APPENDIX C.
POPULATION PROJECTIONS INCORPORATING AIDS

Background

Although it has been clear for a number of years that mortality estimates and projections for many countries would have to be revised due to 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 methodology used to project AIDS mortality into the future for this report follows generally the method adopted for ***World Population Profile: 1994***, ***World Population Profile: 1996***, and ***World Population Profile: 1998*** with continuing modifications. The method consists of the following steps:

1. Establishing criteria for selecting countries for which AIDS mortality will be incorporated into the projections.
2. For each selected country, determining the empirical epidemic trend and a point estimate of national HIV prevalence.
3. Modeling the spread of HIV infection and the development of AIDS in the population, generating alternative scenarios ranging from super high to low AIDS epidemics, and producing the seroprevalence rates and AIDS-related, age-specific mortality rates which correspond to each epidemic.
4. Using the empirical levels and trends (from step 2) to establish a factor representing each country's position on a continuum between super high and low epidemics (from step 3), and the derived factor to generate a unique interpolated epidemic curve.
5. Using weighted country total adult seroprevalence to determine the appropriate location on the interpolated total country epidemic curve from step 4. This curve establishes the likely beginning date of the epidemic in the country in question, the progression of the epidemic up to the date of the last empirical data point, and the projection of HIV seroprevalence into the future.
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 International Programs Center, U.S. Census Bureau, maintains the *HIV/AIDS Surveillance Data Base*. This data base is a compilation of aggregate data from HIV seroprevalence and incidence studies in developing countries. Currently, it contains over 72,000 data items drawn from over 6,500 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 study of seroprevalence levels for high- and low-risk populations in urban and rural areas.[19]

[19] High risk includes samples of prostitutes and their clients, sexually-transmitted disease patients, or other persons 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. Census Bureau (2002).

A review of the data in the summary table suggested that a reasonable cut-off point for selection would be countries which had reached 5 percent HIV prevalence among their low-risk urban populations, or, based on recent trends, appeared to be likely to reach this level in the near future. In addition, countries were selected that had national HIV prevalence above 1 percent, as estimated by UNAIDS for year-end 1999.

A total of 51 countries met these criteria for the incorporation of AIDS mortality in the projections. Thirty-seven of these countries were in Africa. The African countries are as follows (newly added countries in italics):

Angola
Benin
Botswana
Burkina Faso
Burundi
Cameroon
Chad
Central African Republic
Côte d'Ivoire
Congo (Brazzaville)
Congo (Kinshasa)
Djibouti
Eritrea
Ethiopia
Gabon
Ghana
Guinea
Guinea-Bissau
Kenya
Lesotho
Liberia
Malawi
Mali
Mozambique
Namibia
Niger
Nigeria
Rwanda
Senegal
Sierra Leone
South Africa
Swaziland

Tanzania
Togo
Uganda
Zambia
Zimbabwe

Outside of Africa, the following countries met the criteria:

The Bahamas
Barbados
Belize
Burma
Cambodia
Dominican Republic
Guatemala
Guyana
Haiti
Honduras
Panama
Trinidad and Tobago
Suriname
Thailand

Empirical Epidemic Trends

For 50 of the countries meeting the selection criteria, staff members reviewed the HIV seroprevalence information available in the HIV/AIDS Surveillance Data Base to establish urban seroprevalence trends over time (Table C-1, col. 1-4) and to establish the estimated prevalence for the whole country (Table C-1, col. 5). 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. National prevalence figures were based on year-end 1999 estimates prepared by the World Health Organization and the United Nations Joint Programme on HIV/AIDS. Table C-1, column 6 contains the corresponding estimate for year-end 2001.

Alternative Scenarios

To project the impact in the selected countries, five alternative epidemic scenarios were developed, corresponding to low, medium, high, higher, and super high AIDS epidemics. The highest scenarios were added this round to incorporate the very explosive HIV epidemics in southern Africa, and those epidemics where there is little difference between the urban and rural HIV prevalence levels. These scenarios were developed using iwgAIDS, which is a complex deterministic model of the spread of HIV infection and the development of AIDS in a population. This model was developed under the sponsorship of the Interagency Working Group (iwg) on AIDS Models and Methods of the U.S. Department of State (Stanley et al., 1991).

All five of these epidemic scenarios incorporate increasing levels of behavior change in the form of increased condom use. This assumption corresponds to actual changes in behavior that are now beginning to occur in some countries. In addition, all five epidemics exhibit plateauing and subsequent declines in prevalence in the later stages of the epidemic, particularly in urban areas.

Interpolation of a Unique Epidemic

The empirical urban trend from each country was used to interpolate among the five epidemic scenarios to derive an epidemic trend line matching the observed HIV seroprevalence increase between the two points. Thus, both the level and the rate of increase of the urban epidemic were matched through this procedure and resulted in an interpolation factor used in subsequent steps (Figure C-1).

Projected Total Seroprevalence

At this point in the estimation procedure, no direct linkage has been made to the total country prevalence or to a particular calendar year in this country's epidemic. The next step accomplishes these tasks. The total-country adult prevalence estimate (Table C-1, col. 5) was matched with the one implied 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 five scenarios, and the empirical epidemic at the reference date (Figure C-2). The resulting projected epidemics for the 1990 to 2010 period for selected countries in Africa are shown in Figure C-3.

AIDS-Related Mortality Rates

Based on the "interpolation factor" and the "offset" described above, AIDS-related age-sex-specific mortality rates (${}_nm_x$ values) at 5-year intervals from 1990 to 2010 were interpolated and added to non-AIDS ${}_nm_x$ values for the same period.[20] Population projections were prepared with the combined ${}_nm_x$ values as input, using the Rural-Urban Projection (RUP) program of the U.S. Census Bureau.

The future course of the AIDS pandemic is uncertain, but the projections require that some assumptions be made. It was assumed that the epidemics would peak in 2010, with no further growth in HIV infection after that year. AIDS mortality was assumed to decline from the level reached in 2010 to nil by 2070, thus implying a return to "normal" mortality levels in the latter year. To implement the projection process, life tables for 2070, assuming no AIDS mortality, were used.

[20] Non-AIDS ${}_nm_x$ values were derived by making standard assumptions concerning the improvement in mortality conditions.

Table C-1.
Empirical Seroprevalence Data for Urban and Rural Areas for Selected Countries

Country	Urban trend, pregnant women				Estimated percent seropositive, total country	
	Date[4]	Percent seropositive	Date	Percent seropositive	December 31, 1999	December 31, 2001
Angola	1995.00	1.2	1999.00	3.4	2.8	5.5
Benin	1994.50	1.1	1998.50	2.5	2.5	3.6
Botswana	1994.50	27.8	1997.30	34.0	35.8	38.8
Burkina Faso	1991.00	7.8	1996.75	10.0	6.4	6.5
Burundi	1986.00	14.7	1998.90	19.1	11.3	8.3
Cameroon	1992.60	4.0	1994.60	5.7	7.7	11.8
Chad	1995.00	2.4	1999.00	6.2	2.7	3.6
Central African Republic	1986.50	4.7	1996.50	11.7	13.8	12.9
Congo (Brazzaville)	1987.50	3.1	1993.50	7.2	6.4	7.2
Congo (Kinshasa)	1985.50	6.9	1991.50	9.2	5.1	4.9
Côte d'Ivoire	1989.50	6.0	1997.00	15.9	10.8	9.7
Djibouti[3]	1993.00	4.0	1995.50	6.1	6.1	(NA)
Eritrea	(NA)	(NA)	1994.00	3.0	2.9	2.8
Ethiopia	1991.00	10.7	1996.50	17.9	10.6	6.4
Gabon	1998.50	0.5	1994.50	1.7	4.2	(NA)
Ghana	1992.50	1.2	1996.50	2.2	3.6	3.0
Guinea	1990.00	1.1	1996.00	2.1	1.5	(NA)
Guinea-Bissau	1990.00	0.9	1997.00	2.5	2.5	2.8
Kenya	1992.50	14.4	1995.50	18.5	14.0	15.0
Lesotho	1991.50	5.5	1996.50	20.6	23.6	31.0
Liberia	1992.00	3.7	1993.00	4.0	2.8	(NA)
Malawi	1991.50	22.0	1995.50	27.6	16.0	15.0
Mali	1988.00	1.3	1994.00	4.4	2.0	1.7
Mozambique	1994.90	10.7	1998.90	17.0	13.2	13.0
Namibia	1991.50	4.2	1996.60	16.0	19.5	22.5
Niger	1988.00	0.5	1993.00	1.3	1.4	(NA)
Nigeria	1992.00	2.9	1994.00	5.4	5.1	5.8
Rwanda	1989.00	26.8	1992.00	28.9	11.2	8.9
Senegal	(NA)	(NA)	1991.00	0.3	1.8	0.5
Sierra Leone	1990.00	0.8	1992.00	2.0	3.0	7.0
South Africa	1994.90	6.4	1997.90	16.1	19.9	20.1
Swaziland	1993.50	21.9	1998.50	31.6	25.5	33.4
Tanzania	1986.50	3.7	1996.50	13.7	8.1	7.8
Togo	1995.50	6.0	1997.50	6.8	6.0	6.0
Uganda—High[1]	1987.50	24.0	1992.00	29.5	12.0	(NA)
Uganda—Low Stable[1]	1996.50	15.3	1997.50	14.7	8.3	5.0
Zambia	1990.00	24.5	1994.75	27.5	20.0	21.5
Zimbabwe	1990.00	23.8	1995.00	30.0	25.1	33.7
Bahamas, The	1990.50	3.0	1993.50	3.6	4.1	3.5
Barbados	1991.00	1.3	1996.00	1.1	1.2	1.2
Belize	1993.50	0.2	1995.50	2.3	2.0	2.0
Dominican Republic	1995.50	1.2	1999.50	1.7	2.8	2.5
Guatemala	1991.50	0.0	1998.50	0.9	1.4	1.0
Guyana	1990.50	1.5	1991.50	1.9	3.0	2.7
Haiti	1989.80	7.1	1993.50	8.4	5.2	6.1
Honduras	1992.35	2.0	1995.50	4.1	1.9	1.6
Panama	1993.50	0.8	1995.50	0.9	1.5	1.5
Suriname	1991.50	0.8	(NA)	(NA)	1.3	1.2
Trinidad and Tobago	1991.50	0.2	1999.50	3.4	1.1	2.5
Burma	1992.50	0.5	1997.50	[2]1.4	2.0	(NA)
Cambodia	1995.75	3.0	1998.75	4.9	4.0	2.7
Thailand[1]	(NA)	(NA)	(NA)	(NA)	2.2	1.8

NA Data not available.

[1]Country-specific "modeling" was undertaken for Thailand and Uganda.
[2]Burma military recruit data.
[3]Estimated percentage shown in column 5 for Djibouti is for 1995.
[4]The decimal part of dates shown refers to the timing of seroprevalence estimates within calendar years. For example, 1995.00 is January 1, 1995; 1994.50 is June 30, 1994 (midyear 1994).

Source: Urban and rural data are from U.S. Census Bureau, International Programs Center, HIV/AIDS Surveillance Data Base, January 2000. Estimated seropositive percentages at the national level are from UNAIDS (2000), UNAIDS/WHO (2000), and Burton and Mertens (1998).

The Special Case of Uganda

Prevalence levels for pregnant women in major urban areas in Uganda appear to have peaked in the early 1990s, with rather dramatic declines subsequently. Infection levels of nearly 30 percent were detected in 1992; by 1996, HIV prevalence rates had declined by nearly 50 percent (Table C-1). Although discussion of the causes of these declines is still underway, it appears clear that a substantial change has occurred. Consequently, the approach described above needed to be modified to conform to the empirical evidence of declining HIV prevalence rates.

To handle this epidemiological pattern in Uganda, the 1990-2010 period was divided into a rising epidemic period (1990-1995), a transition period (1995-2005), and a period of a relatively low and stable epidemic (2005-2010). This classification is represented in Figure C-4. Mortality rates corresponding to the rising epidemic and the stable epidemic were separately derived, and the transition between the two was accomplished by linear interpolation between the two epidemics.

The Special Case of Thailand

Modeling activities have also been undertaken for Thailand with the support of the Interagency Working Group. The AIDS epidemic in Thailand has substantial injecting drug use components, while those in Africa do not (WHO/GPA, 1993). For Thailand, AIDS-related mortality rates from recent epidemiological and demographic projections (TNESDB, 1994) were added to the non-AIDS ${}_nm_x$ values for the 1990 to 2010 period.

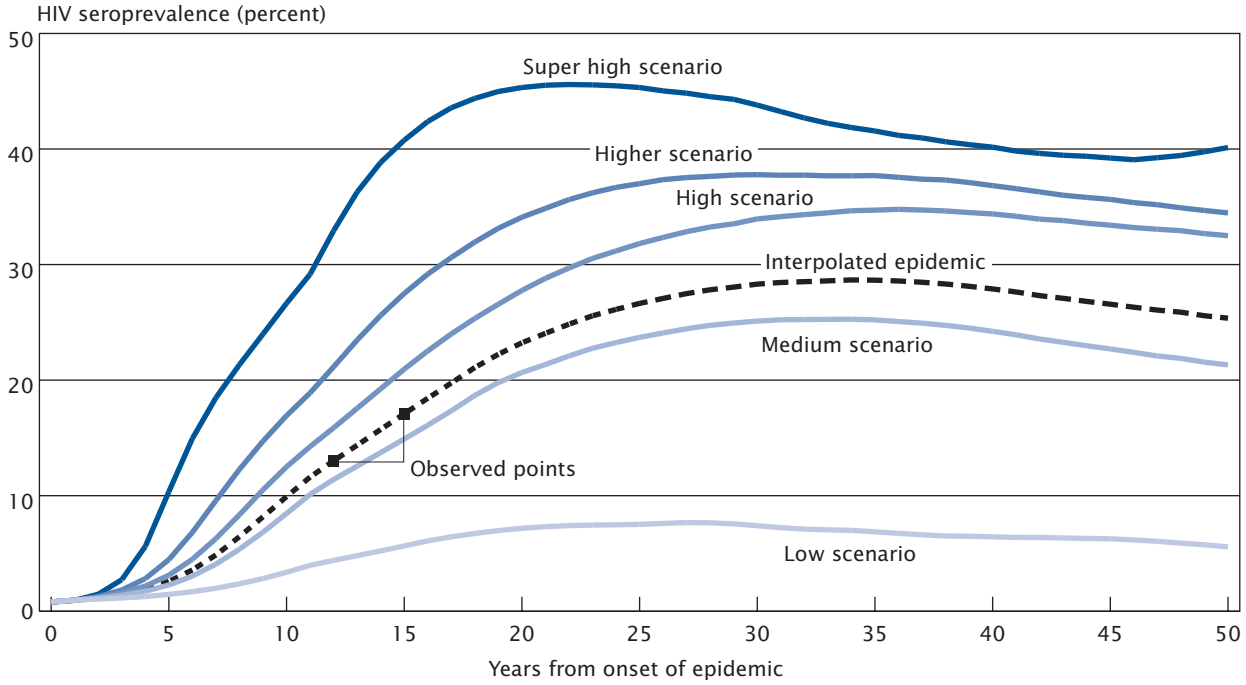
Caveats and Limitations

In developing the methodology for these projections, the International Programs Center has attempted to maximize the use of both the empirical data and the modeling tools available. However, much 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.

What if AIDS epidemics do not peak in 2010 as assumed? Will entire populations become infected with HIV and eventually die from AIDS? The simulations used for this report and available epidemiological and behavioral evidence 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 is not at high risk of HIV infection. And when substantial proportions of the population are at lower risk of infection, a plateau in HIV seroprevalence after an initial rise is likely. Indeed, some of the countries with high HIV seroprevalence levels are beginning to show evidence of this plateau effect. However, as evidenced in our projections, population declines are possible in countries with a sustained widespread epidemic, particularly in the presence of low fertility levels.

Figure C-1.

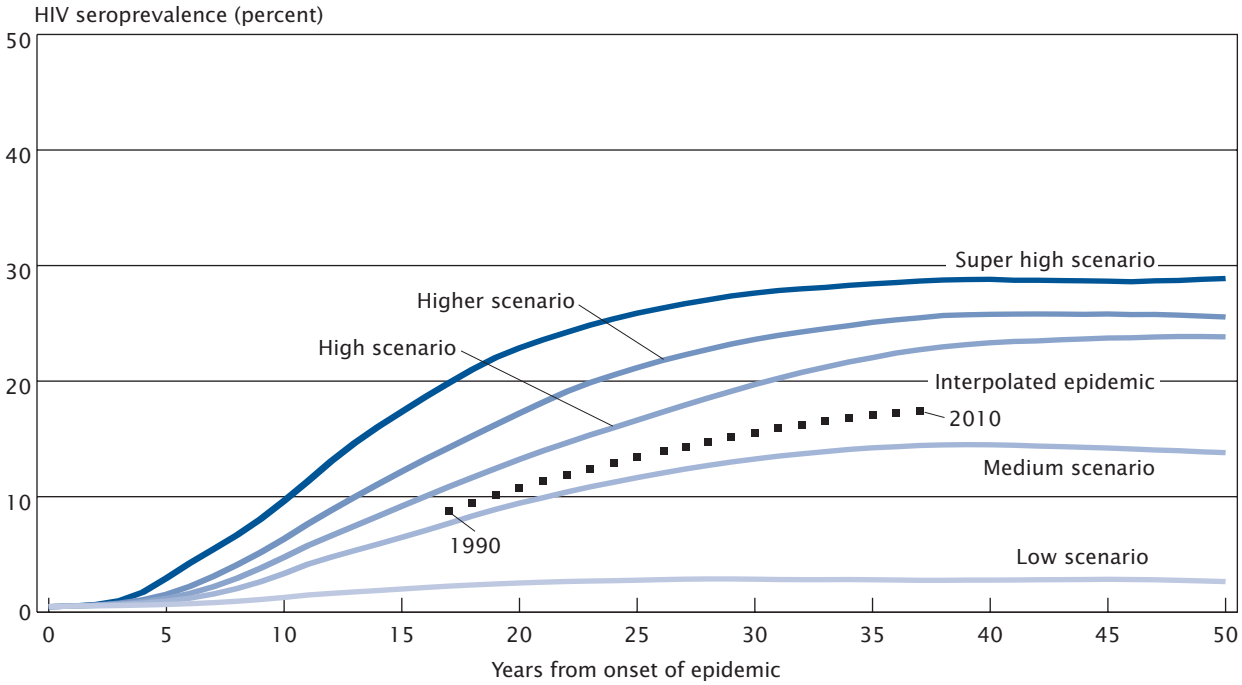
Scenarios and Empirical Trend: Urban Female HIV Seroprevalence



Note: For assumptions, see text of Appendix C.
Source: U.S. Census Bureau, International Programs Center, unpublished tables.

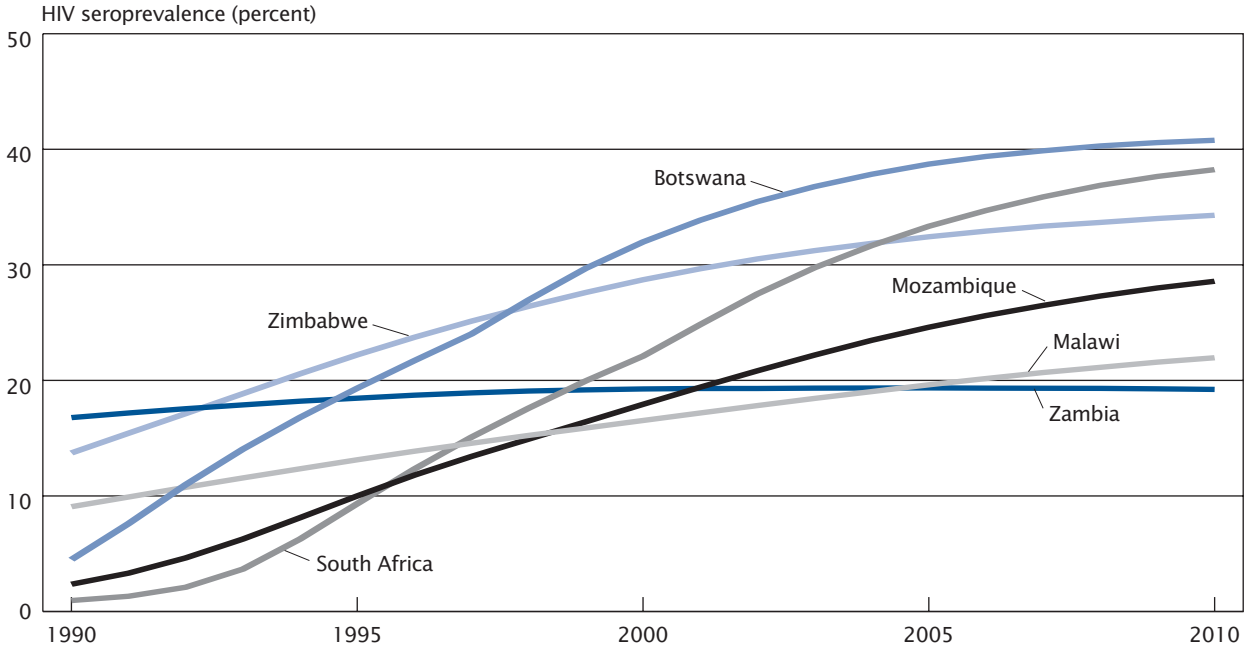
Figure C-2.

Five Scenarios and Empirical Trend: Total Female HIV Seroprevalence



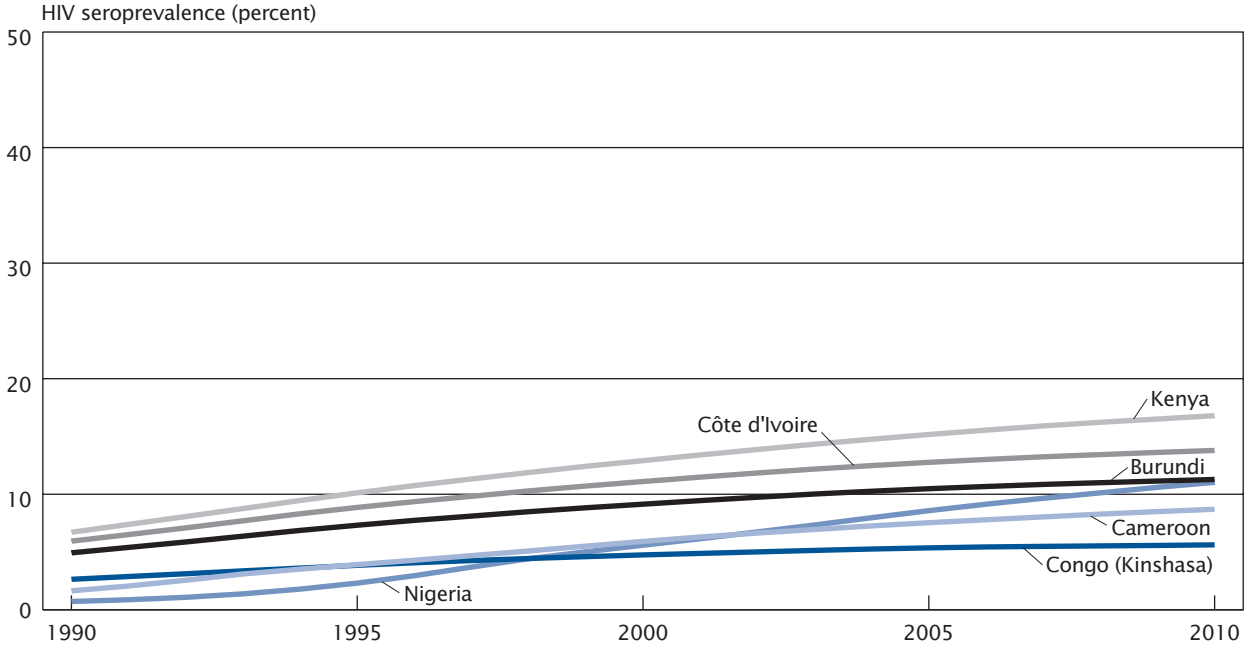
Note: For assumptions, see text of Appendix C.
Source: U.S. Census Bureau, International Programs Center, unpublished tables.

Figure C-3a.
Projected HIV Seroprevalence for Selected Countries of Africa: 1990-2010



Note: For assumptions, see text of Appendix C.
Source: U.S. Census Bureau, International Programs Center, unpublished tables.

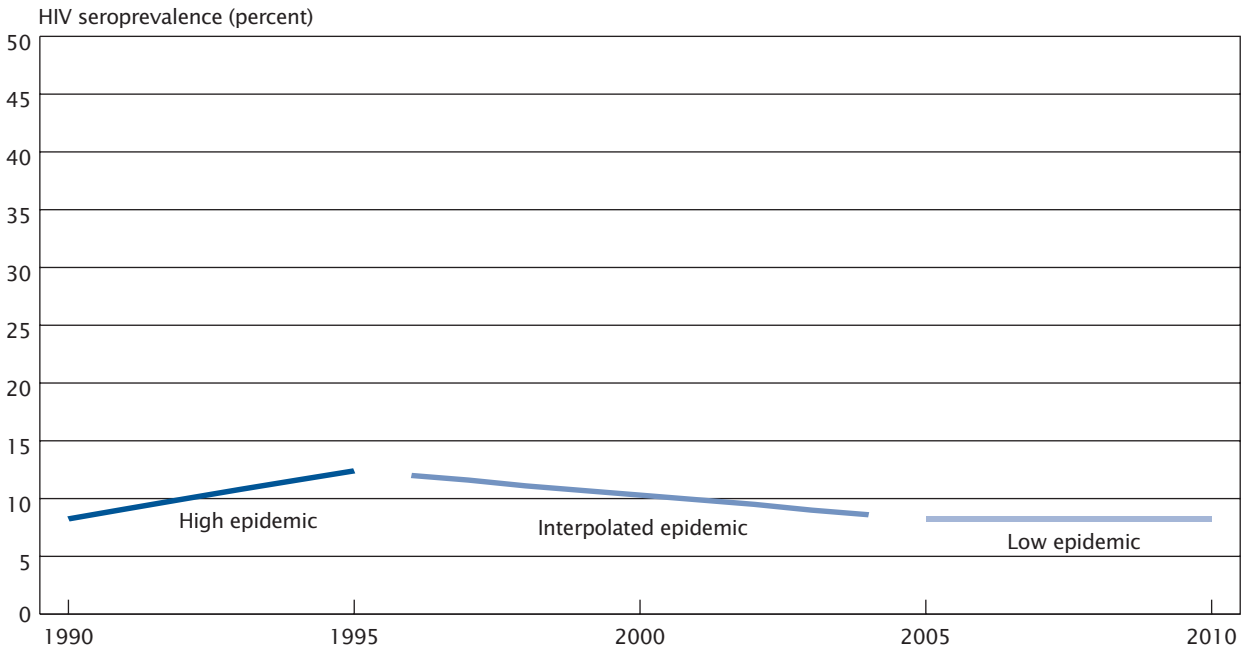
Figure C-3b.
Projected HIV Seroprevalence for Selected Countries of Africa: 1990-2010



Note: For assumptions, see text of Appendix C.
Source: U.S. Census Bureau, International Programs Center, unpublished tables.

Figure C-4.

Projected HIV Seroprevalence for Uganda: 1990-2010



Note: For assumptions, see text of Appendix C.
Source: U.S. Census Bureau, International Programs Center, unpublished tables.