33. *Wall Street Journal* (15 December 1987), p. 36.
34. R. Rothenberg, M. Woelfel, R. Stoneburner, J. Milberg, R. Parker, and B. Truman [*N. Engl. J. Med.* **317**, 1297 (1987)] report that 13% of a large sample of New York City AIDS patients survived for more than 2 years after their initial diagnosis.
35. J. Pechman and B. Okner, *Who Bears the Tax Burden?* (Brookings Institution, Washington, DC, 1974).
36. Population data are for 1980. U.S. Bureau of the Census, *Statistical Abstract of the United States,* table 29 (Washington, DC, 1984).
37. J. I. Boufford, testimony before the Subcommittee on Social Security and Family Policy, U.S. Senate (10 September 1987).
38. See Health Insurance Association of America (no date) "Results of the Health Insurance of America and the American Council of Life Insurance AIDS survey of member companies," mimeo.
39. P. S. Arno, *J. Am. Med. Assoc.* **258**, 1376 (1987).
40. R. Jacob, U.S. Office of Management and Budget (January 1988).
41. D. Rice, T. Hodgson, A. Kopstein, *Health Care Financ. Rev.* 7, 61 (Fall 1985).
42. We thank N. Bennett, H. Fineberg, R. Freeman, A. Garber, D. Sencer, J. Trahan, and two anonymous reviewers for helpful comments.

Epidemiology of HIV Infection and AIDS in the United States

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By the end of 1987, nearly 50,000 cases of acquired immunodeficiency syndrome (AIDS) had been reported since 1981, 20,745 in the past year alone. Black and Hispanic adults and children have reported rates 3 to 12 times as high as whites. This can be largely attributed to higher reported rates in black and Hispanic intravenous (IV) drug abusers, their sex partners, and infants. In 1986, reported AIDS deaths increased adult male and female mortality in the United States by an estimated 0.7 and 0.07%, respectively, with much greater increases in selected age groups or areas of the country. The greatest variation in infection with the human immunodeficiency virus (HIV) (0 to 70%) has been found in surveys of IV drug abusers, while surveys of homosexual men reveal infection rates of 20 to 50%. Infection with HIV ranged from 0 to 2.6% in limited sexually transmitted disease clinic surveys of heterosexual men and women without a history of IV drug abuse or known sexual contact with persons at increased risk. The modes of HIV transmission are now well understood, but a large amount of biologic variability in efficiency of transmission remains to be explained. The period between initial infection with HIV and the development of AIDS is variable, but the risk for disease progression increases with duration of infection.

SINCE 1981, MORE THAN 70,000 CASES OF ACQUIRED IMMUNODEFICIENCY SYNDROME (AIDS) have been reported from more than 127 countries (*1*). Of these, well over half have been reported from the United States, reflecting the relatively high incidence of the syndrome here and a well-established national active surveillance system. By the end of 1987, 49,793 cases of AIDS in adults and children had been reported to the Centers for Disease Control (CDC); 27,909 (56%) were reported to have died, including over 80% of those diagnosed before 1985. During the past 12 months, 20,745 reports were received, a 57% increase over the preceding year. Since 1981, most adults in the United States with AIDS have been homosexual or bisexual men without a history of intravenous (IV) drug abuse (65%); 8% have been homosexual or bisexual IV drug abusers.

More than 60% of the 13,492 cases reported in heterosexual men and women were among those with a history of IV drug abuse, representing 17% of total cases. One percent of adults with AIDS (484) had hemophilia and 2% (1124) of the cases were associated with transfusions, almost always received before 1985. Of the 4% of cases of discare attributed to heterosexual transmission, 1107 (243 men and 864 women) had a history of heterosexual contact with a person with documented infection with human immunodeficiency virus (HIV) or in one of the main transmission categories, whereas 857 were born in countries (such as Haiti or central Africa) where heterosexual contact has been shown to be the major route of HIV transmission. The proportion of reported cases associated with heterosexual contact increased from 1.1% in 1982 to 2.3% in 1986. Approximately 70% of the index partners for these cases were IV drug abusers; 18% of the index partners for female cases were bisexual men. The male to female ratio of heterosexual contact cases in the United States is 1:3. In part, the predominance of women in the heterosexual contact category is probably due to a larger pool of infected men, but the relative efficiencies of male-to-female versus female-to-male transmission might also be relevant.

The presumed means of acquiring HIV infection was undetermined in only 3% of adults with AIDS; in most of these instances, risk information was incomplete. Within this group, no risk was identified for 211 heterosexual men who were interviewed or for whom other follow-up information was obtained. However, of those men responding to a standardized questionnaire, 51 (42%) of 122 gave a history of a sexually transmitted disease (STD) and 33 (34%) of 96 gave a history of prostitute contact.

Of the 737 cases of AIDS in children under 13 years old, 317 were reported in the past 12 months, a 64% increase over the previous year. Seventy-seven percent of pediatric AIDS cases were acquired perinatally, 13% were associated with transfusions, and 5% occurred in children with hemophilia. Over 70% of the perinatally

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acquired AIDS cases were related to IV drug abuse in the child's mother or her sexual partner.

Racial and Ethnic Characteristics of Victims

In the United States, 62% of reported AIDS in adults and 23% in children have occurred in whites. Blacks have accounted for 25% of adult and 56% of pediatric cases and Hispanics for 13% of adult and 20% of pediatric cases. In contrast, blacks and Hispanics, respectively, account for 11.6 and 6.5% of the U.S. population (excluding territories). The disproportionate percentage of AIDS in blacks and Hispanics largely reflects higher reported rates of AIDS in black and Hispanic IV drug abusers, their sex partners, and infants (Table 1). The relative risks of AIDS for blacks and Hispanics are two to ten times as high in the Northeast as in other regions of the country because of the concentration of IV drug abuse–related AIDS (*2*).

Rates for transfusion-associated AIDS do not show statistically significant differences by race or ethnicity for adult cases; rates are significantly higher for black infants, perhaps due to a greater need for transfusion in managing low birth weight infants.

Magnitude of the Problem and Projections

In 1986, reported AIDS deaths increased adult male and female mortality rates in the United States by at least 0.7 and 0.07%, respectively (Table 2). For black men, AIDS increased adult mortality in 1986 by 1.5%. From 1984 to 1986, mortality rates for AIDS doubled for men and women in New York City and accounted for at least 4.4 and 0.6%, respectively, of the adult mortality. During the same period, for men in San Francisco, the rate increased 2.5 times and accounted for at least 15% of the adult male mortality in that city in 1986. By 1986, AIDS had undoubtedly become the leading cause of death in hemophiliacs and IV drug abusers in the United States.

AIDS-related mortality disproportionately affects persons in the 20- to 44-year-old age group, leading to substantial decreases in life expectancy. One measure of this premature mortality is "years of potential life lost" (YPLL) before age 65. Most causes of YPLL decrease or increase only slightly over time, but AIDS increased from 13th in 1984 to an estimated 8th in 1986 (*4*). In 1986, AIDS accounted for 2.1% of total YPLL in the United States. More than 90% of the AIDS-related premature mortality occurs in men, with nearly 75% in those 25 to 44 years old. In 1986, AIDS will be the seventh leading cause of YPLL in men; for men 25 to 44 years, AIDS will rank sixth in 1986.

The Public Health Service projected the number of AIDS cases to be diagnosed from 1986 through 1991 by using a statistical extrapolation of trends in cases reported to the CDC through April 1986 (*2, 5*). Cases reported through August 1987 represent 92% of the total projected, within the broad confidence intervals of the original projection (Fig. 1). A review of death certificates in Washington, D.C., New York, Boston, and Chicago in late 1985 indicated that reporting of definitively diagnosed AIDS was 90% complete in 1985; an additional 13% of cases of opportunistic infections and cancers that were presumptively AIDS did not meet the diagnostic requirements for reporting purposes (*6*). In recognition of the increasing frequency of such presumptive methods of diagnosis and the need to include HIV encephalopathy and wasting syndrome in the surveillance of severe HIV-associated morbidity and mortality, the CDC surveillance definition of AIDS was revised in 1987 (*7*). Delays in reporting of AIDS to state and local health departments and the CDC have increased. In 1986, the median and mean delays between diagnosis and report were 2.4 and 3.5 months, respectively, with 83% of cases reported within 6 months of diagnosis. In 1987 the median and mean delays have increased to 2.9 and 4.8 months, with 80% of cases reported within 6 months of diagnosis.

Although the peak level of AIDS cannot yet be accurately predicted from available data or models, reported cases may level off before actual cases do. Interpretation of trends of reported cases of AIDS in the future will necessitate careful evaluation of delays in and completeness of reporting, as well as changes in diagnostic practices and therapeutic regimens.

Incidence and Prevalence of HIV Infection

Close monitoring of reported AIDS cases since 1981 has provided valuable information on the distribution of severe HIV-related illness. However, since HIV infection often precedes AIDS by many years, trends in reported AIDS cases may not reflect the current prevalence of HIV infection. (In this article, the term HIV refers to infection with or antibody to HIV type 1, the virus thus far found in the United States.) Furthermore, the delayed progression rate to AIDS suggests that the incidence of reported AIDS will continue to increase, perhaps for many years, after the incidence of HIV infection has stabilized or even declined. For example, reported cases

Table 1. Cumulative incidence (per million population) of AIDS and relative risk (shown in parentheses) by racial and ethnic groups, age, and transmission category, 1981–1987. Relative risk is the ratio of the cumulative incidence in each race or ethnic group to the incidence in whites.

Category	White	Black	Hispanic	Other
Adult men	380.8 (1.0)	1068.1 (2.8)*	1036.3 (2.7)*	141.0 (0.4)*
Adult women	12.2 (1.0)	161.1 (13.2)*	104.6 (8.6)*	11.1 (0.9)
Adults, total†	188.9 (1.0)	578.2 (3.1)*	564.4 (3.0)*	74.4 (0.4)*
Homosexual men	298.6 (1.0)	413.8 (1.4)*	513.9 (1.7)*	94.7 (0.3)*
Bisexual men	46.8 (1.0)	177.7 (3.8)*	126.3 (2.7)*	24.9 (0.5)*
Heterosexual IV drug abusers	10.1 (1.0)	201.2 (19.9)*	195.1 (19.3)*	4.2 (0.3)*
Hemophilia	2.6 (1.0)	1.4 (0.6)*	2.7 (1.0)	1.7 (0.7)
Transfusion	5.1 (1.0)	7.5 (1.5)	6.5 (1.3)	5.0 (1.0)
Pediatric, total†	3.8 (1.0)	46.3 (12.1)*	26.1 (6.8)*	3.2 (0.8)
Mother, IV drugs	0.8 (1.0)	21.8 (26.4)*	13.9 (16.9)*	1.3 (1.6)
Mother's partner, IV drugs	0.2 (1.0)	5.5 (25.8)*	6.2 (29.2)*	0.0 (0.0)
Transfusion-associated	1.1 (1.0)	2.7 (2.3)*	2.1 (1.9)	0.0 (0.0)
Hemophilia	0.6 (1.0)	0.7 (1.0)	1.3 (2.0)	0.6 (1.0)

*Relative risk significantly different from 1.0 ($P < 0.05$). †For all men, homosexual men, and bisexual men, the denominator consisted of all men ≥15 years; for all women, the denominator was all women ≥15 years; for other adult categories, the denominators included all men and women ≥15 years. For pediatric categories, the denominators consisted of all children <15 years.

of AIDS associated with transfusions and in persons with hemophilia have continued to increase for the past 3 years despite the sharp decline in incidence of HIV infection in these groups since 1984 and 1985 when antibody screening of blood donations and heat treatment of clotting factor concentrates were fully implemented.

HIV prevalence in groups at recognized risk. Observed prevalence of HIV infection remains highest in those groups accounting for the majority of reported AIDS cases. Since 1984, more than 50 HIV surveys conducted throughout the country of homosexual and bisexual men show prevalence rates ranging from 10% to as high as 70%, with most between 20 and 50% (*8*). The highest rates have been in cities with the highest rates of AIDS reported in homosexual men, but the geographic variation in prevalence is relatively low (that is, two- to threefold). The much larger variation in reported AIDS rates undoubtedly reflects differences in the absolute size of sexually active populations of homosexual men, as well as earlier entry of HIV into some communities. The data probably overestimate the true prevalence of HIV infection in most homosexual men since most surveys are conducted of persons seeking medical attention for STDs or because of concern that their past or present sexual behavior has placed them at risk.

The prevalence of HIV infection in IV drug abusers varies much more widely, ranging from 0% to nearly 70%. Data from more than 18,000 persons tested in nearly 90 surveys consistently show very high prevalence rates in major East Coast cities with geographic or close cultural connections to New York City and northern New Jersey (*8*, *9*). Most surveys are conducted in drug abuse treatment facilities of persons who are being treated for chronic heroin abuse. Since only 10 to 20% of the estimated 1,100,000 IV drug abusers in the country are currently in treatment, available data may not be entirely representative (*10*). More data are needed on HIV prevalence among IV drug abusers not currently in treatment since HIV infection associated with IV drug abuse is directly or indirectly the major source of heterosexual and perinatal transmission of HIV in the United States.

More than 30 HIV seroprevalence surveys have been conducted of hemophiliacs who received clotting factor concentrates before HIV screening of plasma and treatment of clotting factor concentrates became universal in the United States in 1984 and 1985 (*8*, *11*). Seroprevalence ranges from 15% to over 90% and varies with the type and severity of hemophilia—being highest for persons with severe hemophilia A and somewhat lower for those with hemophilia B and mild to moderate hemophilia A. Within these clinical

Table 2. AIDS incidence rates and mortality for 1986 compared to 1984 total mortality by group (per 100,000 population).*

Group	United States			New York City			San Francisco		
	AIDS		Total mortality rate	AIDS		Total mortality rate	AIDS		Total mortality rate
	Incidence	Mortality rate		Incidence	Mortality rate		Incidence	Mortality rate	
Men >15 years	15.7	9	1245	110	64	1452	348	220	1469
White	12.4	7	1332	86	48	1915	523	331	1898
Black	32.9	21	1413	152	95	1575	195	115	1524
Women >15 years	1.1	0.7	1027	12	7	1158			
White	0.4	0.3	1118	4	2	1639			
Black	5.3	3.4	997	28	17	1026			
IV drug abusers									
Male	498	312		696	429				
Female	200	312		381	237				
Hemophilia	968	560							
Type A	1106	657							
Type B	415	173							

*Incidence rates and mortality rates for AIDS in selected populations were calculated by dividing AIDS cases diagnosed in 1986 and AIDS deaths occurring in 1986 by estimates of age, sex, and race-specific denominators from the 1980 census for the United States, New York City, and San Francisco. Data on 1986 reported AIDS mortality is compared to 1984 total adult mortality. For IV drug abusers, denominators were obtained from the National Institute for Drug Abuse and the New York State Division of Substance Abuse Services; for hemophiliacs, results of a 1976 survey provided denominator estimates (*3*).

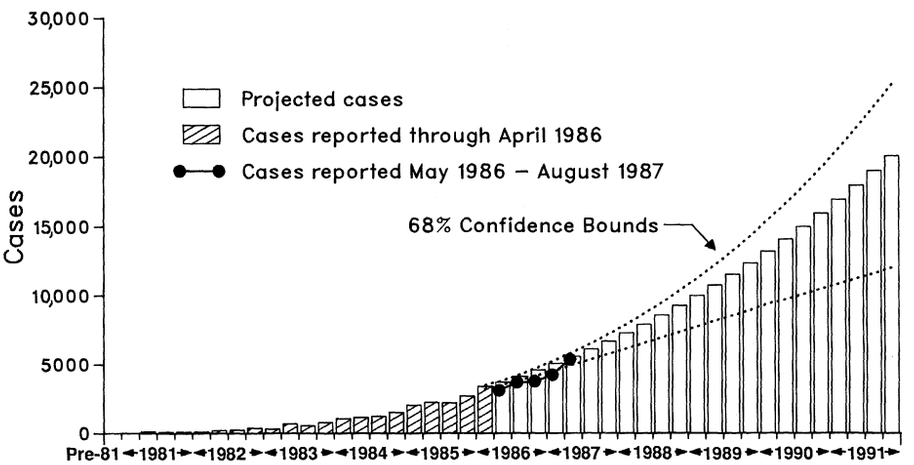

Fig. 1. Cases of AIDS in the United States with projections through 1991. The projections (open bars), shown by quarter of diagnosis, were made for the U.S. Public Health Service Planning conference on AIDS and represent a statistical extrapolation of the trends in cases reported to the Centers for Disease Control through April 1986 (striped bars) (*5*). Cases reported from May 1986 through August 1987 are shown for comparison (solid line with bullets). Both sets of reported cases have been lagged 2 months to partly adjust for the median delay between the time cases are diagnosed and reported to the CDC. Cases since May 1986 add up to roughly 92% of the total projected. The shortfall is partly associated with increasing reporting delays as state and local health departments work to handle the growing number of case reports. None of the projections account for an estimated 10% of cases that are diagnosed but never reported to the CDC or the additional 15% that are presumptively diagnosed and fail to meet the AIDS surveillance definition (*6*). A new surveillance definition that relies more heavily on the use of laboratory tests for HIV infection will allow for the future reporting of both presumptive AIDS cases and an expanded spectrum of severe HIV-associated disease (*7*).

categories, rates are uniform throughout the country. Differences in prevalence are associated with the amount of clotting factor received before 1985. The data probably slightly overstate the true HIV seroprevalence for hemophiliacs, since most surveys have been conducted at hemophilia treatment centers, where persons with more severe disease are more likely to be encountered.

Relatively few data are available from studies of male or female prostitutes or incarcerated persons. HIV prevalence in female prostitutes in the U.S varies widely from 0% to over 50%, with the differences predominantly related to the extent of IV drug abuse in the population tested and the HIV prevalence in IV drug abusers in the area (*8*, *12*). In a seven-city collaborative study, 75% of HIV infections were detected in prostitutes with a history of IV drug abuse; rates were higher in black and Hispanic prostitutes than in whites independent of a history of IV drug abuse (*12*).

Prevalence in selected segments of the general population. The general population consists of persons at widely varying risks for HIV infection. National data are already available from antibody testing of military recruit applicants and blood donors, and additional sentinel surveillance systems are already set up or planned.

Since April 1985, more than 25 million blood or plasma donations have been tested for HIV antibody in the United States. The HIV prevalence in blood donors declined from 0.035% in 1985 to less than 0.015% in 1987 due to exclusion of previously tested seropositive donors from repeat donation and very active deferral of persons at increased risk for HIV infection (*8*, *13*). All applicants for military service have been serologically screened for HIV infection since October 1985. Burke *et al.* have described in detail the data from the first 6 months of testing (*14*). During the 2 years since testing began, more than 1.2 million applicants have been tested; HIV seroprevalence rates have remained two to three times as high in male as female applicants and three to ten times as high in black and Hispanic as white applicants (*8*, *14*). The geographic distribution of HIV prevalence in military applicants is similar to that for reported cases of AIDS with the adjusted prevalence of HIV in recruit applicants usually three to ten times as high as the cumulative incidence of reported AIDS (Fig. 2).

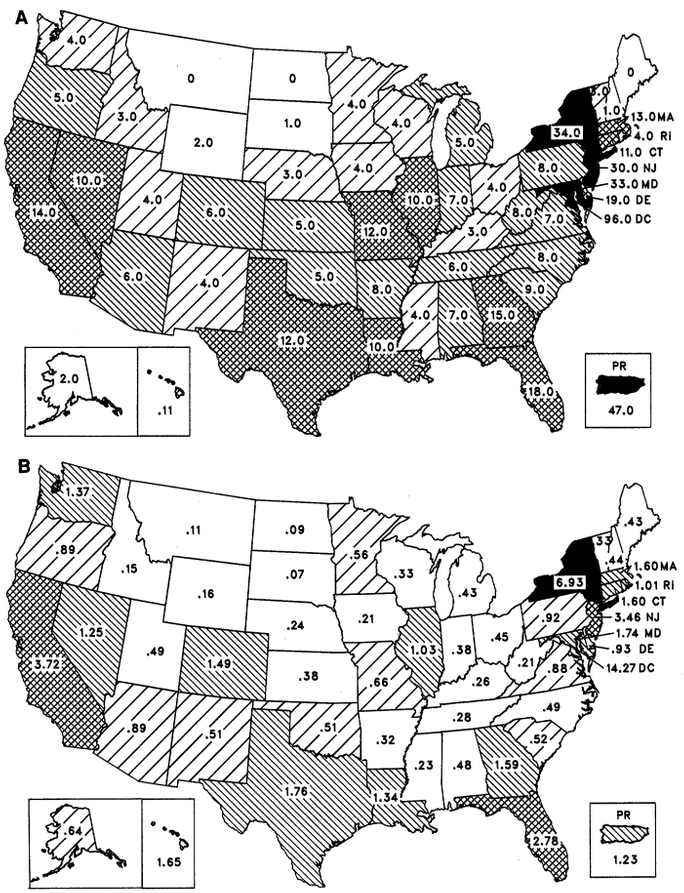

Fig. 2. (**A**) HIV seroprevalence in U.S. military recruit applicants, by state, November 1985 to September 1987 and (**B**) cumulative reported incidence of AIDS by state as of 2 November 1987. Rates shown are per 10,000 population; recruit applicant data are sex adjusted.

The prevalence of HIV infection detected in both blood donors and military applicants greatly underestimates the true national HIV prevalence rate since homosexual men, IV drug abusers, and hemophiliacs are actively deferred from donating blood and discouraged from applying for military service.

Studies of risk factors and transmission categories of seropositive blood donors and military recruits have been limited, but more than 85% of those interviewed have recognized risk factors for HIV (*8*, *15*). These preliminary data suggest that the proportion of "unexplained" heterosexual HIV transmission is not much higher than predicted from analysis of reported cases of AIDS. More extensive follow-up interview studies are planned throughout the country of both seropositive blood donors and military applicants.

The extent of heterosexually acquired infection can be monitored by measuring HIV prevalence in patients in STD clinics, where persons at highest risk for other STDs are seen. In surveys conducted in six cities, seroprevalence in heterosexual men and women without a history of IV drug abuse or known sexual contact with persons at risk ranged from 0 to 2.6%, depending on the populations studied and the method of interview (*8*, *16*). Seroprevalence in heterosexual men and women was higher in areas where HIV seroprevalence is high in IV drug abusers. Similarly, Landesman *et al.* found a HIV seroprevalence of 2% in parturient women in New York City, with the 12 infections detected divided between IV drug-associated and those presumed to be heterosexually acquired (*17*).

Incidence and Trends of HIV Infection

The national course of HIV infection might best be viewed as a composite of many varied, partially overlapping "subepidemics," each with its own rate of spread. Although current data are not yet sufficient to determine whether overall annual HIV incidence has stabilized, some data are encouraging in this regard. HIV data from prospectively followed cohorts of homosexual men consistently show lower HIV incidence rates for 1985 to 1987 than in the early 1980s. Some of the decline may be related to the early infection of highest risk persons in a closed group or to a "study effect," but the results are consistent with reports of substantial behavior changes in homosexual men as well as declines in reported syphilis and

Table 3. Rate of HIV transmission to heterosexual partners of infected index patients [from studies cited in (*22*)].

Transmission category of index patient	Number of infected partners per number tested (%)*	
	Women	Men
Hemophilia	25/288 (8.7)	
Bisexual man	17/66 (25.7)	
Transfusion recipient	12/61 (19.7)	4/27 (14.8)
Intravenous drug abuser	43/90 (47.8)	4/8 (50.0)
Heterosexual patient with AIDS born in Haiti or Zaire	14/27 (51.9)	8/8 (100.0)

*Partners denied other known risk factors for HIV infection.

gonorrhea in this group (*18*). In addition, in the first 24 months of serologic testing of military recruit applicants, the HIV infection level has remained stable for recruits as a group or when analyzed by age, sex, race, ethnicity, or geographic region (*14*). Progressively increasing rates of self-deferral by persons suspecting they may be at risk could possibly mask a true increase in prevalence, but these data do not suggest an explosive rise in infection in the population from which recruits are drawn. It will remain a difficult challenge to accurately determine HIV incidence in the United States since "new" infections seldom cause persons to seek medical care and serial sampling of truly representative populations is extremely difficult.

Modes of Transmission

HIV is transmitted primarily during sexual contact, through parenteral exposure to blood and blood products, and from mother to child during the perinatal period.

Sexual transmission. In the United States, most sexual transmission of HIV has occurred between homosexual men. The risk of infection in these men increases with the number of sexual partners and the frequency with which they are the receptive partner in anal intercourse (*19*). Other practices that lead to rectal trauma, such as receptive "fisting" and douching, appear to increase the risk of infection in receptive partners. Insertive anal intercourse is also likely to transmit HIV and one report has described infection in the receptive partner in orogenital intercourse (*20*). The relative efficiency of transmission through various practices is difficult to determine precisely because most infected homosexual men have engaged in multiple practices.

Female-to-female transmission of HIV has been reported in one case and suggested in another (*21*). In the former, a woman infected through IV drug abuse appeared to have transmitted HIV to a female partner through traumatic sex practices. As with other sexually transmitted infections, the frequency of female-to-female HIV transmission would seem to be very low.

A number of studies have documented male-to-female as well as female-to-male transmission of HIV but study populations have been too small to compare the relative efficiencies of transmission in the two directions (*22*, *23*). Most heterosexual transmission of HIV occurs during vaginal intercourse, but two studies have suggested that receptive anal intercourse increased the risk of infection in women (*23*).

In studies of patients born in the United States, the reported rate of infection in the female partners of infected male IV drug abusers (43/90) is significantly higher than that in the female partners of other index patients (54/415)($P < 0.001$)(Table 3). Although many of the couples included in studies of heterosexual HIV transmission have had unprotected sex over prolonged periods of time, no more than 50% of partners have been infected in most studies. This suggests that, in addition to behavioral factors, biologic factors may contribute to HIV transmission.

Some infected persons may be more efficient transmitters than others, and infectiousness may vary over the course of the infection. In a prospective study of the partners of infected hemophiliacs, Goedert *et al.* reported that the best predictor of HIV transmission was the absolute number of T-helper lymphocytes in the hemophiliac (*5*). Their preliminary data suggested that as these patients become more immunosuppressed, their sex partners were more likely to become infected, with duration of infection and frequency of exposure controlled for. This is consistent with the finding by Redfield *et al.* that the ability to isolate HIV significantly increases as the number of T-helper cells declines and the clinical course progresses (*24*).

Genetic or acquired factors may affect transmission or acquisition of HIV infection. Eales *et al.* found that HIV-infected homosexual men were significantly more likely to have a particular allelic form of group-specific component, a serum vitamin D–binding protein, than a control group, although many subsequent reports failed to confirm this association (*25*). Several studies of heterosexual men in Africa have shown that genital ulcer disease, particularly chancroid, is associated with an increased risk of HIV infection (*26*). Coexisting genital ulcers may partially explain the higher prevalence of HIV infection in partners of AIDS patients in developing countries. Syphilis and genital herpes simplex virus infection, other causes of genital or anal ulcers, have also been associated with HIV infection in homosexual men (*27*). The damage these ulcerative diseases cause to genital skin and mucous membranes may facilitate HIV acquisition or transmission. If coexisting sexually transmitted infections increase the transmission rate of HIV, then populations with high rates of these infections will be at higher risk for HIV infection. Conversely, prevention and early treatment of other sexually transmitted infections could slow HIV transmission.

Transmission through parenteral exposure to blood or blood products. Sharing of needles or other drug-related paraphernalia can result in HIV transmission between IV drug abusers. In several studies, nonwhite IV drug abusers had a higher prevalence of infection than white IV drug abusers with similar reported frequencies of IV drug use and needle sharing, perhaps reflecting a tendency of persons to share needles with others of their own race (*28*).

Receipt of blood from an HIV seropositive donor is very likely to result in infection. Mosley *et al.* reported that 89% of recipients of HIV seropositive transfusions were infected, while Ward *et al.* showed that once a donor transmitted HIV to a recipient, all subsequent recipients of that donor's blood became infected (*29*).

Parenteral exposure to HIV-infected blood also results in a small but definite occupational risk of HIV infection for health care workers. In a collaborative surveillance project conducted by CDC, 3 (0.9%) of 351 health care workers with documented parenteral exposure to the blood of HIV-infected persons developed HIV infection in association with a needlestick injury (*30*). Three health care workers have been reported to have been infected through non–needlestick exposures to blood of infected patients; all three had skin lesions that may have been contaminated with blood, and one also had a mucous-membrane exposure; recently, two persons working with concentrated virus in laboratories have been reported to have become infected (*31*). In a prospective study of health care workers at the National Institutes of Health, more than 2000 reported skin and mucous membrane exposures to blood or body fluids of AIDS patients have occurred without infection in the worker (*32*).

Perinatal transmission. Perinatal transmission could occur during pregnancy or during the immediate postpartum period. Detection of HIV in fetal tissues supports the hypothesis that infection can occur in utero (*33*). This was supported by the description of a dysmorphic syndrome in HIV-infected infants (*34*); however, the existence of this syndrome was not confirmed in one controlled study (*35*). HIV transmission at birth through exposure to maternal blood also seems plausible. In addition, case reports of three women who acquired HIV by a transfusion given in the immediate postpartum period and subsequently infected their infants suggest that breast-feeding can result in HIV transmission (*36*).

Studies on the rate of perinatal HIV transmission are complicated by the lack of reliable diagnostic procedures to detect HIV infection in newborns, since infants born to HIV-infected mothers have maternally derived antibodies to HIV. It is necessary to follow seropositive and seronegative infants to detect the loss of maternal antibodies and the development of serologic or virologic markers of infection.

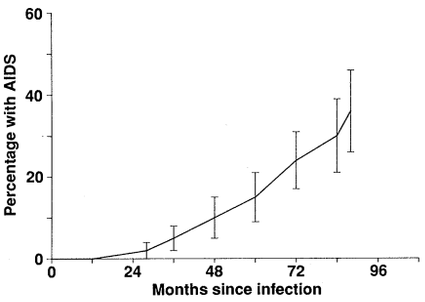

Fig. 3. Kaplan-Meier survival curve showing proportion of men developing AIDS by estimated duration of HIV infection, San Francisco City Clinic Cohort Study. (Bars represent 95% confidence intervals.) These estimates are based on an analysis of a subgroup of 155 men who were seropositive for HIV on entry to the cohort or who had known seroconversion dates within a 24-month period. Infection was assumed to have occurred on entry to the cohort for men who were initially seropositive or at the midpoint between the last negative and first positive test for those who seroconverted. Five percent (95% confidence interval, 2 to 8%) developed AIDS during the first 3 years; 10% (5 to 15%) by 4 years; 15% (9 to 21%) by 5 years; 24% (17 to 31%) by 6 years; and 36% (26 to 46%) by 7⅓ years (*50*).

In a retrospective study of infants born to mothers who had already given birth to an infant with AIDS, 13 (65%) of 20 infants had clinical signs of HIV infection within several months of birth (*47*). This reported transmission rate would be artificially high if mothers who had already transmitted HIV to one infant were more likely to infect subsequent offspring. Recent prospective studies have suggested a rate of perinatal transmission of 25 to 50% (*38*, *39*).

Preliminary results from a large study in Zaire found an association between a low T-helper to T-suppressor ratio in the mother and early laboratory and clinical markers of HIV infection in the infant, suggesting that increasing immunosuppression in the mother may facilitate perinatal transmission (*40*). In another report, the development of AIDS or AIDS-related complex (ARC) in perinatally infected children was significantly associated with the presence of symptomatic HIV infection in their mothers (*41*). Chiodo *et al.* (*39*) suggested that cesarian section would prevent perinatal transmission but this finding has not been confirmed by other studies.

Other theoretical routes of transmission. The previously described routes of transmission clearly account for most HIV infections, but there has been considerable concern that, in rare circumstances, other types of transmission might occur, particularly through contact with saliva, other "casual" contact with HIV-infected persons, or insect vectors.

HIV has been recovered from saliva, but the isolation rate is much lower than from blood (*42*). One report suggested oral-oral transmission of HIV from a man with transfusion-associated AIDS to his wife. The wife was initially reported to be seronegative and culture-positive for HIV, but she has remained seronegative and repeated efforts to culture virus from her have been unsuccessful (*43*). In a case report from West Germany, a bite was suggested as the route of HIV transmission between two young siblings, but the bite did not break the skin; other studies have failed to document transmission through bites (*44*). In a CDC study, none of 48 health care workers became infected after parenteral or mucous-membrane exposure to the saliva of HIV-infected persons.

To evaluate the risk of HIV transmission through "casual" contact, studies have been conducted of the family members of both children and adults with HIV infection (*45*). Despite extensive and prolonged household contact with an infected person, none of over 400 family members has been infected except sex partners, children born to infected mothers, or persons with independent risk factors. The potential risk of transmission in other social settings, such as schools and offices, would be even lower than in such household settings.

HIV can survive for several hours to days in insects fed blood with high concentrations of HIV or injected with HIV-contaminated blood (*46*). However, no evidence of HIV replication in insects or insect cell lines has been reported, and epidemiologic studies show no patterns of HIV infection consistent with transmission by insect vectors (*47*, *48*). Recently, the Office of Technology Assessment concluded that "there is no evidence that insect transmission causes HIV infections in temperate zones or even in tropical climates," and that "if insect transmission is occurring at all, each case would be a rare and unusual event" (*46*).

The possibility that some previously unrecognized modes of HIV transmission might exist can never be entirely excluded, but they appear to be unusual. Concern regarding such theoretical events does not justify any change in current public health policies.

Natural History of HIV Infection

The period between infection with HIV and development of AIDS is long and variable. In 1984, the mean observed incubation periods for transfusion-associated AIDS were 21 months in children and 31 months in adults (*49*). Because persons with longer incubation periods had not yet become ill, these observations underestimated the true incubation period. A mathematical model described by Medley *et al.* suggested that mean incubation periods in children under age 5 and persons aged 5 to 59 years with transfusion-associated infection will be 1.97 years and 8.23 years, respectively, while Lui *et al.* predicted the mean incubation of AIDS in homosexual men to be 7.8 years (*50*).

Since the risk for disease progression increases with the duration of infection, comparison of the natural history of HIV infection in different patient groups can be made only when the durations of infection are known. In the San Francisco City Clinic Cohort Study, 6700 homosexual and bisexual men who enrolled in studies of hepatitis B virus infections between 1978 and 1980 have been followed for AIDS since late 1983. As of 30 September 1987, 804 cases of AIDS had been reported and 75% of all cohort members had HIV infection; approximately 16% of infected men have developed AIDS. After 88 months of infection, 36% of the men had progressed to AIDS, while more than 40% had other signs or symptoms of infection; only 20% had remained completely asymptomatic (Fig. 3) (*51*).

In studies of other adult risk groups for AIDS in which duration of HIV infection is known, the cumulative incidence of AIDS is similar to that noted for homosexual men (*52*). Eyster *et al.* estimated that approximately 30% of hemophiliacs over age 21 develop AIDS within 6 years after infection. Wart *et al.* estimated a 25% risk of AIDS within the 5 years following HIV infection by transfusion. Several preliminary studies of perinatally infected infants suggest a high rate of disease progression during the first year of life (*52*).

Infections with DNA viruses or activation of T cells by mitogens can lead to enhanced expression of HIV in latently infected cells in vitro (*53*). These findings have led to speculation that infection with other microorganisms in HIV-infected patients or exposure to other foreign antigens could activate HIV in vivo and accelerate disease progression. More direct clinical and epidemiologic evidence is needed to accept or refute this hypothesis.

Conclusion

HIV infection and AIDS are now major causes of morbidity and mortality in the United States. Due to the large number of Americans already infected, morbidity and mortality will continue to increase in the next few years and remain particularly high in

young and middle-aged men and in black and Hispanic minorities where large numbers of IV drug abusers are already infected with HIV. More information is needed on the incidence and prevalence of HIV infection, particularly at the local level where prevention efforts must be targeted, implemented, and evaluated. The accumulating scientific data indicate that the major modes of HIV transmission for the present (and the future) are known. The problem of HIV transmission through blood and blood products in the United States is largely solved. Epidemiologic principles should provide the basis for directing the considerable resources needed to prevent sexual, perinatal, and IV drug abuse transmission of HIV. Progress in prevention efforts and control of HIV infection will require a long-term commitment of both science and society.

REFERENCES AND NOTES

1. Centers for Disease Control, *Morbid. Mortal. Wkly. Rep.* **30**, 250 (1981); Communication, World Health Organization Special Program on AIDS (1987).
2. R. M. Selik and M. F. Rogers, paper presented at the Third International Conference on AIDS, Washington, DC, June 1987; R. M. Selik and K. G. Castro, personal communication.
3. A. M. Hardy, J. R. Allen, W. M. Morgan, J. W. Curran, *J. Am. Med. Assoc.* **253**, 215 (1985); J. W. Curran *et al.*, *Science* **229**, 1352 (1985).
4. Centers for Disease Control, *Morbid. Mortal. Wkly. Rep.* **36**, 55 (1987).
5. W. M. Morgan and J. W. Curran, *Public Health Rep.* **101**, 459 (1986); *ibid.*, p. 342.
6. A. M. Hardy *et al.*, *ibid.* **102**, 386 (1987).
7. Centers for Disease Control, *Morbid. Mortal. Weekly Rep.* **36**, 15 (1987); *ibid.*, in press.
8. Surveillance monitoring database, AIDS Program, Centers for Disease Control, Atlanta, GA, 1987.
9. H. Cohen *et al.*, paper presented at the First International Conference on AIDS, Atlanta, GA, April 1987.
10. National Institute on Drug Abuse, unpublished data.
11. M. E. Eyster *et al.*, *J. Am. Med. Assoc.* **253**, 2219 (1985); J. Jason *et al.*, *ibid.*, p. 3409.
12. U. Tirelli *et al.*, *Lancet* **1985-II**, 1424 (1985); W. W. Darrow *et al.*, paper presented at the Third International Conference on AIDS, Washington, DC, June 1987; Centers for Disease Control, *Morbid. Mortal. Wkly. Rep.* **36**, 157 (1987).
13. R. Dodd, personal communication.
14. Centers for Disease Control, *Morbid. Mortal. Wkly. Rep.* **36**, 273 (1987); D. S. Burke *et al.*, *N. Engl. J. Med.* **317**, 131 (1987); Department of Defense, unpublished data.
15. J. Potterat *et al.*, *J. Am. Med. Assoc.* **257**, 1727 (1987); J. Ward *et al.*, *Transfusion*, in press; R. Y. Dodd, *Blood, Blood Products, and AIDS*, R. Madhok, C. D. Forbes, B. L. Evatt, Eds. (Chapman and Hall, London, 1987), chap. 8.
16. T. C. Quinn *et al.*, *N. Engl. J. Med.*, in press; A. R. Lifson *et al.*, paper presented at the Third International Conference on AIDS, Washington, DC, June 1987.
17. S. Landesman *et al.*, *J. Am. Med. Assoc.* **258**, 2701 (1987).
18. W. Winkelstein *et al.*, *Am. J. Public Health*, 77, 685 (1987); C. E. Stevens *et al.*, paper presented at the Third International Conference on AIDS, Washington, DC, June 1987.
19. J. J. Goedert *et al.*, *Lancet* **1984-II**, 711 (1984); E. Jeffries *et al.*, *Can. Med. Assoc. J.* **132**, 1373 (1985); C. E. Stevens *et al.*, *J. Am. Med. Assoc.* **255**, 2167 (1986); W. W. Darrow *et al.*, *Am. J. Public Health* 77, 479 (1987); W. Winkelstein *et al.*, *J. Am. Med. Assoc.* **257**, 321 (1987); L. A. Kingsley *et al.*, *Lancet* **1987-I**, 345 (1987); A. R. Moss *et al.*, *Am. J. Epidemiol.* **125**, 1035 (1987); G. J. D. van Griensven *et al.*, *ibid.*, p. 1048.
20. K. H. Mayer and V. DeGruttola, *Ann. Intern. Med.* **107**, 428 (1987).
21. M. Marmor *et al.*, *ibid.* **105**, 969 (1986); O. T. Monzon and J. M. B. Capellan, *Lancet* **1987-II**, 40 (1987).
22. J. K. Kreiss, L. W. Kitchen, H. E. Prince, C. K. Kasper, M. Essex, *Ann. Intern. Med.* **102**, 623 (1985); P. Jones *et al.*, *Br. Med. J.* **291** 695 (1985); D. N. Lawrence *et al.*, *Blood* **66**, 703 (1985); R. R. Redfield *et al.*, *J. Am. Med. Assoc.* **253**, 1571 (1985); J. P. Allain, *N. Engl. J. Med.* **315**, 517 (1986); J. M. Jason *et al.*, *J. Am. Med. Assoc.* **255** 212 (1986); B. A. McVerry *et al.*, *Br. J. Haematol.* **63**, 347 (1986); M. A. Fischl *et al.*, *J. Am. Med. Assoc.* **257**, 640 (1987); N. Padian *et al.*, *ibid.* **258**, 788 (1987); T. A. Peterman, R. L. Stoneburner, J. R. Allen, H. W. Jaffe, J. W. Curran, *ibid.* **259**, 55 (1988); J. J. Goedert, M. E. Eyster, R. J. Biggar, paper presented at the Third International Conference on AIDS, Washington, DC, June 1987; J. M. Mann, *et al.*, *J. Am. Med. Assoc.* **256**, 721 (1986).
23. N. Padian *et al.* paper presented at the Third International Conference on AIDS, Washington, DC, June 1987; N. H. Steigbigel *et al.*, *ibid.*
24. R. R. Redfield, D. C. Wright, N. C. Khan, D. S. Burke, *ibid.*
25. L. J. Eales *et al.*, *Lancet* **1987-I**, 1377 (1987); M. Thymann *et al.*, *ibid.*, p. 1378; D. F. Nixon, R. P. Eglin, S. A. Westwood, D. J. Werrett, C. R. Rizza, *ibid.* **1987-II**, 39 (1987); J. Constans, W. Smilovici, J. Ducos, J. Robert, B. Boneu, *ibid.*, p. 40; G. G. deLange, P. H. van Eede, J. H. ten Veen, H. W. Reesink, *ibid.*, p. 282; J. J. Lefrere *et al.*, *ibid.*, p. 283; K. Gilles, L. Louie, B. Newman, J. Crandall, M.-C. King, *N. Engl. J. Med.* **317**, 630 (1978); S. P. Daiger, G. W. Brewton, A. A. Rios, P. W. Mansell, J. Reuben, *ibid.*, p. 631.
26. D. W. Cameron *et al.*, paper presented at the Third International Conference on AIDS, Washington, DC, June 1987; R. M. Greenblatt *et al.*, *ibid.*
27. H. H. Handsfield *et al.*, *ibid.*; S. D. Holmberg *et al.*, *J. Am. Med. Assoc.*, in press.
28. R. E. Chaisson, A. R. Moss, R. Onishi, D. Osmond, J. R. Carlson, *Am. J. Public Health* 77, 169 (1987); M. Robert-Guroff *et al.*, *J. Am. Med. Assoc.* **255**, 3133 (1986); E. E. Schoenbaum *et al.*, paper presented at the Third International Conference on AIDS, Washington, DC, June 1987; R. D'Aquila *et al.*, *ibid.*
29. J. W. Mosley, The Transfusion Safety Study Group, in *Abstracts of the III International Conference on AIDS* (Washington, DC, 1987), p. 160; J. W. Ward *et al.*, *Ann. Intern. Med.* **106**, 61 (1987).
30. Centers for Disease Control, *Morbid. Mortal. Wkly. Rep.* **36** (suppl.), 1S (1987).
31. Centers for Disease Control, *ibid.*, p. 285; S. H. Weiss *et al.*, *Sc* **239**, 68 (1988).
32. D. Henderson, personal communication.
33. N. Lapointe, J. Michaud, D. Pekovic, J. P. Chausseau, J.-M. Dupuy, *N. Engl. J. Med.* **312**, 1325 (1985); E. Jovaisas, M. A. Koch, A. Schafer, M. S[illegible]er, D. Lowenthal, *Lancet* **1985-II**, 1129 (1985); S. Sprecher, G[illegible]oum[illegible]off, F. Puissant, M. Degueldre, *ibid.* **1986-II**, 288 (1986).
34. R. W. Marion, A. A. Wiznia, R. G. Hutcheon, A. Rubenstein, *Am. J. Dis. Child.* **140**, 638 (1986).
35. T. M. Sheikh, Q. H. Qazi, S. Fikrig, H. Menikoff, *Pediatr. Res.* **21**, 230A (1987).
36. J. B. Ziegler, D. A. Cooper, R. O. Johnson, J. Gold, *Lancet* **1985-I**, 896 (1985); P. Lepage *et al.*, *ibid.* **1987-II**, 400 (1987).
37. W. P. Parks and G. B. Scott, in *AIDS: Modern Concepts and Therapeutic Challenges*, S. Broder, Ed. (Dekker, New York, 1987), p. 253.
38. A. E. Semprini, A. Vucetich, G. Pardi, M. M. Cossu, *Br. Med. J.* **294**, 610 (1987); P. A. Selwyn *et al.*, paper presented at the Third International Conference on AIDS, Washington, DC, June 1987; S. Blanche *et al.*, *ibid.*
39. F. Chiodo *et al.*, *Lancet* **1986-I**, 739 (1986).
40. N. Nzilambi *et al.*, paper presented at the Third International Conference on AIDS, Washington, DC, June 1987.
41. J. Q. Mok *et al.*, *Lancet* **1987-I**, 1164 (1987).
42. D. D. Ho *et al.*, *N. Engl. J. Med.* **313**, 1606 (1985); J. A. Levy *et al.*, *Ann. Intern. Med.* **103**, 694 (1985).
43. S. Z. Salahuddin *et al.*, *Lancet* **1984-II**, 1418 (1984); J. E. Groopman, personal communication.
44. V. Wahn *et al.*, *Lancet* **1986-II**, 694 (1986); J. Drummond, *J. Am. Med. Assoc.* **256**, 2342 (1986); M. F. Rogers *et al.*, paper presented at the Second International Conference on AIDS, Paris, June 1986; C. Tsoukas *et al.*, *ibid.*
45. J. E. Kaplan *et al.*, *Pediatr. Infect. Dis.* **4**, 468 (1985); R. R. Redfield *et al.*, *J. Am. Med. Assoc.* **253**, 1571 (1985); D. N. Lawrence *et al.*, *Blood* **66**, 703 (1985); G. H. Friedland *et al.*, *N. Engl. J. Med.* **314**, 344 (1986); A. Berthier *et al.*, *Lancet* **1986-II**, 598 (1986); J. Jason *et al.*, *J. Am. Med. Assoc.* **255**, 212 (1986); M. A. Fischl *et al.*, *ibid.* **257**, 640 (1987).
46. S. F. Lyons, P. J. Jupp, B. D. Schoub, *Lancet* **1986-II**, 45 (1986); Office of Technology Assessment, U.S. Congress, *Do Insects Transmit AIDS?* (Government Printing Office, Washington, DC, 1987). p. iii.
47. P. A. Selwyn *et al.*, in (*38*).
48. Centers for Disease Control, *Morbid. Mortal. Wkly. Rep.* **35**, 609 (1986); A. Srinivasan, D. York, C. Bohan, *Lancet* **1987-II**, 1094 (1987), K. Castro *et al.*, *Science*, in press.
49. T. A. Peterman *et al.*, *J. Am. Med. Assoc.* **254**, 2913 (1985).
50. G. F. Medley, R. M. Anderson, D. R. Cox, L. Billard, *Nature (London)* **328**, 719 (1987); K.-J. Lui, W. W. Darrow, G. W. Rutherford, in preparation.
51. H. W. Jaffe *et al.*, *Ann. Intern. Med.* **103**, 210 (1985); N. A. Hessol *et al.*; abstract from the Third International Conference on AIDS, Washington, DC, June 1987.
52. M. E. Eyster, M. H. Gail, J. O. Ballard, H. Al-Mondhiry, J. J. Goedert, *Ann. Intern. Med.* **107**, 1 (1987); J. E. Ward *et al.*, paper presented at the Third International Conference on AIDS, Washington, DC, June 1987.
53. H. E. Gendelman *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **83**, 9759 (1986); J. D. Mosca *et al.*, *Nature (London)* **325**, 67 (1987); G. Nabel and D. Baltimore, *ibid.* **326**, 711 (1987).