The Impact of HIV/AIDS on World Population

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The Impact of HIV/AIDS on World Population

by
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**Population Projections Incorporating AIDS**

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Highlights

- The World Health Organization estimates that as of mid-1993, 14 million people worldwide were infected with the Human Immunodeficiency Virus (HIV), of which 8 million were in Sub-Saharan Africa. In some urban centers in Africa, more than 25 percent of pregnant women are infected with HIV.

- In the United States and Europe the majority of HIV infectious are because of homosexual contact or through the sharing of needles among intravenous drug users.

- Unlike Europe and the United States, the majority of HIV infections in Sub-Saharan Africa occur through heterosexual contact.

- In Latin America and the Caribbean, the HIV epidemic affected homosexual men early on but heterosexual contact has become a major if not the primary mode of HIV transmission.

- The HIV/AIDS epidemic arrived later in Asia, however, alarming trends are developing in South and South East Asia. In recent years, the increase in infection among commercial sex workers in two countries, India and Thailand, has been striking and raises the specter of future levels of infection in countries of the region approaching those in some Sub-Saharan African countries.

- Since most adult AIDS mortality occurs after the average age of childbearing (about 30 years), overall fertility measures such as the crude birth rate are not much affected by an AIDS epidemic. However, because adult AIDS deaths occur largely among relatively young adults (ages 30 to 45 years), the impact of AIDS on life expectancy is considerable.

- The AIDS epidemic will result in increases in infant and child mortality rates, reversing hard-won improvements in child survival that had been achieved in many countries over the last several decades.

- Despite more than doubling the number of deaths in those countries most affected, AIDS is not likely to result in negative population growth, at least in Africa. In countries with low fertility rates, a substantial AIDS epidemic has the potential to cause population declines in the coming decades.
Introduction

The Acquired Immune Deficiency Syndrome (AIDS) epidemic has begun to substantially revise our thinking about patterns and trends of mortality in countries around the world. The age pattern of mortality determines the impact of AIDS on demographic measures such as the age-sex distribution of the population, fertility, and derived mortality measures such as the expectation of life at birth. Where HIV is spread heterosexually, AIDS can significantly increase the mortality of infants and children.

Despite these impacts, AIDS will not succeed in overcoming the momentum of population growth in most affected countries, particularly in Sub-Saharan Africa. The region's current high population growth rate insures that, despite considerable expansion in HIV infection, the population will continue to increase.

This report presents the method and results of incorporating AIDS mortality into the U.S. Census Bureau's population estimates and projections for selected countries of the world. It includes information on the impact of AIDS on fertility, mortality, and population. This report was also presented as a chapter in the World Population Profile: 1994.

The HIV/AIDS epidemic as of mid-1992 is described in this report by region of the world. Transmission patterns, populations at risk and geographic variations are presented. The impact on infant, child and adult mortality; fertility; life expectancy; and population growth is demonstrated. The available information and the methodology and assumptions used for incorporating AIDS mortality into the population estimates and projections are described in appendix A. Additional sources of information are cited in appendix B, and technical terms and acronyms are defined in appendix C.
HIV/AIDS Is Pandemic

In 1981, a new syndrome, the acquired immune deficiency syndrome (AIDS), was first recognized among homosexual men in the United States. By 1983, the etiological agent, the human immunodeficiency virus (HIV), had been identified. By the mid 1980's, it became clear that the virus had spread, largely unnoticed, throughout much of the world.

The HIV/AIDS pandemic consists of many separate epidemics. Each epidemic has its own distinct origin, in terms of geography and specific populations affected, and involves different types and frequencies of risk behaviors and practices, for example, unprotected sex with multiple partners or sharing drug injection equipment.

Two serotypes of HIV are currently recognized, HIV-1 and HIV-2. HIV-1 is found worldwide, while HIV-2 is found predominantly in West Africa. The routes of transmission (DeCock and Brun-Veginet, 1989) and risk factors for HIV-1 and HIV-2 are similar and both result in AIDS. However, the latency period for HIV-2 appears to be longer, and vertical transmission (from mother to child) of HIV-2 is rare (Andreasson et al., 1993). In contrast, for HIV-1, the European Collaborative Study (1991) has reported a vertical transmission rate of 13 percent, and studies in many African countries have reported rates of 30 to 40 percent (Newell et al., 1990). HIV-1 appears to be more easily transmitted through other routes as well. Even though HIV-2 appears to have been in West Africa longer than HIV-1, levels of HIV-1 infection have surpassed those of HIV-2 in many West African countries.

Fourteen Million People Are Infected by HIV

By the end of 1992, over 611,000 cases of AIDS had been reported to the World Health Organization Global Programme on AIDS (WHO/GPA) (figure 2). Reported AIDS cases are a crude indication of HIV infections and AIDS cases. The actual number of AIDS cases is estimated to be much higher, around 2.5 million. The discrepancy between the reported and the estimated actual number of cases is due to (1) under diagnosis, (2) underreporting to public health authorities, (3) delays in reporting, and (4) the use of different surveillance case definitions of AIDS in different countries around the world (WHO/GPA, 1993a).

AIDS cases represent HIV infections that occurred several years ago and do not give an accurate picture of the current HIV epidemic. The HIV incubation period, that is, the interval between initial HIV infection and the development of AIDS, is estimated to be about 7 to 10 years. WHO/GPA estimated in mid 1993 that 13 million adults and 1 million children had been infected by HIV (figure 2). By the year 2000, WHO projects that between 30 and 40 million people will have been infected by the virus (WHO/GPA, 1993b).

Worldwide, Many AIDS Cases Go Unreported

Among all AIDS cases reported to WHO/GPA, over half are reported by Europe (13 percent) and the United States (40 percent). However, other regions are less accurate in their reporting; in late 1992, WHO estimated that U.S. cases actually represented only 18 percent of the world total. At that same time, WHO estimated that over 1 million people were infected with the HIV virus in North America and 500,000 in Western Europe.

At the end of 1992, over 87,000 AIDS cases had been reported in the countries of the WHO European region. During 1992, over 21,000 cases were reported, representing an increase of 16 percent over 1991. The majority of European AIDS cases are reported from five Western European countries (France, Spain, Italy, Germany and the United Kingdom).
WHO reported global total AIDS cases: 611,589

WHO estimated global total HIV seroprevalence: 13 million +

Homosexual Contact and IV Drug Use Account for Most Adult AIDS Cases in Europe and North America

In 1985, the majority (63 percent) of European adult AIDS cases were attributed to homosexual contact. In contrast, by 1992, only 42 percent of the reported adult AIDS cases were due to infections through either homosexual or bisexual contact (figure 3). The proportion of European AIDS cases infected through IV drug use increased from 5 percent in 1985 to 36 percent by late 1992. In Spain and Italy, the major form of HIV transmission for the reported AIDS cases has been IV drug use (64 percent and 65 percent, respectively). In France, Germany, and the United Kingdom, it is homosexual/bisexual contact (50 percent, 69 percent and 76 percent, respectively).

By the end of 1992, the United States had reported a total of nearly 245,000 AIDS cases. Among adults, 57 percent were infected through homosexual or bisexual contact (figure 3), a decrease from 66 percent in 1985.

Figure 3.
Adult AIDS Cases for Europe and the United States, by Mode of Transmission: 1992

Sub-Saharan Africa: Over 8 Million People Infected by HIV

Although nearly 211,000 AIDS cases had been reported to WHO from Sub-Saharan Africa by the end of 1992, WHO estimated that a cumulative total of 1.75 million people in the region had developed AIDS. In mid-1993, WHO estimated that over 8 million people in Sub-Saharan Africa were HIV infected, representing more than half of all HIV infections in the world. WHO expects the number of AIDS cases to exceed 5 million by the end of the century.

Unlike in Europe and the United States, most (94 percent) HIV infections in Sub-Saharan Africa occur through heterosexual contact (figure 4). HIV transmission through homosexual or bisexual contact or through IV drug use is minimal.

Given the predominance of heterosexual transmission in the HIV epidemic of Sub-Saharan Africa, it should be no surprise that commercial sex workers and their clients play a central role. Because of their number of sexual partners, commercial sex workers are the group most at risk for HIV infection in many countries. In many cities of the region, this risk has resulted in infection levels approaching 50 percent. In some, infection has become nearly universal, especially among commercial sex workers in the low socio-economic stratum who tend to have more clients (figure 5).

Since 1985, HIV seroprevalence studies have been conducted in many Sub-Saharan African countries, including studies of pregnant women. Seroprevalence data from those studies provide an initially confusing picture of regional trends. A variety of studies over the past 6 or more years in Uganda, Zambia, and Malawi show a consistent and rapid increase in HIV infection levels among pregnant women in the capital cities (figure 6). By 1990, over 20 percent of pregnant women tested for HIV in those areas were infected, more than double the 1986 infection levels in Lusaka, Zambia, and Lilongwe, Malawi. Kigali, Rwanda (not shown in figure 6) is another major urban area with a high rate of infection (30 percent in 1989).

In contrast, a moderate increase in HIV seroprevalence has been documented among pregnant women in Bangui, Central African Republic, and infection levels in Kinshasa, Zaire, remained relatively stable at around 5 or 6 percent up to 1990. Infection

Figure 5.
HIV Seroprevalence Among Commercial Sex Workers for Selected Urban Areas in Africa: 1983 to 1992

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
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<tbody>
<tr>
<td>Kenya</td>
<td>1992</td>
</tr>
<tr>
<td>Rwanda</td>
<td>1983-84</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>1990</td>
</tr>
<tr>
<td>Malawi</td>
<td>1986</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>1990</td>
</tr>
<tr>
<td>Mali</td>
<td>1991</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1988</td>
</tr>
<tr>
<td>Zaire</td>
<td>1989</td>
</tr>
<tr>
<td>Guinea-Bissau</td>
<td>1987</td>
</tr>
<tr>
<td>Congo</td>
<td>1987</td>
</tr>
<tr>
<td>The Gambia</td>
<td>1999</td>
</tr>
<tr>
<td>Benin</td>
<td>1990</td>
</tr>
<tr>
<td>Burkina</td>
<td>1989</td>
</tr>
<tr>
<td>Ghana</td>
<td>1987</td>
</tr>
<tr>
<td>Central African Republic</td>
<td>1989</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1990</td>
</tr>
<tr>
<td>Djibouti</td>
<td>1991</td>
</tr>
<tr>
<td>Niger</td>
<td>1989</td>
</tr>
<tr>
<td>Cameroon</td>
<td>1989-90</td>
</tr>
<tr>
<td>Sudan</td>
<td>1989</td>
</tr>
<tr>
<td>Senegal</td>
<td>1990-91</td>
</tr>
<tr>
<td>Somalia</td>
<td>1990</td>
</tr>
</tbody>
</table>

Note: Data include infection from HIV-1 and/or HIV-2.
levels among pregnant women in Abidjan, Côte d'Ivoire, increased rapidly to around 10 percent by 1987, then the levels appeared to have reached a plateau for a few years before increasing again after 1990. In Nairobi, Kenya, moderate increases were noted among pregnant women until 1990 when HIV prevalence began to increase rapidly.

**Geographical Variation in HIV-1 and HIV-2 Infection Is Considerable**

Recent data on HIV-1 infection of low risk urban populations are available by country for Africa based largely on rates for low-risk groups such as pregnant women and blood donors (figure 7). High levels of infection are evidenced in many countries in Central and Eastern Africa along with Côte d'Ivoire in West Africa. Relatively lower levels of infection of HIV-1 occur in Southern, West, and North Africa.

Factors that can be shown or hypothesized to contribute to the observed variation include the timing of HIV entry into the population, sexual practices before and outside of marriage, prevalence of sexually transmitted diseases in the population, and male circumcision. The geographic pattern of infection is likely to change over time.

The geographic pattern of HIV-2 infection shows higher prevalence in West Africa (figure 8) along with other African countries with a Portuguese colonial history. Troop movements among these former Portuguese colonies and travel facilitated by cultural ties may have contributed to the spread of HIV-2 infection in these select countries. Several countries bordering those with substantial HIV-2 infection as yet show little evidence of an HIV-2 epidemic.
Figure 7.
HIV-1 Seroprevalence Among Low-Risk Urban Populations in Africa: Circa 1992

Figure 8.
HIV-2 Seroprevalence Among Low-Risk Urban Populations in Africa: Circa 1992

Latin America and the Caribbean: Epidemic Affected Homosexual Men Early, But Heterosexual Contact Has Become Major if not Primary Mode of HIV Transmission

Among all the AIDS reported cases in the Americas, the United States has nearly 80 percent. Brazil is second, with over 36,000 reported cases, or 10 percent of the total; followed by Mexico, with over 12,000, or 3.5 percent of the total. However, some of the highest rates in 1992 were recorded in the Caribbean: 105.7 per 100,000 population in The Bahamas, 29.8 per 100,000 in Bermuda, and 29.4 per 100,000 in Barbados. In contrast, the United States reported a 1992 rate of just under 20, and Brazil and Mexico reported rates of 4.8 and 3.4 per 100,000 population, respectively, in 1992. For mid 1993, WHO estimated that 1.5 million people in Latin America were HIV infected.

Transmission patterns in Latin America have changed over time. Initially, the majority of AIDS cases were due to homo/bisexual transmission. Recently, the largest increases have occurred among intravenous drug users (figure 4). The proportion of cases attributable to heterosexual transmission has also increased. Changes in transmission patterns have led to a higher number of cases among women and among children who acquired AIDS through perinatal transmission (PAHO, 1991).

In Mexico, Argentina, Brazil, and Honduras, the levels of HIV infection among homosexual men in urban areas range from about 20 to 35 percent. In some other countries in Latin America (Colombia, Costa Rica, and Peru), the levels of HIV infection among urban homosexual men hover around 5 percent. Available data from Latin America and the Caribbean show high HIV infection levels among commercial sex workers in several regional settings. They surpass 40 percent among sampled populations in Haiti and Martinique; in studies in Honduras, they reach 20 percent in the two major urban settings. In South America, infection levels recorded over the past several years are generally lower.

Among intravenous drug users, HIV infection rates have generally reached or exceeded 30 percent. For example, in Brazil, HIV infection rates of 40 percent among injecting drug users have been reported in Rio de Janeiro, along with 54 percent in São Paulo and 57 percent in Santos.

Striking Increases in HIV Infections Have Occurred in Thailand and India in Recent Years

The HIV/AIDS epidemic arrived later in Asia. A total of 2,000 AIDS cases had been reported to WHO by the end of 1992. However, there are some alarming trends in HIV infection in South and Southeast Asia. WHO estimates that 1.5 million HIV infections have occurred among adults in this region. The majority of AIDS cases have been reported from India and Thailand, but high rates of infection have been noted also in specific populations in other countries.

Despite high rates of sexual contact, HIV infection had been generally slow to spread to sex workers in Asia. For example, the latest data from South Korea, the Philippines, and Taiwan show levels of infection among commercial sex workers of below 1 percent. In recent years, however, the increase in infection in this population group in two countries, India and Thailand, has been striking and raises the specter of future levels of infection in countries of the region approaching those in some African countries.

In Bombay, infection quadrupled over a 4-year period, reaching 40 percent

Figure 9.
HIV Seroprevalence Among Commercial Sex Workers in Bombay, India: 1986 to 1992

![HIV Seroprevalence Among Commercial Sex Workers in Bombay, India: 1986 to 1992](chart)

* Represents zero.

Note: Data pertain to varying months of the years indicated.

of a sample of commercial sex workers in 1992 (figure 9). In Thailand, data from the national sentinel surveillance system document the rapid increase in infection among commercial sex workers working in brothels throughout the country (figure 10).

Among IV drug users, high rates of infection have been reported in Burma (62 to 76 percent) and Malaysia (10 percent).

AIDS Increases Mortality Rates Many Times Over Among Persons Age 30 to 45 Years

Studies based both on models and on empirical information have identified the most important aspects of the impact of HIV infection and an AIDS epidemic on a population. New HIV infections among adults are concentrated in the ages of peak sexual activity—from the late teens to about age 30 or 35. Because of the 7 to 10 year average incubation period between infection and the onset of AIDS, and about a 1-year survival period after acquiring AIDS, deaths from AIDS are shifted into older ages and tend to occur most often in the 30 to 45 year age range. These ages are characterized by non-AIDS mortality rates for most causes of death that are among the lowest of all age groups. Thus, AIDS can increase the mortality rates in these age groups many times over (figure 11).

Where HIV is spread heterosexually, AIDS can significantly increase the mortality of infants and children. Since about one in three children born to HIV-infected mothers in developing countries are themselves HIV positive, infant and child mortality can be increased by several times in situations where adult female infection levels are moderately high.
Overall Fertility Measures Not Much Affected by AIDS Epidemic; Impact of AIDS on Life Expectancy Is Considerable

The age pattern of mortality determines the impact of AIDS on other demographic measures, such as the age-sex distribution of the population, fertility, and derived mortality measures such as the expectation of life at birth (Way and Stanecki, 1991). Since most adult AIDS mortality occurs after the average age of childbearing, overall fertility measures such as the crude birth rate are not significantly affected by an AIDS epidemic. Similarly, since AIDS mortality occurs among both children and adults, the dependency ratio is relatively stable despite the epidemic. But because adult AIDS deaths occur among relatively young adults, the impact of AIDS on life expectancy is considerable.

AIDS mortality (figure 12, represented by the difference between the two curves) is evident both among infants and children and among adults. For example, under an illustrative AIDS scenario, the number of survivors at age 45 is less than one-half that expected without AIDS.

Recent Studies Begin to Show Increases in Infant/Child Mortality and Crude Death Rates

So far, efforts to measure the impact of AIDS on mortality in developing countries have been minimal. However, the impact of AIDS is likely to become evident in the results of population censuses and surveys that will be conducted in many countries in the latter part of this decade. Some impact is already evident. The level of infant and child mortality in Zambia,
as measured in a recent survey, is 15 percent higher than that measured 10 years ago (Gaisie et al., 1993). Orphanhood status recorded in the 1991 census of Uganda implies that recent adult male mortality after the period of civil unrest is higher than that reported in the census of 1969 (Uganda Statistics Department, n.d.). And a longitudinal survey being conducted in the Masaka district of Uganda reports a doubling of the crude death rate as a result of moderate levels of HIV infection (8 percent of adults HIV positive) (Mulder et al., 1993).

In addition to these direct effects, AIDS may also have an indirect impact on affected populations. For example, the survival of non-HIV-infected children may be endangered by the death of one or both parents. Similarly, the well-being of other non-infected household members may be threatened by the death of a principal breadwinner. Some studies are underway to examine the extent of such impacts. For example, a study in the Kagera region of Tanzania, near the Uganda border, is attempting to assess the direct and indirect social and economic impact of AIDS in the households of the region (Over et al., 1993, and Ainsworth and Koda, 1993).

### AIDS Mortality Adjustment Made to Statistics of Selected Countries

HIV/AIDS epidemics vary widely from country to country, and most current mortality estimates, especially for developing countries, do not reflect the impact of AIDS-related mortality. To remedy this statistical deficiency, the most recent population projections of the U.S. Bureau of the Census incorporate an independent estimate of the mortality impact of current and future AIDS epidemics in selected developing countries. The countries for which this was done are shown below.

**Countries Selected for AIDS-Modified Mortality**

**Africa**
- Burkina
- Central African Republic
- Côte d'Ivoire
- Congo
- Malawi
- Rwanda
- Tanzania
- Uganda
- Zaire
- Zambia

**Other regions**
- Brazil
- Haiti
- Thailand

For each country, the projected non-AIDS mortality was increased to include the AIDS-related mortality, resulting in revised age-sex-specific mortality rates for use in the cohort-component projections. The projections assume that the epidemic will peak in 2010, with no further HIV infection after that year. They assume that AIDS mortality will decline from the level reached in 2010 to nil by 2020. (Further details about the projection methodology are presented in appendix A.)

### In Highly Infected Countries, AIDS Is Projected to More Than Double the Number of Deaths

The most direct impact of AIDS is to increase the number of deaths in the populations affected (figure 13). Non-AIDS deaths, in the 13 Sub-Saharan African countries with AIDS-modified mortality, are projected to increase slightly during the 1985 to 2010 period as a result of both increasing population size and decreasing rates of non-AIDS mortality. AIDS deaths increase over the 25-year period to a level more than equal to the non-AIDS deaths. Thus, in these countries, the number of deaths is projected to more than double because of AIDS.
Rate of Natural Increase Remains Positive in Sub-Saharan Africa

AIDS epidemics have relatively little direct impact on childbearing. Because of the long incubation period of HIV, infected women will have completed much of their expected childbearing before developing AIDS. During the period 1985 to 2010, the projections indicate that the crude birth rate will decrease as a result of projected decreases in fertility levels in the aggregated populations of the 13 Sub-Saharan African countries (figure 14).

The increased number of deaths is reflected in the higher crude death rate of the projection “with AIDS” than the one “without AIDS.” Overall, AIDS is projected to result in a 150 percent increase in the crude death rate for 2010 of this 13-country aggregate. But because of the high projected levels of fertility, the aggregate rate of natural increase (the difference between crude birth and death rates) remains strongly positive, never dropping below about 2 percent. In fact, analysis has shown that national adult HIV seroprevalence of about 50 percent or higher would be required in the Sub-Saharan Africa setting to cause population growth rates to turn negative (Way, 1992).

In 2010, the peak year in the projected AIDS epidemic, the impact of AIDS on projected crude death rates reflects the underlying differences in projected proportions infected (figure 15). The impact of AIDS as measured by the relative increase in the crude death rate ranges from a low of under 50 percent for Zaire and Brazil to more than 300 percent for Zambia and Zimbabwe.

![Figure 15. Crude Death Rate With and Without AIDS, for Selected Countries: 2010](chart.png)

Source: Center for International Research, U.S. Bureau of the Census.
Consistent with the predominantly heterosexual transmission of HIV in the countries studied, many women are infected. Mother-to-child transmission is significant, as reflected in the infant mortality rate (figure 16). The projected AIDS epidemic results in a near-doubling of infant mortality in Zambia and Zimbabwe. Because of the low levels of infant mortality projected for Thailand without AIDS, the rate projected with AIDS is more than double. In countries with more moderate epidemics, the impact is less severe, though still significant. In Kenya and Uganda, for example, AIDS results in about a 50 percent increase in infant deaths. Because of the relatively slow progress of the epidemic as projected for Haiti and Zaire, infant mortality rates increase by only about 10 percent over the non-AIDS scenarios in these two countries.

Source: Center for International Research, U.S. Bureau of the Census.
The impact of AIDS on child mortality (figure 17) will be even greater than on infant mortality because many infected children survive more than 1 year. For example, in Zambia and Zimbabwe, AIDS will increase child mortality rates (ages 0 to 4 years) nearly threefold. In Thailand, the child mortality rate including AIDS will increase nearly fivefold, and in Kenya and Uganda it will double. Overall, the impact of these increases will reverse some of the hard-won improvements in child survival that had been achieved in many countries over the last several decades.

Figure 17.
Child Mortality Rate With and Without AIDS, for Selected Countries: 2010

Deaths ages 0-4 per 1,000 live births

Source: Center for International Research, U.S. Bureau of the Census.
Because AIDS deaths are concentrated in the childhood and middle adult ages, several countries show a relatively larger impact on life expectancy in 2010 than indicated by other measures (figure 18). These are generally countries where the non-AIDS life expectancy is higher. Under such circumstances, each AIDS death represents a relatively greater loss of potential years of life than is the case where the underlying non-AIDS life expectancy is shorter. Thus, the impact of AIDS on life expectancy, measured as years of potential life lost, is greater in Zimbabwe than in Malawi, despite the fact that the projected AIDS epidemic in Malawi is more severe than in Zimbabwe. At this peak point in the projected AIDS epidemics, AIDS has reduced the projected life expectancy at birth by 9 years (Zaire) to more than 25 years in a number of countries.
Negative Population Growth Rate Projected for Thailand

According to the projections, by 2010, AIDS will have reduced the population growth rate of a majority of affected countries to a level less than one-half that expected without AIDS (figure 19). Four Sub-Saharan African countries (Central African Republic, Congo, Kenya, and Zimbabwe) show growth rates of 1 percent or less in 2010, compared with an expected growth rate without AIDS of over 2 percent per year.

Thailand provides the only example of negative population growth in these AIDS-adjusted projections. Overall, AIDS is projected to reduce Thailand's growth rate in 2010 from +0.9 percent (without AIDS) to -0.8 percent (with AIDS).

Note: For 2010, the portion of the bar "without AIDS" represents additional growth that would take place without AIDS.

Source: Center for International Research, U.S. Bureau of the Census.
Figure 20.
Population Size With and Without AIDS, for Selected Countries: 2020

121 Million Fewer People Expected in the 16 Countries With AIDS-Adjusted Mortality

This analysis assumes that by 2020 mortality rates will have returned to the level projected under a non-AIDS scenario. Differences in population growth that remain after that time are due to differences in population structure rather than differences in underlying fertility or mortality rates.

Differences in population size in 2020 between the AIDS-adjusted and the non-AIDS scenarios are often substantial, amounting to millions of persons (figure 20). Some, but not all, of these differences are due to AIDS mortality. The balance of the differences in population size is because of decreased population resulting from premature female deaths and the lost future population growth resulting from that deficit. In the combined population of the 16 countries with AIDS-adjusted mortality, the deficit in the year 2020 is 120.8 million persons.
AIDS Mortality Is Less Concentrated in Particular Ages Than Are Military Deaths During a War

How different will future age and sex structures of populations be because of AIDS? AIDS has relatively little direct effect on fertility rates, because of the delay between HIV infection and AIDS mortality. Similarly, an AIDS epidemic has only a slight effect on the population dependency ratio because AIDS mortality occurs both in the numerator and the denominator of that measure. Thus, although AIDS mortality occurs primarily in the childhood and middle adult years, it is perhaps less concentrated in particular ages than, for example, the effects of military deaths during a war.

Population age and sex structures for the year 2010 vary in the projections under AIDS-adjusted and non-AIDS scenarios. The age distribution for Zambia shows the effect of a severe epidemic over an extended period of time (figure 21). For Kenya, it portrays a strong epidemic of more recent origins, and for Zaire it shows a more moderate epidemic. The absolute size of each age cohort is shown in the population pyramids reflecting differences in both the number of AIDS deaths and the reduced population growth.

The greatest relative differences in future population size by cohort are evident in the youngest age groups and in those 30 to 50 years of age. AIDS has a relatively minor impact on the population age structure of Zaire in this scenario; progressively stronger effects are apparent in the distributions for Kenya and Zambia. In the latter case, the cumulative effect of AIDS mortality over the years is found in the cohorts ages 35 to 50 years in 2010. In each age group within the 35 to 50 years range, nearly one-half or more of the potential population is missing, because of the impact of AIDS mortality.
Figure 21. Population of Zambia, Kenya, and Zaire, With and Without AIDS: 2010

Note: The portion of the bar "without AIDS" represents additional population that would be present at each age without AIDS.
Source: Center for International Research, U.S. Bureau of the Census.
Summary and Conclusions

AIDS has already begun to substantially revise our thinking about patterns and trends of mortality in countries around the world. In a number of cities and in five States of the United States, AIDS is already the leading cause of death among young adult males (Selik et al., 1993). In Abidjan, the capital of Côte d'Ivoire, HIV-related illness in 1988-89 was already the leading overall cause of death for males and the second leading cause for females, accounting for 15 percent of male deaths and 13 percent of female deaths (DeCock et al., 1990). The present analysis of 13 Sub-Saharan African countries suggests that AIDS will increase future crude death rates by 1.5 times in the aggregate, and more in the case of some individual countries. Life expectancy, which had enjoyed a 40-year period of advance, is now declining in many of these countries. Recent evidence also shows that infant and child mortality levels are increasing in several countries most affected by AIDS.

The cumulative effect of national AIDS epidemics will be staggering. Government health programs and facilities, with meager budgets already stretched, will be unable to cope with the numbers of people with AIDS and other HIV-related illnesses. Private voluntary organizations and community-based programs will assist in covering the need, but in the end this help will also be insufficient. Economic growth will be encumbered by increased morbidity and decreased productivity of HIV-infected workers, and many others will be unable to enter the work force because of care-giving responsibilities among families.

Despite these impacts, AIDS will not succeed in overcoming the momentum of population growth in most affected countries, particularly in Sub-Saharan Africa. The region's current high population growth rate ensures that, despite considerable expansion in HIV infection, the population will continue to increase, although changes in population structure may result. In other developing regions, for example in Asia and in Latin America, a strong AIDS epidemic has the potential to reverse population growth, because of the initially lower rates of fertility.

At the present time, epidemics in the developed regions, for example the United States and Europe, are more moderate than those in many developing countries. The impact, too, will be moderated. Consequently, this analysis focuses on the situation in developing countries. Sophisticated modeling tools help to examine the potential course of AIDS epidemics in countries with emerging or existing epidemics. However, they cannot predict which countries that currently show little sign of rapidly spreading HIV infection will have serious AIDS epidemics in the future. To be sure, available information on sexual behavior, condom use, and the prevalence of other sexually-transmitted diseases can help to identify potential epidemics, but AIDS epidemics result from a complex interaction of biomedical and behavioral factors that are not easily categorized. Some of the countries in this analysis will undoubtedly have less severe epidemics than projected, while some may have worse. Among the determinants of these outcomes will be the success of AIDS prevention and intervention programs.

In the countries most affected by HIV and AIDS, a quarter or more of the adult urban populations are infected with HIV. As these infections progress to AIDS and death, the impact of AIDS and death, the impact of AIDS will be felt by the majority of the urban population as friends and relatives begin to die of AIDS. There is evidence that such exposure has resulted in behavior change in some settings.

Such spontaneous behavior change can be supplemented by intervention programs designed to encourage a reduction in the number of casual sex partners, increased condom use, and prompt treatment of sexually transmitted diseases other than HIV/AIDS. Such interventions are the focus of AIDS control programs such as the AIDSCAP program sponsored by the U.S. Agency for International Development and other national AIDS control programs around the world.

Changes in behavior, both spontaneous and induced, may help to create an early plateau in some epidemics and ultimately may result in declines in HIV infection levels. But, with rapidly rising levels of HIV infection in countries around the world conclusively demonstrating the presence of high-risk behavior, it will take major changes in behavior to significantly alter the course of these epidemics.

This analysis examined the potential courses of current epidemics and the implications for the populations affected without attempting to predict the future course of behavior change or of possible AIDS treatments or cures. Given the uncertainties surrounding the course of AIDS epidemics, it is probable that refinements and adjustments in the method for the incorporation of AIDS-related mortality into these population projections will be adopted in future rounds of the projection process.
Appendix A

Population Projections
Incorporating AIDS
Appendix A.
Population Projections Incorporating AIDS

Background
Over the last decade, HIV infection and resulting AIDS have spread around the world. In a relatively short period of time, scientific studies have documented rapid increases of HIV infection in the general populations of many countries, particularly in urban areas. Studies of the demographic impact of HIV and AIDS using mathematical modeling and a hypothetical population have demonstrated the substantial impact that elevated HIV infection levels in the general population can have on both adult and child mortality (Way, 1992).

Although it has been clear for a number of years that mortality estimates and projections for many countries would have to be revised because of AIDS mortality, the lack of accurate empirical data on AIDS deaths, the paucity of data on HIV infection among the general population, and the absence of tools to project the impact of AIDS epidemics into the future have all hampered these efforts. Currently, although the accuracy of data on AIDS deaths has not substantially improved, knowledge of HIV infection has expanded and modeling tools have become available to project current epidemics into the future.

The discussion in this report focusing on HIV/AIDS highlighted patterns and trends of HIV infection in various regions. Based on that presentation, it is evident that AIDS is likely to have a significant impact on the populations of some countries, while others will be much less affected. The range of variation in HIV infection among countries mandates that whatever method is used to project future trends must be responsive both to the variation in current levels of infection and to the differences in the speed of epidemic increase. While much remains unknown about levels of HIV infection, for most countries infection levels for urban low-risk samples (pregnant women, for example) have been measured at more than one point. Rural areas present a more difficult problem, both because they are underrepresented in the few studies conducted and because there is a lack of repeated samples over time. Thus, an approach that incorporates trend information from urban areas and uses data from rural areas to provide a point estimate makes maximum use of available empirical data while excluding relatively few countries (or forcing few exceptions) because of a lack of required data.

A critical decision is the selection of countries. Virtually all Sub-Saharan African countries have reported AIDS cases to the World Health Organization, but some do not have HIV epidemics widespread enough to result in demographic impact of sufficient magnitude to warrant adjustment to projected mortality data. For the future, the situation is far from clear, as the variability in AIDS epidemics suggests that there are many potential future paths. In other regions, infection levels so far have lagged behind the more severely affected African countries.

The methodology used to project AIDS mortality into the future consists of the following steps:

1. Establish criteria for selecting countries for which AIDS mortality will be incorporated into the projections.
2. For each selected country, determine the empirical epidemic trend and a point estimate of national HIV prevalence.
3. Using the wgAIDS model, generate alternative scenarios ranging from high to low AIDS epidemics, and produce the seroprevalence rates and AIDS-related age-specific mortality rates which correspond to each epidemic.
4. Use the empirical levels and trends (from step 2) to establish a factor representing each country's position on a continuum between high and low epidemics (from step 3). Use the derived factor to generate a unique interpolated epidemic.
5. Use weighted country total adult seroprevalence to determine an appropriate location on the total country epidemic curve implied by the interpolation factor. This projects adult HIV seroprevalence for the total country.
6. Interpolate AIDS-related mortality rates, by age and sex, associated with the estimated speed and level of HIV from epidemic results for the period 1990 to 2010.

In the sections that follow, each of these steps is described, and the method is illustrated.

Country Selection Criteria
The Center for International Research, U.S. Bureau of the Census, maintains an HIV/AIDS Surveillance Data Base. This data base is a compilation of aggregate data from HIV seroprevalence studies in developing countries. Currently, it contains over 16,000 data items drawn from nearly 2,200 publications and presentations. As a part of the biannual updating of the data base, new data are reviewed for inclusion into a summary table which, for each country, lists the most recent and
best available study of seroprevalence levels for high- and low-risk populations in urban and rural areas.\(^1\)

A review of the data in the summary table suggested that a reasonable cut-off point for selection would be countries with 5 percent HIV prevalence among their low-risk urban populations. In typical AIDS epidemics in developing countries, urban rates are generally several times higher than rural rates. Thus, countries with less than 5 percent HIV infection in urban areas tend to have total-country prevalence levels of about 1 percent or less. Center for International Research studies have shown only minimal population impacts at such levels. Furthermore, countries with low levels of infection have tended to conduct relatively few HIV seroprevalence studies, making the task of establishing an empirical trend more difficult.

A total of 14 countries met the 5-percent criterion for the incorporation of AIDS mortality in the projections. All but one of these countries were in Africa, with Haiti the exception. The countries are as follows:

Burkina
Burundi
Central African Republic
Congo
Côte d'Ivoire
Haiti
Kenya

Two other countries, Brazil and Thailand, were also included because some country-specific modeling work had already been completed. The method for projecting the AIDS epidemics in these two countries differed somewhat from the others.

The simplified approach taken in these special cases is described in a later section.

In future revisions of this methodology, it is possible that alternative cut-off levels will be used as additional information is gained concerning the spread of HIV infection and the impact of AIDS on populations.

### Empirical Epidemic Trends

For each of the 14 countries meeting the 5 percent criterion, staff members reviewed the HIV seroprevalence information available in the HIV/AIDS Surveillance Data Base to establish urban seroprevalence trends over time and to identify available rural data points. The two data points judged to be most representative for the urban low-risk population were identified and used to calculate the annual change between the dates of the two studies. Rural data were used in conjunction with the urban data to establish a total-country seroprevalence point estimate. These data are shown in table A-1 and figure A-1.

### Alternative Scenarios

Various models have been developed to try to understand the dynamics of AIDS epidemics and to anticipate their future course. These models have

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\(^1\) High risk includes samples of commercial sex workers and their clients, sexually-transmitted disease patients, or others with known risk factors. Low risk includes samples of pregnant women, volunteer blood donors, or others with no known risk factors. For a more complete description of the selection criteria, see U.S. Bureau of the Census, 1992.

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### Table A-1.

<table>
<thead>
<tr>
<th>Country</th>
<th>Urban pregnant women</th>
<th>Rural adults</th>
<th>Estimated total country</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Earlier</td>
<td>Later</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>Percent</td>
<td>Year</td>
</tr>
<tr>
<td>Burkina</td>
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<td>1.7</td>
<td>1991</td>
</tr>
<tr>
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<td>1986</td>
<td>16.3</td>
<td>1988</td>
</tr>
<tr>
<td>Central African Republic</td>
<td>1986</td>
<td>4.7</td>
<td>1989</td>
</tr>
<tr>
<td>Congo</td>
<td>1990</td>
<td>7.7</td>
<td>1991</td>
</tr>
<tr>
<td>Côte d'Ivoire</td>
<td>1987</td>
<td>8.0</td>
<td>1991</td>
</tr>
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<td>1986</td>
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<td>1988</td>
</tr>
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<td>1990</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1988</td>
<td>10.6</td>
<td>1991</td>
</tr>
<tr>
<td>Uganda</td>
<td>1985</td>
<td>10.7</td>
<td>1992</td>
</tr>
<tr>
<td>Zaire</td>
<td>1985</td>
<td>6.9</td>
<td>1988</td>
</tr>
<tr>
<td>Zambia</td>
<td>1987</td>
<td>11.6</td>
<td>1990</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>(NA)</td>
<td>(NA)</td>
<td>1990</td>
</tr>
</tbody>
</table>

NA Data not available.

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Note: Data pertain to varying months of the years indicated.

ranged from the relatively simple to the highly complex. Simpler models have been used to extrapolate the number of AIDS cases or to calculate the population impacts of a given level of HIV infection. More complex approaches model the HIV transmission that results from particular behaviors as well as the impact of HIV infection on subsequent population processes (United Nations, 1991).

The wigAIDS model is a complex deterministic model of the spread of HIV infection and the development of AIDS in a population. It was developed under the sponsorship of the Interagency Working Group (wig) on AIDS Models and Methods of the U.S. Department of State (Stanley et al., 1991). Given a set of user inputs, the model can project the future path of an AIDS epidemic in both urban and rural sectors. Among the many potential outputs from the model are age- and sex-specific seroprevalence levels, AIDS cases, AIDS deaths, and AIDS-related mortality rates.

This model has been used by the Center for International Research to examine the potential demographic and macro-economic impacts of an AIDS epidemic in a "typical" African country (Way and Stanek, 1991; Way and Over, 1992). In these applications, demographic parameters characteristic of all of Sub-Saharan Africa were used, together with selected behavioral data based on regional studies. It has also been used in Thailand, in collaboration with the Thai AIDS Working Group, to project the spread of AIDS in that country during the decade of the 1990's.

To project the impact in the 14 selected countries, three alternative scenarios were developed, corresponding to low, medium, and high AIDS epidemics. For all of these epidemics, the demographic parameters corresponding to Sub-Saharan Africa were used, while the behavioral parameters were varied. Slightly different initial HIV seroprevalence levels were also used in the three scenarios.

The purpose of the three scenarios was to represent alternative long-term trends in the spread of HIV in human populations for use in projecting country-specific epidemics. The alternative scenarios also reflect an appropriate lag between HIV infection and AIDS mortality under circumstances of varying rates of epidemic growth. In a rapidly growing epidemic, for example, AIDS mortality at a given HIV infection level tends to lag behind the mortality associated with the same HIV infection level in a slowly growing epidemic.

Interpolation of a Unique Epidemic

Outputs from the three scenarios, in the form of annual HIV seroprevalence levels for urban women age 15 to 49 years over a 50-year period, were combined into a spreadsheet. Next, the empirical urban trend from
each country was entered into the spreadsheet, which was designed to calculate the annual change from the empirical trend and to interpolate among the three epidemics to derive an epidemic that matched the observed HIV seroprevalence increase between the two points. For example, if a country had an observed increase of HIV prevalence from 8.5 percent in 1988 to 12.3 percent in 1991, the spreadsheet would interpolate to derive an epidemic that increased between these two points over a similar 3-year period. Thus, both the level and the rate of increase of the urban epidemic were matched through this procedure. One important output from this spreadsheet was an "interpolation factor" to indicate where the empirical epidemic fell in the range from low (factor=1) through medium (factor=2) to high (factor=3).

Figure A-2 illustrates the process. The three solid lines in this figure correspond to HIV prevalence rates for urban women in the three scenarios. The large markers (*) indicate the two empirical observations, and the dashed line indicates the interpolated epidemic which matches those points. In this case, the interpolation factor is 1.8, indicating an epidemic nearly as rapid as the medium scenario.

Projected Total Seroprevalence

At this point in the estimation procedure, the rate of increase of the urban epidemic has been matched, but as yet no direct linkage has been made to the total country prevalence or to a particular calendar year in this country's epidemic. The second part of the spreadsheet accomplishes these tasks. The total-country adult prevalence estimate (shown in table A-1) was entered into the spreadsheet, along
with its reference date. The spreadsheet, which had already determined the interpolation factor, compared this total prevalence level with the one implied by using the interpolation factor. From this comparison, an “offset” figure was calculated, corresponding to the number of years of difference between the start of the epidemics in the three scenarios, and the empirical epidemic at the reference date.

Figure A-3 illustrates the process just described. Total female HIV seroprevalence levels from the three alternative scenarios are shown as solid lines. The interpolated epidemic for the whole country is illustrated by a shorter line with markers (▲), indicating annual estimates for the 1990 to 2010 period. By inspection, the spreadsheet calculated the offset, that is, the number of years between the start of the scenarios and the reference date. In this example, total seroprevalence in 1990 is 3 percent, a level that the interpolated epidemic reaches between the seventh and the eighth year of the projection. Thus, in this case, the offset is 7.65 years.

Projected adult epidemics for each country are shown in figure A-4. The method incorporates the variation in the speed of the empirical epidemics into the projected epidemics. For example, epidemics for Burundi and Malawi began in 1990 at similar levels of adult infection (around 10 percent). By 2010, however, HIV seroprevalence was projected to increase to over 20 percent of adults in Malawi, but to only about 14 percent in Burundi. The projected increase in infection levels in the 14 countries ranges from about half to more than triple during the two decades from 1990 to 2010.

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2 Reference dates were entered into the spreadsheet including fractions of years. For example, 1989.50 represented July 1 of the specified year.
AIDS-Related Mortality Rates

For each of the three scenarios, annual AIDS-related age-sex-specific mortality rates ($\mu_{mx}$ values) were derived and combined into a second spreadsheet. The "interpolation factor" and the "offset" described above were entered into this second spreadsheet. Based on these two values, AIDS-related age-sex-specific $\mu_{mx}$ values at 5-year intervals from 1990 to 2010 were interpolated and added to non-AIDS $\mu_{mx}$ values for the same period. Population projections were prepared with the combined $\mu_{mx}$ values as input, using the rural/urban projection program of the U.S. Bureau of the Census.

The future course of the AIDS pandemic is uncertain, but the projections require some assumptions be made. It was assumed that the epidemics would peak in 2010, with no further HIV infection after that year. AIDS mortality was assumed to decline linearly from the level reached in 2010 to nil by 2020, thus implying a return to "normal" mortality levels in the latter year. Such a scenario could result from the widespread availability of a prophylactic vaccine or drug beginning in 2010 or the introduction of a fully-effective therapeutic vaccine or drug therapy over the 2010 to 2020 period. To implement the projection process, life tables for 2020, assuming no AIDS mortality, were used.

The Special Cases of Brazil and Thailand

As mentioned earlier, Brazil and Thailand had been the subject of country-specific modeling activities supported by the Interagency Working Group. AIDS epidemics in these two countries have substantial homosexual and intravenous drug use components, while those in Africa do not (WHO/GPA, 1993a). For these reasons, a different approach was taken to project the AIDS epidemic for Brazil and Thailand. AIDS-related age-sex-specific mortality rates for these countries were derived from the iwgAIDS model and added directly to the non-AIDS mortality rates previously prepared for the projection program.

Caveats and Limitations

In developing the methodology for these projections, the Center for International Research has attempted to maximize the use of both the empirical data and the modeling tools available. However, there is much that is unknown about the dynamics of AIDS epidemics in countries around the world, and the methodology is necessarily imprecise. The actual path of AIDS epidemics in the countries that were selected will undoubtedly differ from the course projected. As epidemics grow, future behavior changes and interventions being implemented in countries around the world may alter that course.

The choice of 2010 as a peak year for the epidemics is arbitrary, but perhaps not unrealistic. Despite intensive efforts to develop an effective and safe vaccine for HIV, the widespread availability of such a vaccine is still many years away. In addition, recent simulations by the U.S. Centers for Disease Control and Prevention suggest that even should such a vaccine become available, its impact on the epidemic would not be felt for a number of years (Dowdle, 1993). A variety of therapeutic drugs have also shown some promise, but none has yet demonstrated the ability to do more than extend the survival of those infected by perhaps a year or two.

What if AIDS epidemics do not peak early in the next century as projected? Will entire populations become infected with HIV and eventually die from AIDS? The simulations used for this report suggest that this will not happen in any population. Variations in sexual behavior help to ensure that the majority of the population in countries around the world are not at high risk of HIV infection. With substantial proportions of the population at lower risk of infection, each of the epidemic scenarios displays a definite plateau after the initial rapid rise.

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3 Non-AIDS $\mu_{mx}$ values were derived by making standard assumptions concerning the improvement in mortality conditions as described in World Population Profile: 1994.


**Age structure.** The distribution of a population according to age, usually by 5-year age groups.

**AIDS.** Acquired immune deficiency syndrome.

**Birth rate.** The average annual number of births during a year per 1,000 population at midyear. Also known as crude birth rate.

**Crude birth rate.** See birth rate.

**Crude death rate.** See death rate.

**Death rate.** The average annual number of deaths during a year per 1,000 population at midyear. Also known as crude death rate.

**Death rate.** The average annual number of deaths during a year per 1,000 population at midyear. Also known as crude death rate.

**Growth rate.** The average annual percent change in the population, resulting from a surplus (or deficit) of births over deaths and the balance of migrants entering and leaving a country. The rate may be positive or negative. Also known as population growth rate or average annual rate of growth.

**HIV:** Human immunodeficiency virus.

**HIV-1:** Human immunodeficiency virus, type 1.

**HIV-2:** Human immunodeficiency virus, type 2.

**Infant mortality rate.** The number of deaths of infants under 1 year of age during a calendar year per 1,000 live births occurring in the same year.

**IVDU:** Intravenous drug user.

**iwgAIDS:** Interagency Working Group on AIDS.

**Life expectancy at birth.** The average number of years a group of people born in the same year can be expected to live if mortality at each age remains constant in the future.

**Natural increase.** The difference between the number of births and the number of deaths.

**Pandemic.** A global epidemic.

**Projections.** Data on population and vital rates derived for future years based on statistics from population censuses, vital registration systems, or sample surveys pertaining to the recent past, and on assumptions about future trends.

**Rate of natural increase.** The difference between the crude birth rate and the crude death rate.

**Replacement level fertility.** The average number of children each woman would have to bear for a population to remain the same size over the long term. Conventionally taken to be an average of 2.1 children per woman.

**Seroprevalence.** The percent of an identified population that is infected with HIV.

**Vital events.** Births and deaths.

**Vital rates.** Birth rates and death rates.

**WHO:** World Health Organization.

**WHO/GPA:** World Health Organization/Global Programme on AIDS.