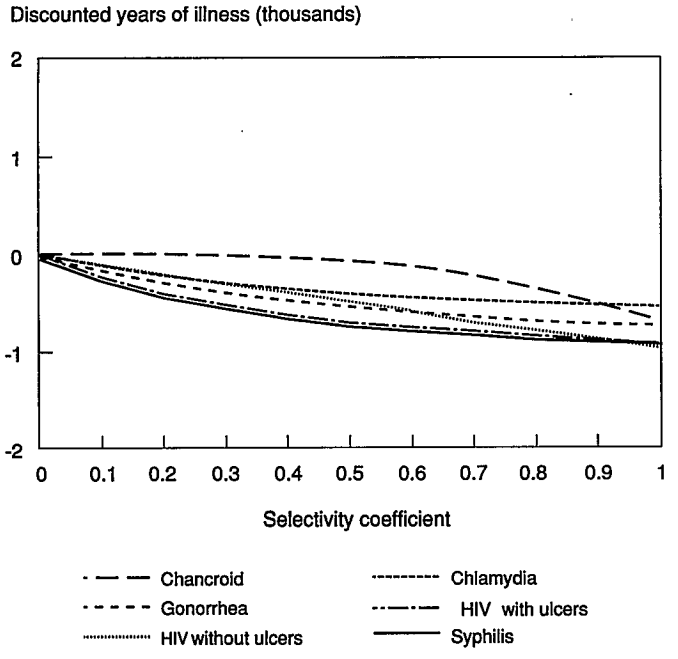
It is shown in figure 20B-1 that, although the long-run equilibrium prevalence in the noncore is lower at G = 30 percent than at G = 0 percent, the equilibrium rate is approached more quickly. How could this be the case if the relatively uninfected noncore (starting at a prevalence rate of only 1 percent) is now selecting a smaller proportion of its

Figure 20B-1. Effect on Evolution of Epidemic in Noncore Group from Increasing Selectivity: Gonorrhea and Syphilis



Source: Authors.

Figure 20B-2. Effect of Selectivity Coefficient on Present Value of Averted Case-Years in Noncore Group



Source: Authors.

partners from the more heavily infected core (starting prevalence of 20 percent)?

The explanation is in the dynamic behavior of the seroprevalence rate in the core group. In the early stages of a gonorrhea or syphilis epidemic, a higher selectivity makes the prevalence rate of the core group increase much more rapidly. As a result, even though fewer persons in the noncore are contacting core individuals, this effect is more than offset by the fact that more of the core individuals are infected. Thus the prevalence rate of the noncore climbs faster than it would if G were 0 percent.

Figures 20B-2 and 20B-3 display the effect on the core and noncore, respectively, of alternative selectivity coefficients from 0 to 100 percent. Both figures display on the vertical axis the present value of the case-years of illness that would be averted in each group by changing the selectivity coefficient at the beginning of the epidemic from 0 percent to the level indicated on the horizontal axis. Note from figure 20B-2 that increasing G increases the burden on the core group for all diseases, the effect being greater at higher selectivity coefficients. Now examine figure 20B-3.

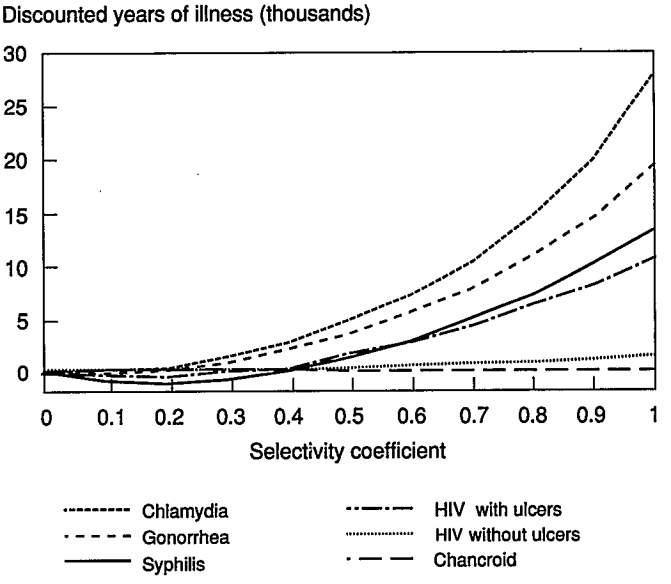
For small increases in selectivity, the burden of illness of four of the diseases is greater on the noncore than it would be with a zero selectivity. Because of the more rapid early increase in the epidemic demonstrated in figure 20B-1, the three-year burden on the noncore actually gets worse when selectivity is slightly increased above zero. Within this three-year horizon the worst selectivity value for syphilis and HIV with ulcers is 20 percent. Selectivity must be increased to 40 percent before the three-year burden on the noncore of these two diseases would be reduced.

Interaction of STD and HIV Epidemics

The model presented in equations (1) through (6) above represents the dynamic of a single STD, in the absence of any risk factors other than sexual activity. As reviewed in the text, however, there is substantial evidence that infection with several of the CSTDs increases the transmission probability of HIV infection. When both diseases exist in a sexually active population, preventing or curing an STD will avert cases of HIV infection even in the absence of an intervention aimed directly at HIV. To estimate the magnitude of this effect requires that the HIV epidemic be simulated simultaneously with the epidemic of one of the CSTDs. In such a simulation, the probability that a contact between an HIV-infected person and an HIV-susceptible person will result in an infection will depend on the probability that one or both of these individuals is suffering from the STD on the day of the contact.

We assume that HIV infection has no effect on the simultaneous epidemic of a CSTD. Thus, simultaneous modeling of the two epidemics affects the value of Q in equation (3) and therefore the values of the C_{ij} in equations (4) through (6) for the HIV epidemic only. Let V_1 be the instantaneous prevalence rate of the STD in the core group and V_2 be the rate in the noncore group. Then, the probability of a new HIV infection

Figure 20B-3. Effect of Selectivity Coefficient on Present Value of Averted Case-Years in Core Group



Source: Authors.

on a given sexual contact, H_{ij}, varies over time with the STD prevalence rate according to:

$$(9) \quad H_{ij} = (1 - V_i) \cdot (1 - V_j) \cdot h + (1 - V_i) \cdot V_j \cdot \alpha \cdot h + V_i \cdot (1 - V_j) \cdot \alpha \cdot h + V_i \cdot V_j \cdot \alpha^2 \cdot h,$$

where h is the probability of HIV infection without concomitant STD and α is the multiple by which h is increased when either of the two partners is infected. Note that we assume a multiple of ^{2} when both partners have the STD.

Using equation (9), the coefficients of the equations of motion for the HIV epidemic are modified to become:

$$(10) \quad C_{ij} = M_{ij} \cdot H_{ij} \cdot a_i .$$

Substitution of equation (10) into equations (5) and (6) yields equations of motion for HIV infection which are sensitive to a simultaneous STD epidemic.

Reduced Transmission Probability

In the main part of the text, we presented simulation results for an intervention which consists of assuring that all sex contacts by 100 individuals in one of the two groups are protected for a year. To model this intervention, let U_1 be the proportion of individuals who are unprotected in the core group and U_2 be the proportion unprotected in the noncore. Then the modified versions of equations (5) and (6) above can be written:

$$(11) \quad \frac{dI_1}{dt} = \left(C_{11} U_1 I_1 + C_{12} U_2 I_2\right) \cdot U_1 \cdot (1 - I_1) - \frac{I_1}{D};$$

$$(12) \quad \frac{dI_2}{dt} = \left(C_{22} U_2 I_2 + C_{21} U_1 I_1\right) \cdot U_2 \cdot (1 - I_2) - \frac{I_2}{D}.$$

The base simulation is run with both U_1 and U_2 set to 1.0. To run the simulation of 100 protected individuals in the core, we set U_1 to 0.9 and maintain the value of U_2 at 1.0. To run the simulation of 100 protected individuals in the noncore, we return U_1 to 1.0 and set U_2 to 0.998. In both cases we use equations (11) and (12) to track the epidemic for one year and then continue the simulation for nine more years with both U parameters reset to 1.0.

We model each CSTD jointly with HIV infection by using equation (10) to modify the transmission probability of the simultaneous HIV epidemic. We assume that the protected individuals are simultaneously protected from both concomitant epidemics by introducing the U_1 and U_2 parameters in the same way in the equations for both epidemics. In addition, we maintain the link between the CSTD epidemic and the HIV epidemic by maintaining the substitution of equation (10) for the C_{ij} parameters. The result is that an intervention which protects 100 individuals has three beneficial effects: (a) it directly prevents cases of the CSTD being modeled, (b) it directly prevents transmission of the concomitant HIV epidemic, and (c) it indirectly prevents HIV infection through the mechanism modeled in equations (9) and (10) above.

Appendix 20C. Management of Selected Classic Syndromes

Effective therapy is available for all bacterial CSTDs. The main issues are discussed below.[61]

Management of Gonorrhea and Chlamydial Infection

Isolation of the etiologic agent is the optimal method of diagnosis but is technically demanding and expensive. Though nonculture methods for the diagnosis of both genital infections are now available, they are as yet rarely used in the developing world. A decrease in their cost may increase their use and have a significant effect on the diagnostic capacity for STDs.

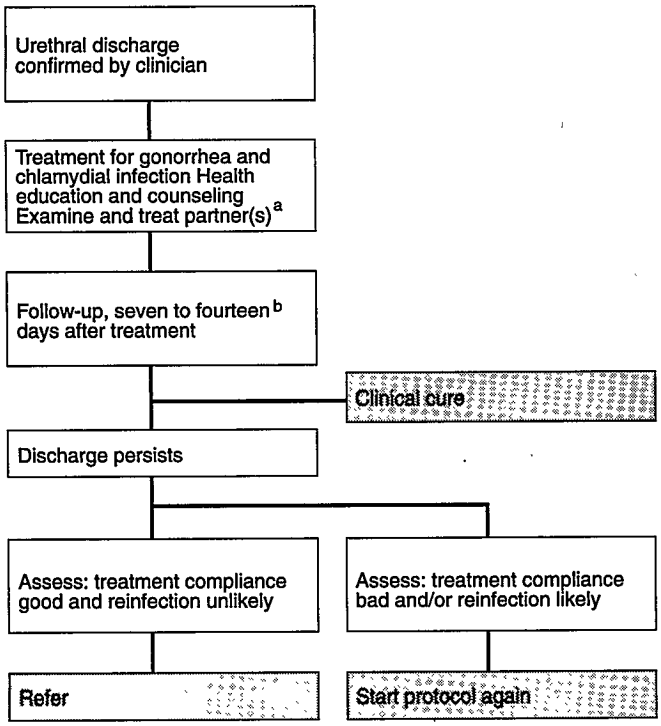
Oral tetracycline taken for seven to fourteen days is the treatment of choice for chlamydial infection and has a cure rate of 85 to 90 percent. Oral erythromycin at the appropriate dosage should be given to pregnant women and infants and children.

In those areas in which gonococci are still susceptible to penicillin, procaine penicillin as a single intramuscular injection together with oral probenecid has a cure rate of 90 to 95 percent, as has oral amoxicillin. In most areas in Sub-Saharan Africa and in Southeast Asia, however, more than 50 percent of gonococcal strains are highly resistant to penicillin, as well as to the tetracyclines in 20 to 30 percent of cases. Single-dose intramuscular injections with third-generation cephalosporins, such as ceftriaxone sodium or cefotaxime sodium, or oral therapy with the new quinolones, such as norfloxacin and ciprofloxacin, have virtually a 100 percent cure rate. Spectinomycin cures 95 percent of cases of gonorrhea, including those caused by penicillin-resistant strains. These are presently the recommended drugs for treatment of gonorrhea, but less-effective alternatives (cure rate below 95 percent, depending on the antimicrobial susceptibility of local strains) are being used because they are less expensive, including thiamphenicol, sulfamethoxazole trimethoprim, and kanamycin (WHO 1989b).

Urethritis in Men

Because basically only two etiological entities have to be considered for urethral discharge in men, a simplified method of management has been used widely. In figure 20C-1 we present such an algorithm and include figures on its effectiveness (WHO 1991). The selection of the antibiotic should ideally be based on the sensitivity of local strains of *N. gonorrhoeae*,

Figure 20C-1. Algorithm: Urethral Discharge (in the Absence of Laboratory Support)



a. Notification and treatment of female partners of men with urethritis are of the highest priority as one of the best ways of identifying women at high risk of having asymptomatic gonococcal and chlamydial infections.
b. Patient may be advised to return only if symptoms persist.
Source: WHO 1991b.

besides such other considerations as cost, availability, and mode of administration. In addition, the relative frequency of gonococcal and nongonococcal urethritis in the patient population should be taken into account. Microscopy of a Gram's stained smear of the discharge represents the minimal standard of laboratory examination.

Vaginal Discharge

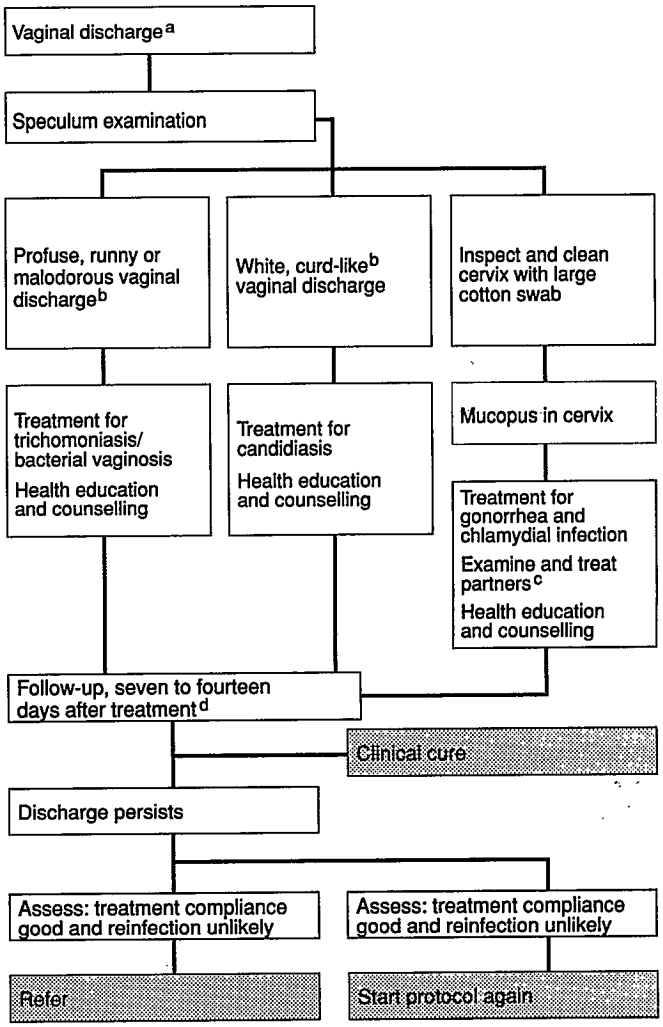
Because the etiology, and consequently the therapy, of cervicovaginal discharge is complex, clinical algorithms have not been successful for the management of this syndrome. The primary objective of case management of this problem should be the diagnosis and treatment of gonococcal and chlamydial cervical infection and the identification of women with an associated PID. Though a simple "swab test" had an acceptable sensitivity and specificity for the diagnosis of mucopurulent cervicitis—mainly caused by *C. trachomatis* and *N. gonorrhoeae*—in one study in Seattle, Washington, its validity was limited in field studies in Africa with a sensitivity and specificity for chlamydial and gonococcal infection combined of less than 50 percent, respectively (Brunham and others 1984; Braddick and others 1990).

A simplified clinical algorithm using a clinical examination with visualization of cervix but no microscopy is shown in figure 20C-2. Several other algorithms have been proposed, but evaluations of them have not been published and their effectiveness is unknown (WHO 1991b).

Pelvic Inflammatory Disease

The objectives of PID management are twofold: cure of PID and prevention of tubal infertility and ectopic pregnancy. Pelvic inflammatory disease has a polymicrobial etiology and its clinical expression includes a variety of fairly non-

Figure 20C-2. Algorithm: Vaginal Discharge (Speculum Examination Possible, but no Laboratory Support)



a. If vaginal discharge is accompanied by lower abdominal pain or pain on moving the cervix, use the appropriate "lower abdominal pain" algorithm.
b. In addition, the pH paper test can be used: if pH lower than 4.5, treat for candidiasis; if pH higher than 4.5, treat for trichomoniasis/bacterial vaginosis.
c. In the absence of a confirmed diagnosis, the decision to notify partner(s) should take into account local cultural and epidemiological factors.
d. Patient may be advised to return only if symptomatic.
Source: WHO 1991b.

specific signs and symptoms, such as lower abdominal pain and tenderness, malaise, fever, and adnexal tenderness. When validated by laparoscopy, the sensitivity and specificity of a clinical diagnosis of PID, particularly cases caused by C. *trachomatis*, are found to be in the range of 65 to 85 percent (Jacobson and Weström 1969; De Muylder 1986). Valid diagnostic criteria for postpartum endometritis and PID remain to be developed. Because of the serious outcome, sequelae, and mortality, early recognition and treatment are essential, and sensitive criteria for diagnosis should be set even if overtreatment is the result.

Treatment should be directed against infection with *N. gonorrhoeae*, C. *trachomatis*, and anaerobes and may consist of a regimen of spectinomycin single-dose plus tetracycline and metronidazole taken for two weeks. Cheaper regimens, such as thiamphenicol, have also been used (De Muylder 1986). The cure rate with these regimens is not precisely known, but it is presently estimated that 15 percent of women with acute PID fail to respond to initial antimicrobial treatment and 20 percent have at least one recurrence (Brunham 1984). The effect of antimicrobial therapy on long-term tubal function is unclear, but several studies have shown that women treated within two days of the onset of symptoms have a lower incidence of tubal occlusion than do women treated later in the disease (Weström and others 1979).

Hospitalization is required in a substantial but ill-defined proportion of women with PID in developing countries. Up to 25 percent of PID patients were hospitalized in Zimbabwe in 1986 (X. De Muylder, personal communication 1989). Peritonitis, a pelvic mass, and a tubo ovarian abscess are the main reasons for hospitalization and require intravenous therapy and often surgery as well.

Neonatal Infection with N. gonorrhoeae *and* C. trachomatis

The objectives of the management of ophthalmia neonatorum are the identification of cases of gonococcal infection; the clinical cure of conjunctivitis; the prevention of visual impairment and blindness (a complication of infection with *N. gonorrhoeae* and, to a lesser extent, C. *trachomatis*); and the treatment of STDs in the parent. The proportion of cases of neonatal conjunctivitis caused by *N. gonorrhoeae* depends mainly on the use of effective eye prophylaxis at birth. Treatment for both gonococcal and chlamydial (nongonococcal) ophthalmia should include a systemic antibiotic, because extraocular infection and disease (pneumonia) are common.

The accuracy of a stained conjunctival smear is high for the differentiation between gonococcal and nongonococcal ophthalmia (Fransen and others 1986), and this method should be used for every case of purulent conjunctivitis in the first week of life, because these have a high probability of being gonococcal. Single-dose ceftriaxone administered intramuscularly ($5 for 125 milligrams) has a 100 percent cure rate for gonococcal conjunctivitis but is not available everywhere (Laga and others 1986a and 1986b). Other recommended treatment regimens for this indication in areas with penicillin-resistant strains include tetracycline ointment for ten days plus kanamycin or cefotaxime as a single injection, the cure rates of which are 90 to 95 percent (Fransen and others 1984; WHO 1985a and 1985b). A regimen of tetracycline ointment plus erythromycin syrup for ten days is the recommended treatment of nongonococcal ophthalmia neonatorum, but in practice only topical therapy is given. As for other respiratory infections, the diagnosis of chlamydial infant pneumonia is extremely complex and is possible only in sophisticated medical centers.

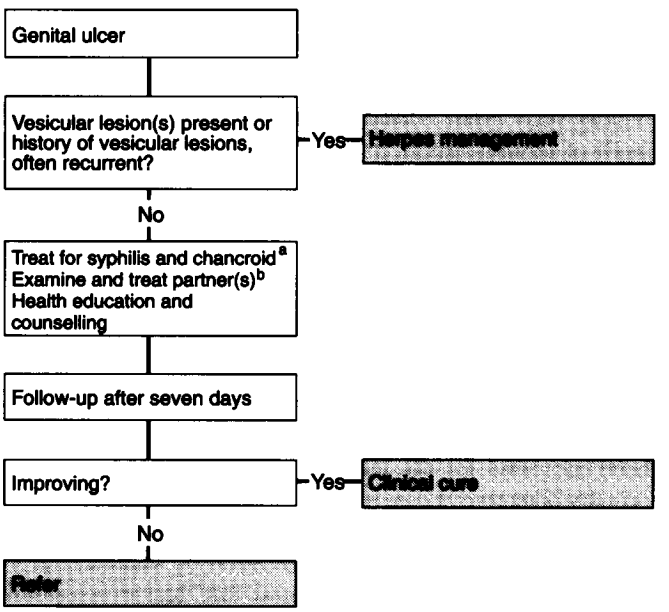
Infertility and Ectopic Pregnancy

Tubal infertility is an irreversible sequela of PID and may be repaired with microsurgery at a low (<10 percent) rate of success. In vitro fertilization (rate of success 10 to 20 percent) is also used to achieve pregnancy. Both techniques are expensive and rarely available in developing countries. Hospitalization with surgery, often with removal of the tuba, is virtually always required for ectopic pregnancy.

Genital Ulcer Disease

Though the etiology of genital ulcer disease is diverse, clinical algorithms for management have been used with success in

Figure 20C-3. Algorithm: Genital Ulcer (without Laboratory Support)



a. Combined treatment for both syphilis and chancroid is recommended, except in areas where chancroid is very uncommon. Where granuloma inguinale occurs, treatment for this condition should also be considered.
b. In the absence of a confirmed diagnosis, the decision to notify partner(s) should take into account local cultural and epidemiological factors.
Source: WHO 1991b.

several settings. The basic objectives of these algorithms are cure of chancroid, the most common cause of GUD; and treatment of syphilis, the most severe cause with respect to systemic complications and sequelae. Though genital herpes is a common cause of GUD throughout the world, specific therapy is not considered in these algorithms because the high cost of antiviral treatment with acyclovir makes it rarely available. Early diagnosis and treatment of GUD has become critical in populations with HIV infection, because genital ulcers have been shown to increase the rate of transmission of HIV (WHO 1989a).

A management algorithm for GUD is shown in figure 20C-3 and includes probabilities for the different outcomes. The simultaneous presence of HIV infection, however, may significantly decrease the cure rate of both chancroid and primary syphilis when the recommended single-dose treatment regimens are used (Lukehart and others 1988; Cameron and others 1989).

Syphilis

Whereas the treatment of the various stages of syphilis is fairly simple and well standardized and has cure rates approaching 100 percent for primary, secondary, and latent syphilis, its diagnosis is more problematic, requiring the use of laboratory tests. Nevertheless, assays such as the rapid plasma reagin tests are inexpensive (+ $0.40 per test) and easy to perform, and they should be available as a minimum laboratory support for the management of STD and the screening of pregnant women. Their sensitivity for infectious syphilis beyond the primary stage (where the algorithm for genital ulcer disease can be applied in most instances) is virtually 100 percent.

Treatment of syphilis of less than two years' duration and of neonates born to mothers with a positive serological test for syphilis consists of one or two injections of benzathine penicillin G. Therapy of neurosyphilis and cardiovascular syphilis consists of a course of penicillin, in addition to palliative measures often requiring hospitalization.

Cost-Effective Treatment Strategies

In order to devise recommendations for a cost-effective approach to controlling STDs, it is necessary to estimate the approximate average cost and the approximate effectiveness of treating a case of each STD (Washington, Browner, and Korenbrot 1987). In a developing country, where diagnostic materials are difficult to obtain and the diagnostic test may cost five to fifty times the cost of the drug treatment, part of the choice of treatment is the decision whether or not to condition treatment on a positive test for the disease. Here we consider two alternatives. The first alternative is simply to treat everyone in a given population regardless of whether they have symptoms and without attempting to diagnose the disease. The second alternative is to screen the population and then treat only those who test positive. For some diseases, the option of screening only by clinical examination is compared with the option of using microscopy or of using a culture.

In table 20C-1 we present basic comparative cost data on the various diseases. In the costs for treating a given disease we include the drug cost per treatment episode and the number of minutes of clinic time per treatment episode. For the classic STDs, the latter cost typically is the duration of a single encounter between patient and medical practice. For AIDS and HIV infection, however, the number of minutes is an estimate of the total number of minutes in all encounters with a medical practice in a period of twelve months. In the last three columns, we give three different estimates of the cost per treatment for each of the classic STDs. If we denote the drug cost by Rx, the number of minutes by T, and the proportion of cures that are effective by E, the figures in these columns can be calculated from the relationship:

$$C_i = \frac{Rx + \left(\frac{T}{60}\right) \cdot H_i}{E}, \tag{13}$$

where H_i is the assumed cost per hour of clinic time, which varies from $2 to $10 to $30 across the three columns.

Table 20C-1. Average Cost per Treatment of Case of STD by Disease and Cost per Clinic Hour

Disease	Sex	Drug cost (U.S. dollars per episode)	Clinic time (minutes per episode)	Treatment by cost per clinic hour $2	$10	$30
AIDS with AZT	Both	2,000	2,400	2,080.00	2,400.00	3,200.00
AIDS without AZT	Both	35	1,200	75.00	235.00	635.00
Chancroid	Both	0.15	10	0.48	1.82	5.15
Chlamydia	Both	0.25	15	0.75	2.75	7.75
Gonorrhea	Female	1.00	12	1.40	3.00	7.00
	Male	1.20	10	1.53	2.87	6.20
HIV with AZT	Both	2,000	120	2,004.00	2,020.00	2,060.00
Syphilis	Both	0.80	15	1.30	3.30	8.30

Source: Estimates by authors.

Table 20C-2. Alternative Diagnostic Approaches for STDs: Costs, Time, and Positive Predictive Value

Disease	*Sex*	*Diagnostic method*	*Cost of test (U.S. dollars per test)*	*Lab or clinic time (minutes per test)*	*Sensitivity*	*Specificity*	*Positive predictive value*		
							1 percent prevalence	*5 percent prevalence*	*25 percent prevalence*
AIDS with AZT	Both	Serology	2.00	10	98	98	0.33	0.72	0.94
AIDS without AZT	Both	Serology	2.00	10	98	98	0.33	0.72	0.94
Chancroid	Both	Clinical	0.00	10	80	60	0.02	0.10	0.40
	Both	Culture	5.00	5	70	100	1.00	1.00	1.00
Chlamydia	Female	Clinical	0.00	10	20	20	0.00	0.01	0.08
	Female	Culture	12.00	5	80	99	0.45	0.81	0.96
	Female	Antigen	5.00	5	70	95	0.12	0.42	0.82
	Male	Clinical	0.00	10	80	80	0.04	0.17	0.57
	Male	Culture	12.00	5	85	99	0.46	0.82	0.97
Gonorrhea	Female	Clinical	0.00	10	25	25	0.00	0.02	0.10
	Female	Culture	5.00	5	85	100	1.00	1.00	1.00
	Female	Microscopy	1.00	10	50	80	0.02	0.12	0.45
	Male	Clinical	0.00	10	85	90	0.08	0.31	0.74
	Male	Culture	5.00	5	95	100	1.00	1.00	1.00
	Male	Microscopy	1.00	10	95	99	0.49	0.83	0.97
HIV with AZT	Both	Serology	2.00	10	98	98	0.33	0.72	0.94
Syphilis	Female	Serology	1.50	5	95	95	0.16	0.50	0.86
	Male	Serology	1.50	5	95	95	0.16	0.50	0.86
Average			—	—	n.a.	n.a.	0.34	0.54	0.73

— Data not available.
n.a. Not applicable.
Source: Authors' estimates.

Table 20C-3. Minimum Cost per Effectively Treated Case of STD: Sensitivity to Prevalence and Cost per Clinic Hour

Disease	Sex	Diagnostic method	$2 per clinic hour			$10 per clinic hour			$30 per clinic hour		
			1 percent prevalence	5 percent prevalence	25 percent prevalence	1 percent prevalence	5 percent prevalence	25 percent prevalence	1 percent prevalence	5 percent prevalence	25 percent prevalence
AIDS with AZT	Both	Serology	6,521	2,934	2,217	7,623	3,405	2,562	10,380	4,584	3,424
AIDS without AZT	Both	Serology	465	152	89	1,084	401	264	2,632	1,024	702
Chancroid	Both	Clinical	73	15	3	333	67	14	983	199	42
	Both	Culture	821	165	33	928	187	39	1,196	244	53
	Both	Presumptive treatment[a]	304	61	12	452	90	18	822	164	33
Chlamydia	Female	Clinical	516	101	18	2,139	420	77	6,196	1,219	223
	Female	Culture	1,692	339	68	1,789	360	74	2,033	413	89
	Female	Antigen	827	166	34	951	192	41	1,260	258	58
	Female	Presumptive treatment[a]	322	64	13	544	109	22	1,100	220	44
	Male	Clinical	63	13	3	286	59	13	845	172	38
	Male	Culture	1,592	319	64	1,682	338	69	1,908	386	82
	Male	Presumptive treatment[a]	304	61	12	452	90	18	822	164	33
Gonorrhea	Female	Clinical	580	114	20	1,643	324	60	4,301	848	158
	Female	Culture	641	129	27	726	148	32	936	193	45
	Female	Microscopy	341	69	14	690	139	29	1,562	316	67
	Female	Presumptive treatament[a]	295	59	12	463	93	19	884	177	35
	Male	Clinical	62	13	4	245	51	12	702	145	34
	Male	Culture	574	116	25	649	132	29	838	173	40
	Male	Microscopy	151	31	8	302	63	15	678	141	33
	Male	Presumptive treatment[a]	288	50	12	428	86	17	779	156	31
HIV with AZT	Both	Serology	6,291	2,829	2,136	6,475	2,878	2,159	6,936	3,002	2,215
Syphilis	Both	Serology	185	38	9	269	56	14	477	102	27
	Both	Presumptive treatment[a]	293	59	12	495	99	20	1,000	200	40

Note: Cost-effectiveness values are those that would obtain if 100 percent of patients had the specific disease in question. Treatment effectiveness is 99 percent for syphilis, 95 percent for gonorrhea, and 90 percent for chanchroid and chlamydia. For AIDS treatment is assumed 100 percent effective at prolonging life one year without AZT or two years with AZT.

a. Treatment of all patients with the drugs for all four STDs, at an estimated cost of $2.40 per visit.

Source: Authors' estimates.

In table 20C-2 we present the estimated cost of the laboratory test for each disease, the estimated sensitivity and specificity of each test and, in the last three columns, the positive predictive value of the given test for three different prevalence rates. Let x represent the sensitivity of the test (that is, the proportion of truly positive cases which the test finds positive) and y represent the specificity of the test (that is, the proportion of truly negative cases which the test finds negative). Then the positive predictive value of a test is defined for prevalence rate I to be:

$$(14) \qquad PPV = \frac{x \cdot I}{[x \cdot I + (1-y)\ (1 - I)]}.$$

To compare the "treat all" strategy with the "screen" strategy, we calculate the estimated cost per cure using each strategy for each of the classic STDs. For AIDS and HIV infection we simply calculate the cost of treatment. Let N be the number of individuals in a given population and I be the proportion of individuals infected at a given moment, that is, the point prevalence rate of the infection. Then the cost of treating all N individuals will be $C \cdot N$. Because a proportion I is infected, and the treatment is effective on a proportion E of these, the number cured will be $E \cdot I \cdot N$. Hence, the cost per cure for the treat-all strategy is $C/(E \cdot I)$.

The cost of testing all N individuals and treating those who are positive on the test is the sum of these two cost components. At a cost of T dollars per test, the testing cost for N individuals is $T \cdot N$. Let T be defined analogously to C except that the cost per hour of laboratory or clinic time is set to half the value used to compute the treatment cost. The test will be positive for x proportion of the $I \cdot N$ who are truly positive and for $(1 - y)$ proportion of the $(1 - I) \cdot N$ who are truly negative, so the total cost of treatment will be $C\,[x \cdot I \cdot N + (1 - y)\ (1 - I)\ N]$. Of the $x \cdot I \cdot N$-infected people who are treated, a proportion E will be cured. Thus the cost per cure from the screen strategy is given by:

$$(15) \qquad \begin{matrix}\textit{Cost per cure} \\ \textit{of the screen} \\ \textit{strategy}\end{matrix} = \frac{C\,[x \cdot I + (1-y)\,(1-I)] + T}{E \cdot x \cdot I}$$

$$= \frac{C}{E \cdot PPV} + \frac{T}{E \cdot x \cdot I}.$$

A comparison of the cost per cure of the two strategies then reveals the preferred strategy for any given disease and for given assumptions regarding the hourly cost of clinic time, H, and the prevalence rate in the population in question, I. Other things being equal, a higher cost of clinic time in relation to testing cost, T, increases the relative cost advantage of the screen strategy. Conversely a higher prevalence rate, other things being equal, reduces the relative cost advantage of screening. The specific assumptions determine whether one strategy will dominate the entire domain of reasonable parameter values.

In table 20C-3 we present the lowest cost solution for each disease and, for those diseases which vary by sex, for each sex. Two remarkable findings stand out from this table. First, over a large range of parameter values the "treat without testing" option dominates the "screen, then treat" option. Second, in those few situations in which screening is more cost-effective than treating everyone, the clinician's judgment produces a lower cost per effectively treated case than do the alternatives, which in the case of gonorrhea include microscopy and a culture.

Notes

All dollars in this chapter are 1989 U.S. dollars.

1. In his seminal work on the benefits of a syphilis control program, Klarman (1965) was unable to estimate these dynamic benefits.

2. Hethcote and Yorke (1984, pp. 16 and 17) use the terms "contact number" and "infectee number" to refer to different versions of this concept.

3. The concept can be extended further by including tertiary, quaternary, and other cases. This extension presents problems because some of the individuals not infected by the prevented case will instead be infected by a case that has not been prevented. The greater the number of rounds considered, the more serious is this problem, which can be avoided only by addressing the problem more generally in the context of an explicit mathematical epidemiological model. Prevented cases that would have occurred more than twelve months in the future must be discounted by an appropriate rate.

4. The new equation for R becomes $R = QD\,[m + s^2/m]$, where m is the mean of the a_i and s^2 is their variance. Note that as the heterogeneity disappears, s^2 approaches zero and this equation approaches the one given earlier. This result depends on the assumption of proportionate mixing of sexual partners. See appendix 20B for a discussion of alternative models of mixing.

5. The "prevalence" of an infection refers to a point in time and is defined as the proportion of a given population infected at that moment. The "incidence" of infection refers to a specific period of time and is defined as the number of new cases of infection during that period. Economists will note that the former is a "stock" and the latter a "flow."

6. See Heymann (1990) for sensitivity analyses with respect to several parameters not considered by Kennedy and others (1990).

7. None of the three studies reported in table 20-6 breaks out the results by sex. This is more of a problem for the Rwandan and Zambian studies than for the Zairian one, because the latter is based on a group of employees which is almost entirely male.

8. Rural women are much less likely to attend secondary school in Africa than are urban women.

9. Data on urban sex ratios of adults age twenty through thirty-nine are available only for these eighteen Sub-Saharan African countries in Larson (1989, table 1).

10. The number of females enrolled per 100 enrolled males is drawn from World Bank 1989 (table 32). Secondary education is likely to be concentrated in urban women.

11. The regression equation is:

$$\begin{matrix}\text{HIV\%} = -4.3 & - & 0.10 \cdot \text{FENR} & + & 1{,}240 \cdot \frac{1}{\text{FURB}} \\ & & (-0.8)\ \ (-2.3) & & \qquad (3.1)\end{matrix}$$

$$n = 18 \quad R^2 = 0.48 \quad F_{2,15} = 7.03 \quad \text{Prob} > F\ 0.007$$

where FENR is the number of girls enrolled in secondary school for every 100 boys, FURB is the number of females age twenty through thirty-nine resident in urban areas for every 100 males. Numbers in parentheses are t-statistics. Dropping Rwanda from the regression reduces the significance of the coeffi-

cients but does not change their sign or magnitude. Grossbard-Schechtman, DuCharme, and Loomin (1989) also obtain significant coefficients on the young adult female-to-male ratio in their study of gonorrhea and syphilis prevalence in a cross-section of thirty-seven U.S. cities. They did not attempt to control for female education but did control for the prevalence of male homosexuality.

12. The magnitudes of the estimated coefficients suggest that a five-point reduction in the adult prevalence of HIV could be achieved either by increasing FURB by 35 per 100 men or by increasing FENR by 50 girls per 100 boys.

13. Sometimes it will be more convenient to refer to a disability-adjusted life-day (DALD) than a disability-adjusted life-year. There are 365 DALDs in one DALY. GHAP originally used the term healthy life-year, which we have changed for conformity with usage in this volume.

14. This is the parameter referred to as *a* previously and in table 20-10 below.

15. This is referred to in the literature as the assumption of proportionate mixing and is defined by setting a "selectivity parameter" equal to zero. When this parameter, G, is set to 100 percent, each group prefers members of its own group to the complete exclusion of members of the other, so that there is no interaction between the two groups. Although proportional mixing probably does not exactly describe actual behavioral patterns (Anderson 1989), Rothenberg and Potterat (1988, table 3) provide evidence from a Colorado Springs cohort of a remarkably large degree of mixing, especially by core men, for whom only 74 of 251 sexual contacts were with core women. The actual degree of mixing in pattern II countries is currently unknown.

16. Although the parameters of table 20-10 are not currently known for any African population, the guesses here are roughly consistent in order of magnitude with the estimates of doubling time of the infection presented by Anderson and McLean (1988).

17. The case-fatality rates of the other CSTDs, although important for the static burden calculations presented above, are too small and too long after infection to have an appreciable influence on this short-term model and thus are assumed to be zero. For HIV we set *D* equal to ten years, the average time until death, at which point we assume that a new susceptible is recruited through migration on maturation to replace the dead individual.

18. New biomedical findings on the variation of infectivity during the period of infection may affect these results.

19. For other values of the selectivity coefficient G, the two equilibrium prevalence levels are the solutions to two simultaneous quadratic equations, which are solved numerically by the simulations reported below. For G = 0 the solutions are given in the last two rows of table 20-11.

20. Furthermore there is some evidence that other STDs, such as chlamydial infection and trichomoniasis, also increase the efficiency of HIV transmission (Laga and others 1989, 1990; Pepin and others 1989).

21. A further question is whether HIV and other STDs discriminate between the poor and the rich in urban areas. Limited evidence indicates that HIV prevalence rates may be positively correlated with income levels among urban males and negatively correlated with income levels among urban females. This may, however, be only a temporary feature, because the epidemic has not yet reached stable levels in most populations.

22. Indeed the authors later state that "Our parameter values . . . may well lead to conclusions more representative of say Kinshasa and Nairobi than of Zaire and Kenya as a whole" (p. 233).

23. The last two columns of table 20-12 show that the health gain in preventing a single case of STD in a woman is 19 percent larger on average than preventing a single case in a man.

24. Although anthropologists have focused on describing the range and meaning of cultural practices, they have not typically attempted to estimate valid population-based frequencies of those practices.

25. For example, *Forbes* magazine recently reprinted and endorsed the oxymoronic request by the American activist group ACT UP for the public to "demand . . . [e]ffective prevention education programs that target *all* people in *all* cultural groups" (AIDS Coalition to Unleash Power 1989).

26. The youth group entitled "Les jeunes contre les MST" has been organized in Lubumbashi, Zaire, to combat STDs within the peer group.

27. To the extent that different measures of health gained result in different decisions, the decisionmaker will also have to select a preferred measure. The possibilities include discounted disability-adjusted life-days saved, discounted productive disability-adjusted life-days saved, and money-valued discounted disability-adjusted life-days saved.

28. For most diseases, we use relative incidence rates to average the effects over the six age groups. Following GHAP (1981), we distinguish adult from child pneumonia. At the expense of greater complexity, it would be possible to perform a separate analysis for each age group.

29. In the absence of dynamic analyses of the health benefits of preventing the other communicable diseases in figure 20-10 and table 20A-3 (for example, measles, pneumonia), dynamic benefits of STDs cannot be compared with those of other diseases.

30. In 1981 the country of Burkina Faso introduced the activist expression "commando program" for a one-time vaccination campaign.

31. For a full description of the model and sensitivity analyses with respect to its key parameters, see appendix 20B.

32. The net effect of the intervention, however, remains strongly positive, because the averted cases early in the period more than outweigh the small number of additional cases later. The effect of future additional cases is reduced even further because they are discounted at 3 percent.

33. Effectiveness is not the whole story. Cost-effectiveness is discussed in the rest of the chapter.

34. An intervention which produces sustained behavioral change would yield additional benefits from the permanent reduction in the prevalence rate.

35. When both partners are infected with one of these four CSTDs, we assume that infectivity is multiplied by the square of the factor operating when only one is infected. See appendix 20B for a formal statement.

36. These sums are represented graphically by the areas under the two curves in the bottom panel of figure 20-14.

37. For simplicity we model the condom user as absolutely protected, although in fact some condoms break or are incorrectly used and thus do not protect absolutely. Given the (unknown) frequency of condom failure, the cost-effectiveness figures can be inflated by that amount.

38. The others are frequency of sexual partner change (*a*), selectivity (G), and the CSTD's duration of infectivity (*D*). The costs of changing the frequency and duration are much harder to calculate. Theoretically an IEC program could also slow the epidemic in the noncore (and accelerate it in the core) by encouraging increased selectivity of sexual partners. Sensitivity analysis reported elsewhere in this chapter, however, reveals that even a substantial increase in selectivity has a relatively small effect on the speed of the epidemic's spread. Furthermore, IEC programs to encourage selectivity would inevitably also lead to increased stigmatization of people who seem to fit the program's stereotype of "partners to avoid." In addition to creating deep and harmful social divisions and scapegoating, such stigmatization would drive the epidemic further underground, where it would be even harder to combat. For these reasons we do not consider this behavioral parameter to be the legitimate target of an IEC program.

39. Bertozzi (1991) presents two more complex models and sensitivity analyses to show that they differ little from one another.

40. This is the prevalence rate recently reported among blood donors in Delhi, India, by Singh and others (1990).

41. In those countries in which donor assistance has provided virtually unlimited financial assistance, the binding constraint is trained, competent manpower to manage those resources.

42. This is a consensus estimate by a WHO/GPA panel of experts reported in Chin, Sato, and Mann (1989).

43. This is the same Elliot Ness who earlier conducted such a vigorous and unsuccessful war against bootleg liquor.

44. Brandt goes on to point out the illogic of placing the blame for STDs uniquely on women. "The fact that controlling prostitution did not control sexuality forced many to confront the change in American sexual mores" (p. 168).

45. By placing HIV-infected persons in quarantine, Cuba is the only country in which a full-scale mandatory program for the whole population is in effect. There the regulators are presumably closely supervised (Bayer and Healton 1989). Although the program's effectiveness is undoubtedly increased by the

absence of civil rights and by the surrounding ocean barrier at the borders, its actual effectiveness is unknown.

46. An average of 1.9 partners were named per cooperating index case. Interestingly, when asked to choose whether personally to notify their own partners (patient referral) or to have the public health staff perform the notification (provider referral), index cases chose the relatively anonymous provider referral for 75 percent of all named contacts (Spencer, Raevsky and, Wolf 1989).

47. One hundred dollars is 0.5 percent of the U.S. 1987 per capita GNP.

48. In a poor country it may be difficult to persuade the public that any allocation mechanism which distributes treatment to only five or ten of several thousand enrolled HIV-positive candidates is fair. One possible mechanism would be a community review board similar to those used in the United States and Great Britain to allocate scarce kidneys to transplant candidates. Another possibility is simply to use a lottery.

49. Because no population-based studies yet exist which estimate the proportion of adults with multiple sexual partners, these figures must be viewed as hypotheses which require confirmation. The population-based figures, such as proportion of adolescents or of health care providers, can be adjusted to the data of an individual country as they become available.

50. As an analogy with the epidemiology of screening, think of the communication as a screening test. Then the coverage of the target group by the communication is analogous to the proportion of all positives identified by the test, that is, the sensitivity of the test.

51. In accord with the preceding note, the "concentration" of a message on a target group is analogous to the positive predictive value of a screening test for a specific disease.

52. If the delivery of an IEC or training message to the wrong group has political or social costs (for example, by inflaming political antagonism to the AIDS prevention program or by stigmatizing prostitutes), then the "specificity" of the access group for the target group is also a desirable attribute.

53. Behrman (1989) discusses the economics of social marketing programs in a family planning context.

54. For example, Mposo and others (1989) found that HIV-infected infants in Zaire incurred annual health care costs that were 60 percent higher than control infants.

55. The estimate of one DALY saved per case averted is derived by applying the appendix A methodology to gonorrhea after setting to zero all incidence rates for age greater than zero.

56. This policy is cost-effective in comparison with treating later cases, even in populations that have prevalence rates of syphilis as low as 0.005 percent in pregnant women (Stray-Pedersen 1983).

57. The presumptive treatment of syndromes has the additional disadvantage of exposing more people to antibiotics and thereby increasing resistance to those antibiotics in the population of disease agents and potentially causing mild to severe side effects in individuals taking antimicrobials. Consideration of these drawbacks is beyond the scope of this chapter.

58. According to World Bank sources, the cost per clinic-hour in one poor Sub-Saharan African country is $2.20 (1990 U.S. dollars).

59. See Hethcote and Yorke 1984, pp. 25–31, for details.

60. For a more general specification of mixing in a one-sex mixing model, see Blythe and Castillo-Chavez 1988 and the references therein.

61. For a more detailed discussion, the reader is referred to the STD treatment guidelines issued by WHO (1989).

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Source: Dean T. Jamison, W. Henry Mosley, Anthony R. Measham, and Jose Luis Bobadilla (eds.). *Disease Control Priorities in Developing Countries*. New York: Oxford University Press for the World Bank. 1993.