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THE DEMOGRAPHIC IMPACT OF AN AIDS EPIDEMIC ON AN AFRICAN COUNTRY APPLICATION OF THE IWGAIDS MODEL

by

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SUMMARY

This report presents the results of the application of the iwgAIDS mathematical model of the AIDS epidemic to data representative of a subSaharan African country. The primary focus of the study is the demographic impact of an AIDS epidemic, although other important implications are discussed.

Data inputs were selected to represent present-day subSaharan Africa. The population size for this typical country is 1 percent of the 1990 population of the region, while the demographic processes of fertility and mortality were those estimated by the U. S. Bureau of the Census for the region. In terms of epidemiological data, initial infection levels were based on 1990 estimates by the World Health Organization—about 1 percent of the total population. Behaviors were selected for input based on various studies conducted in the region. As a result of this data input, this scenario can be taken to represent the entire region. Rates can be used directly to represent subSaharan Africa, while absolute numbers should be multiplied by 100.

Major findings include:

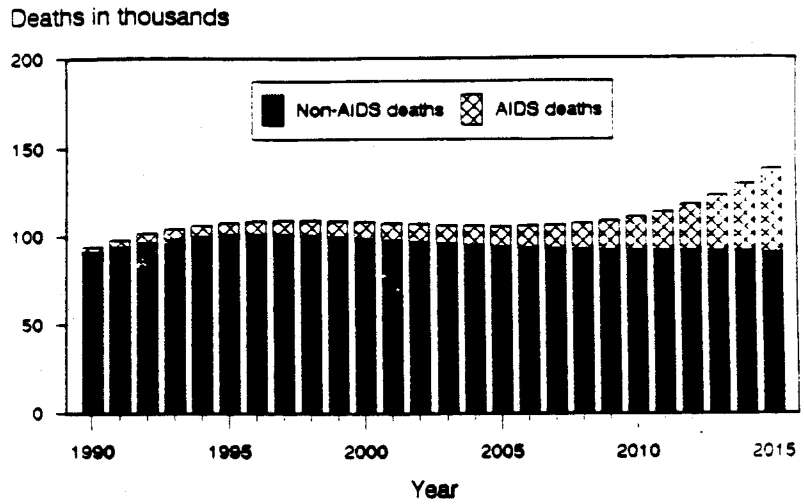
- HIV infection in the population increases sevenfold over the 25-year projection period. Seroprevalence in urban areas increases from under 4 percent to over 16 percent of the total urban population. Rural infection grows slowly for a time and then increases strongly toward the end of the period, reaching 5 percent in 2015—a tenfold increase over 1990.

- By 2015, the number infected increases to over 700 thousand (70 million in subSaharan Africa). At this point in time the *number* of infected persons in rural areas is greater than the number infected in urban areas.

- Population growth continues in both urban and rural areas, due to the excess of births over deaths, even with the AIDS epidemic. By the end of the projection period AIDS has reduced the total population by more than one-half million from a non-AIDS projected total population of nearly 10 million (a 5-percent reduction).

- Death rates in urban areas are more than double rates that would have existed without AIDS by the end of the period. Despite the concentration of the epidemic in urban areas, AIDS increases mortality levels in the country as a whole by nearly 50 percent (see figure below).

Projected Deaths, Total: 1990 to 2015



- By 2015, the model shows a total of nearly 138 thousand deaths (13.8 million in subSaharan Africa) annually—nearly 46 thousand (4.6 million) of these are AIDS deaths.

- As the result of the AIDS epidemic, in urban areas infant mortality levels increase more than 20 percent. Urban mortality under the age of 5 increases by nearly 50 percent, due to the survival of many infected infants beyond their first birthday.

- An examination of the age pattern of the epidemic shows, as expected, a concentration of infection in the young adult ages (ages 25-39), where HIV seroprevalence levels exceed 30 percent in the urban areas. Urban infection levels for infants are over 10 percent.

- Mortality patterns are also age related. Excess urban mortality due to AIDS is six to seven times normal levels for those in their 30's and 40's.

- By the end of the 25-year projection period, AIDS reduces the urban life expectancy in this scenario by 18 years—nearly one-third of the expected level. This reduction results from elevated mortality rates, particularly in young adult ages. Survival to age 45 in urban areas is less than one-half the level expected without AIDS.

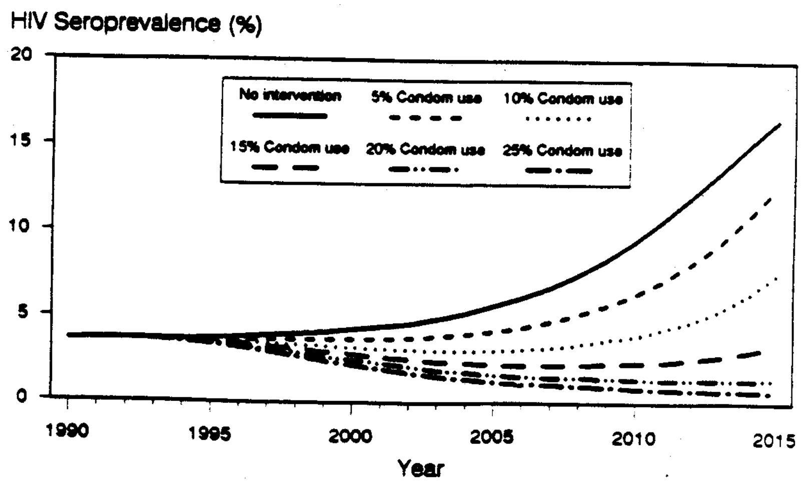
- An examination of alternative interventions suggests that universal blood screening will not substantially reduce the AIDS epidemic because the majority of infection is being transmitted through sexual contact.

- An increase in urban condom use to 10 percent could result in an urban seroprevalence in 2015 about one-half of the no-intervention level. Twenty percent condom use would result in declining urban infection over the period (see figure below).

- A decrease in the duration of sexually transmitted diseases (STDs) by 10 percent would result in an urban seroprevalence level of 12 percent—a one-third decline from the no-intervention level. A 20-percent decline in urban STD duration would result in an actual decline in urban seroprevalence from initial levels.

- A reduction in the number of casual sexual contacts appears to have the greatest relative impact of the interventions examined. A 10-percent reduction in the number of such contacts in urban areas would result in an urban seroprevalence of 6 percent in 2015, while a 15-percent or greater reduction would result in declining urban infection levels.

Projected Urban HIV Seroprevalence Rate--
Condom Intervention: 1990 to 2015



While these analyses apply to a "hypothetical" country, many of the impacts should be directly relevant to the current situation in several African countries at a comparable level of infection. It should be noted that urban areas in several African countries currently have infection levels similar to those projected in this scenario for the year 2015. In such cases, the demographic impacts discussed in this report have direct and current relevance, because they are occurring now.

Results of the intervention analysis indicate the extent to which sexual transmission, particularly outside of long-term unions, is driving the epidemic. A reduction of any of the three factors affecting sexual transmission resulted in a substantial reduction in the epidemic. The optimum intervention for a particular country setting will depend to a large extent on country-specific parameters for sexual activity levels, etc. The cultural and practical feasibility of effectively implementing such interventions is also important to consider.

This analysis demonstrates the potential for continued epidemic growth in HIV infection and AIDS in Africa. Both urban and rural areas experience rapidly-growing levels of infection, although the timing of these epidemics differed. Over the next several decades, African countries should expect growing epidemics, although the timing and the peak infection levels will vary from one country to the next.

PREFACE

The Center for International Research conducts economic and demographic studies, some of which are issued as Staff Papers. A complete list of these papers is included at the end of this report. The use of data not generated by the U. S. Bureau of the Census precludes performing the same statistical reviews the Bureau does on its own data.

The authors would like to thank Jinkie Corbin and Lisa Gist for their continuing work in compiling basic seroprevalence information for the HIV/AIDS Surveillance Data Base and for preparing and verifying various materials used in this report; Jack Gibson for preparing the graphics used in the report; and Cassandra Banks and Edith Robinson for typing the report; and Peggy Seybolt for final editing of the document.

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INTRODUCTION

Much concern has been voiced over the past several years about the potential for significant demographic impact on African countries as a result of the AIDS epidemic and the spread of HIV infection. However, direct measures of such an impact are typically slow in arriving, due to insufficient infrastructure for data collection and reporting. And there has been no readily available tool to examine the likely impact through projection or simulation methods.

With the recent development of the U.S. Department of State's iwgAIDS model, however, researchers and policy makers can examine the potential effects of an epidemic on a population, given a particular set of inputs on demographic processes, behaviors, and disease parameters. The results of such an application should not be considered a prediction, since our knowledge of disease processes and behaviors is incomplete and will be improving over the next several years. Rather, the results should be viewed as the implications of the particular set of assumptions that the user is making about the epidemic. Relatively modest changes in inputs can result in changes, sometimes major, in the projected course of epidemic growth.

The major strength of the model, then, may not be in its ability to predict whether or not a particular country may have an epidemic. Where there is no current epidemic, model inputs that result in an epidemic should be viewed with healthy caution and even skepticism. However, the fact of an epidemic is not in question in many countries as surveillance studies have demonstrated strong growth in infection levels. In such settings, the iwgAIDS model addresses two related aspects of the epidemic:

- With growth in HIV infection and AIDS, what are the major demographic impacts that can be expected on various sectors of the population, namely, infants and children, adults, the urban population? At what levels of infection do these impacts become pronounced?

- Given an epidemic based on demographic processes and patterns of behavior which may be considered typical of the subSaharan African region, what are the opportunities for intervention programs and behavior changes to alter the projected course of the epidemic? How do the various potential interventions compare in terms of their impact on the subsequent epidemic?

The scenario which is presented in this report is based on inputs that have been chosen to represent processes and behaviors not unlike those found in the subSaharan African region. It should be noted, however, that there is considerable variation on these parameters between countries, and particular combinations of these parameters may result in epidemics that are either more or less extreme than the results discussed here. A review of the HIV seroprevalence data available for Africa should convince the reader that the potential exists for wide variation in the course of possible epidemics in Africa.

THE iwgAIDS MODEL

The iwgAIDS model was developed by a team of researchers under the sponsorship of the U.S. Department of State's Interagency Working Group on AIDS Models and Methods. Team members included mathematicians, system analysts and demographers from Los Alamos National Laboratories; Merriam Laboratories, University of Illinois; Center for International Research, U.S. Bureau of the Census; and Department of Mathematical Sciences, U.S. Air Force Academy.[1]

This is a model of the spread of HIV in a population by heterosexual sex [both short-term (casual) and long-term (married) sexual partners], blood transfusions, and by perinatal transmission;[2] and of the demographic impact of the subsequent AIDS epidemic.

The model was designed for various uses, including technical research, policy analysis, and decision making support. Research uses include studying patterns of HIV spread, assessing the relative importance of different processes on the spread of HIV, examining the demographic impact of HIV infections, and modeling the impact of intervention strategies, such as the promotion of condom use. The model can also guide researchers by indicating the types of data that are needed to model the disease and to measure its impact.

But perhaps more importantly, the model can help policy makers and health officials make decisions. It can be used as a "presentation model" to raise the awareness of the AIDS epidemic among local health administrators. Comparisons can be made between various intervention strategies, the impact on the economically active population can be assessed, etc. In fact, iwgAIDS forms the basis of project activity known as the AIDS

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[1] Stanley, E.A., S.T. Seitz, P.O. Way, P.D. Johnson, T.F. Curry. 1989. "The iwgAIDS Model for the Heterosexual Spread of HIV and the Demographic Impact of the AIDS Epidemic." Paper prepared for the UN/WHO workshop on modeling the demographic impact of the AIDS epidemic in pattern II countries. New York. December.

[2] IV drug abuse and homosexual contact modules are currently being tested. However, these processes are not considered to be important determinants of the AIDS epidemic in Africa.

Impact Model (AIM), sponsored by the U.S. Agency for International Development and being implemented by Family Health International and the Futures Group. This non-technical presentation model is aimed at policy makers in developing countries.

The iwgAIDS model can provide qualitative insights into specific demographic and epidemiological questions about the epidemic. Demographic questions include the age pattern of infections and the effect of the epidemic on the age-structure of the population (e.g., dependency ratios, orphanhood), on infant and child mortality, and on overall population growth rates. Epidemiological questions include the relative importance of each infection route, how the virus spreads between age groups, the role that very high risk takers play in driving the epidemic, how the epidemic spreads from urban to rural regions (why does it seem to spread rapidly under some conditions and not spread at all under other conditions), the effect of other STDs on the transmission and spread of HIV, and the impact of interventions on the epidemic.

Intervention studies might include the effectiveness of promoting condom use, especially since this affects other STDS; comparison of condom use strategies with those to make blood screening more effective; the treatment of other STDS; and the impact on HIV incidence and prevalence of treatment strategies such as AZT.

A demographic model is used as the foundation for additional AIDS-related processes. The model projects the population by age, includes a fertility component for births, and uses life tables to calculate deaths. The population is divided into two regions (e.g., urban and rural), so that aspects of interregional spread can be studied. We then include the major processes important in HIV spread:

- Demographic processes—fertility, mortality, migration;
- Marriage and partnership formation/dissolution;
- HIV transmission through heterosexual contact;
- Perinatal HIV transmission; and
- Transmission through contaminated blood.

The age-specific results of the model include uninfected and infected populations by time since infection, the number of new HIV infections and AIDS cases, the impact of AIDS on the population age structure and demographic measures, and the spread of HIV from urban to rural areas.

OVERVIEW OF INPUTS

The following is a brief description of the model inputs. More detail, references, and background information can be found in Appendix A.

Demography

The first requirement for the model is the basic demographic description of the two areas. For this example we look at the urban and rural areas:

- Initial population, by age and sex;
- Initial and projected fertility, by age of mother;
- Initial and projected mortality rates, by age and sex (mortality in the absence of AIDS);
- Initial and projected age patterns of marriage and age difference between partners;
- Initial and projected rates of marital disruption, by age and sex; and
- Initial and projected migration flows between regions, by age and sex.

These estimates can come from the most recent population census and surveys such as a demographic, fertility, contraceptive prevalence, or health survey.

Demographic patterns in Africa have not been constant over the past 40 years or more. Although fertility levels have not declined significantly in many areas, mortality conditions have been improving in most countries. The population age structure used in this analysis is based on a projected 1990 midyear population for the entire subSaharan African region. The initial population size is 5.4 million—1 percent of the 1990 projected population of subSaharan Africa. The country has a growth rate of about 3 percent and a declining mortality rate. Life expectancy levels are 50.4 years for males and 53.5 years for females.

The use of an initial population total equal to 1 percent of the population serves a useful purpose in the interpretation of the results; if the results are interpreted as applying to subSaharan Africa as a whole, the numbers of deaths, new infections, new AIDS cases, etc., can simply be multiplied by 100 to apply to the whole region.

Urban and rural populations were derived using a figure of 20 percent urban. No urban-rural differentials in mortality were assumed for the projection although in many countries there is a difference (i.e., the urban population generally has a longer life expectancy).

The iwgAIDS model maintains the categories of "married" and "single" (i.e., those in long-term partnerships and those not). For this projection, the proportion married (in a union) is a composite based on the reported marriage patterns of Burkina Faso, Malawi, and Liberia. The median age at marriage for males is around 25 years and for females it is 20 years. These estimates were used for rural areas and increased by 2.5 years for urban areas.

Rates of marital disruption and rates of polygamy are used to adjust the partnership formation and dissolution processes. There is very little data available on divorce rates for subSaharan Africa, a modal divorce rate of 10 percent was assumed. The estimate of polygamy, 1.3 wives per husband, is based on data from Malawi, Burkina Faso, and Liberia.

The iwgAIDS model allows for permanent or semipermanent migration of persons to and from the urban area as well as circular migration (i.e., repeated seasonal migration of population from one area to the other). The rates for migration from rural into the urban areas, and from urban areas to rural, are input by age and sex. This application of the model assumes an overall net migration to urban areas of 2 percent per year. Very little information is available on circular migration and it is assumed to be virtually nil in this application. The model also accepts input on international migrants. However, in this application we assumed international migration to be nil.

Sexual Behavior

The next set of data input includes the sexual behavior data. The model requires estimates of the proportions of "promiscuous" (i.e., those having casual sexual contacts), the number of sexual contacts per partner, and the use of condoms. These estimates are input by age, sex, and marital status. Transmission rates, susceptibility, and duration of STDs are also input.

- The proportion of the population engaging in casual sex is used to estimate the population involved in high-risk behavior. Based on several studies, 25 percent of the married men and 75 percent of the single men in the urban areas were considered to be involved in high-risk behavior (i.e., casual sex).

- Only 5 percent of the urban married women were assumed to be involved in high-risk behavior but 50 percent of single urban women were considered to be involved in high-risk behavior.

- In the rural areas 20 percent of married men, 60 percent of single men, 4 percent of married women, and 45 percent of single women are assumed to be involved in high-risk behaviors.

These modal values were decreased for the oldest and the youngest age groups and balanced with the number of sexual contacts per person.

The number of sexual contacts is another important input used in the model. The numbers are input by age, but almost all have a unimodal distribution. For single males, the number of contacts averages four per month. For married high-risk males, the number of sexual contacts averages one per month outside of marriage.

Sexually-transmitted diseases (STDs) play an important role in the transmission of HIV. The model incorporates several aspects of STD infection in modeling the impact of HIV on the population; duration of infection, rate of transmission, and susceptibility. These rates can vary by STD and by country.

The amount of data available on STDs in Africa is scant. Better data are needed in this area to give more reliable estimates of transmission. For this application, an STD transmission rate of 40 percent per contact is assumed along with a 2-month duration for males and a 2.5-month duration for females in urban areas and 2.5 months for males and 3.5 months for females in rural areas.

Condom use has the potential of being an effective intervention in the control of HIV. Presently there is very little data on condom use in Africa. What is available comes from contraceptive prevalence surveys. The results of these studies uniformly show very little condom use. African couples do use some contraceptives, but other forms do not stop the transmission of HIV. A 0.4 percent rate of condom use is input for the low-risk married male and female populations.

Transmission/Natural History

The risk of heterosexual transmission of the AIDS virus is well accepted. For the model the following estimates are input:

- Population by infection status by risk group;

- Rate of standard infectivity per sexual contact;
- Relative HIV infection risk associated with STD infection;
- Rate of progression from HIV infection to AIDS;
- Rate of progression from AIDS to death; and
- Rate of perinatal transmission between mothers and infants.

The pattern of seroprevalence by age used in this example is based on the Uganda National Serosurvey. Using this age/sex pattern, the level of infection was then adjusted to reproduce the recent World Health Organization (WHO) estimate of approximately 5 million infected adults in subSaharan Africa.[3] Based on the population size which is 1 percent of the total Africa population, the corresponding figure of infected adults is 50 thousand.

Variability in transmission remains the most significant unexplained aspect of HIV infection. Very few estimates on the rate of infectivity per sexual contact are available, particularly for developing countries. Based on the available estimates in the literature, per-contact transmission rates from males to females of 0.0030 and from females to males of 0.0015 are assumed.

Sexually transmitted diseases have a well-documented effect on increasing the likelihood of HIV transmission. Based on several studies in Africa, a cofactor of 50 is used in this application. Thus, the likelihood of HIV transmission is increased by 50 in those contacts involving an STD.

The incubation period is defined as the time between infection and the diagnosis of disease. With AIDS the incubation period seems to be long and variable. Estimates of the incubation for transfusion-associated AIDS patients ranges from 4.5 years to 15 years. For this example a Weibull distribution with means of 7.8 for adults and 1.9 for children was used as the incubation period.

Median survival times for AIDS patients in developed countries (prior to the introduction of various therapies, such as AZT) ranges from 9 to 13 months. A figure of 12 months for adults and for children was used in this analysis.

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[3] World Health Organization Global Programme on AIDS. 1990. <u>Current and Future Dimensions of the HIV/AIDS Pandemic: A Capsule Summary</u>. WHO/GPA/SFI/90.2 Rev.1. Geneva.

Maternal transmission is the primary cause of pediatric AIDS. However, it is difficult at birth to identify the actual status of HIV infection. Several studies report infection rates from 24-39 percent. We use the transmission rate of 39 percent based on a study of infants born to seropositive mothers in Kinshasa, Zaire.

Table 1 highlights the values of key input parameters. Since this is a summary table, only selected or aggregate figures are provided by age. In the actual input, many parameters vary by age.

Blood Transfusion

Blood transfusions represent the third major route for transmission of HIV; sexual contact and perinatal transmission being the other two. The following data on blood transfusions and donations are input into the model:

- Proportion of the population donating blood;
- Likelihood of receiving blood;
- Average number of units of blood received; and
- Proportion of blood that is screened for HIV infection.

The distribution of blood donors by age and sex is based on HIV seroprevalence studies of blood donors in Mozambique and Côte d'Ivoire. A patient in an urban hospital is more likely to receive a blood donation than a patient in a rural hospital. Children are also more likely to have blood transfusions due to their lack of immunity to malaria and sickle cell disease.

Table 1. Summary of Key Epidemiological/Behavioral Input Parameters

Parameter	Urban Male	Urban Female	Rural Male	Rural Female
Percent high risk (ages 25-29 years)				
Single	75	50	60	45
Married	25	5	20	4
HIV+, in percent (Avg. ages 20-24 and 25-29)				
Low-risk single[1]	0	0	0	0
High-risk single	15.5	14.6	1.4	1.3
Low-risk married	9.3	8.8	0.8	0.8
High-risk married	15.5	14.6	1.4	1.3
Sexual contact rate (per month, ages 25-29 years)				
Low-risk single[1]	0	0	0	0
High-risk single	4	22.5	4	22.5
Low-risk married	8	5.75	8	5.75
High-risk married[2]	1	1	1	1
Percent using condoms				
High-risk	0.0	—	0.0	—
Low-risk	0.4	—	0.0	—
HIV transmission rate (per contact)				
Proportion infected	.0015	.0030	.0015	.0030
Perinatal transmission rate	—	.39	—	.39
Relative risk for STDs	50	50	50	50
Duration of STD infection (months)	2	2.5	2.5	3.5
Incubation period for HIV (years)	7.8	7.8	7.8	7.8
Survival time after AIDS (years)	1.0	1.0	1.0	1.0

[1]Not sexually active.
[2]Contacts outside of marriage.

RESULTS OF THE MODEL

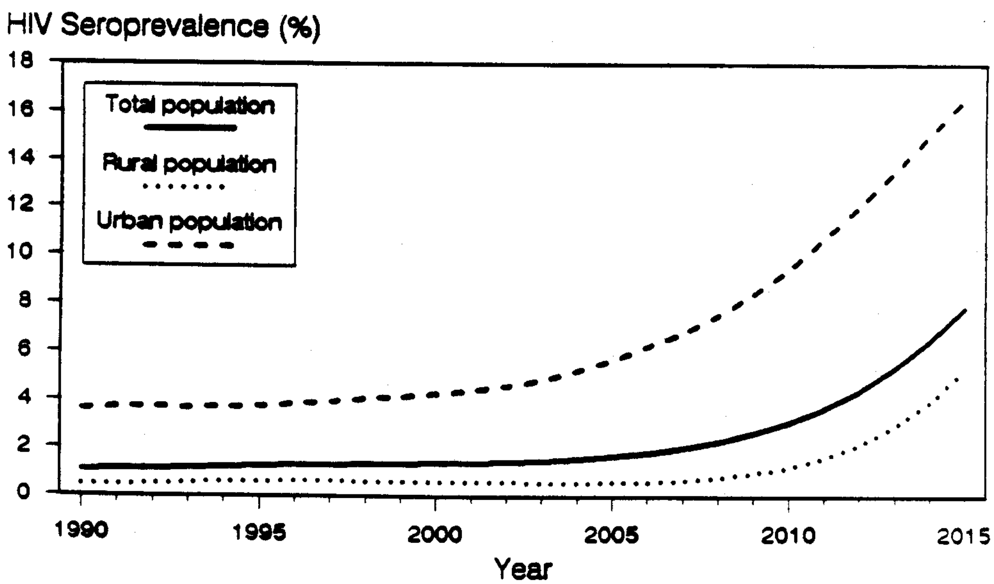
Increase in HIV Seroprevalence

Initial seroprevalence levels for 1990 were selected which resulted in infection levels comparable to those currently estimated by WHO for subSaharan Africa. These figures gave an urban seroprevalence among sexually-active adults of 6.7 percent (3.6 percent overall), and a rural seroprevalence for sexually active adults of 0.7 percent (0.4 percent overall). The combined 1990 seroprevalence for the total country was 1.1 percent.

Using the inputs described briefly above and detailed in Appendix A, the results of the model show an overall increase in seroprevalence levels for both urban and rural areas over the 25-year period (see Figure 1). The rate of growth of the epidemic in the two areas is quite different, however. In urban areas the seroprevalence is projected to increase from 3.6 percent in 1990 to 16.6 percent of urban population in 2015—nearly a fivefold increase. Despite this relatively high level of infection, there is little indication of a plateauing of the epidemic in urban areas, although by 2015 it is increasing at decreasing rates.

In rural areas, seroprevalence levels increase slowly during the first 15 years of the projection period but by the end are increasing rapidly. Infection levels increase tenfold, from

Figure 1. HIV Seroprevalence Rate, by Region: 1990 to 2015



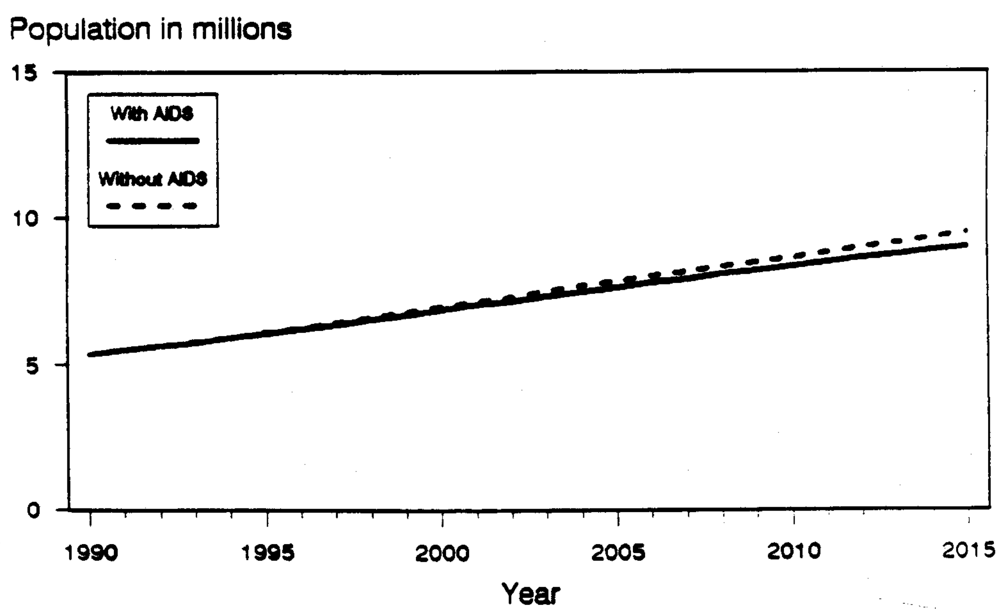
0.5 percent in 1990 to 5.3 percent in 2015. The demographic and behavioral inputs for rural areas do not result in a rapidly-growing epidemic, at least in the short run. As infection levels in urban areas increase, however, increasing numbers of rural residents are exposed to the risk of infection through the migration of infected persons from urban to rural areas. It appears that the combined cumulative effect of this increased exposure and indigenous epidemic growth gains momentum in rural areas toward the end of the projection period.

The results of the model, in terms of the growth of the epidemic, described here may be considered to be conservative, especially if applied to an individual country. Recent seroprevalence data for several countries in subSaharan Africa show short-term increases in seroprevalence more rapid than those shown here. Local variation in behavior and possibly in health conditions and disease parameters may account for these differences.

Population Size and Growth

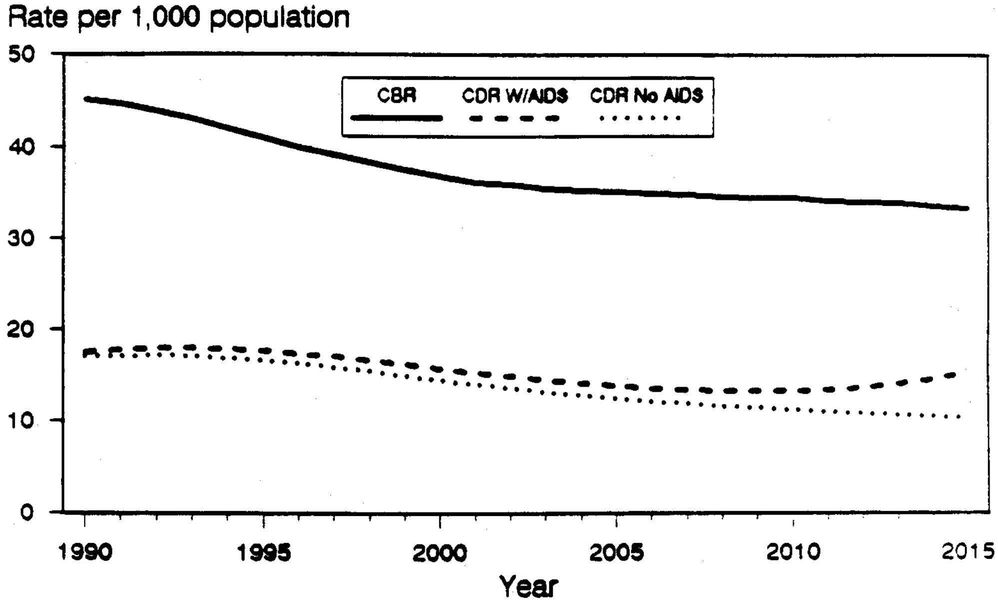
The demographic input to the iwgAIDS model assumes declining fertility levels and increasing levels of life expectancy in the absence of AIDS. At the national level, the epidemic projected by the model has a moderate effect—reducing expected population growth rates. Without AIDS, the population is projected to increase by over 75 percent in the 25-year period from 5.4 to 9.5 million (see Figure 2). Annual population growth rates over this period decrease from about 2.8 percent to 2.2 percent, due to the demographic trends mentioned above.

Figure 2. Projected Total Population: 1990 to 2015



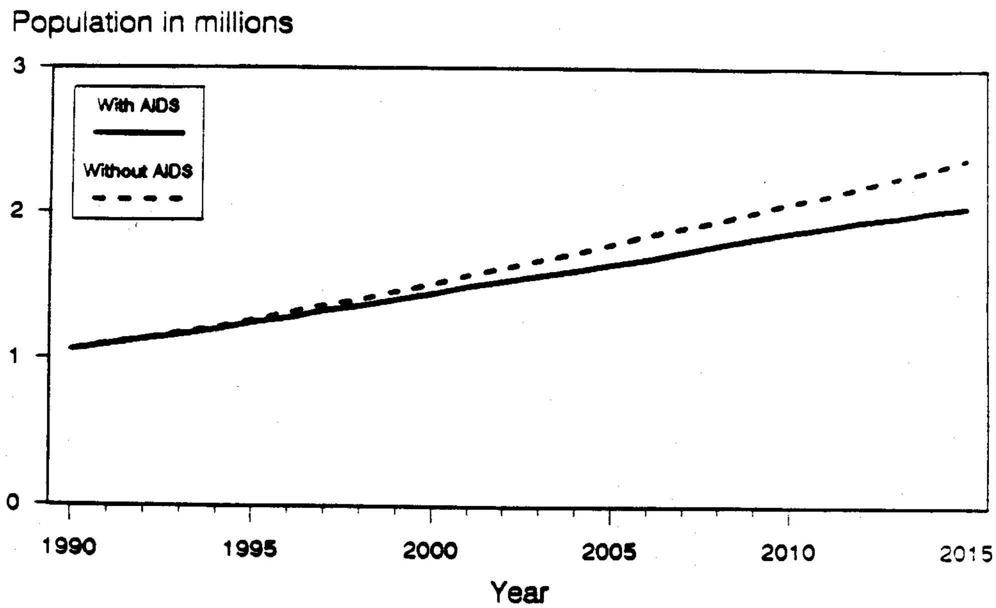
In the face of the AIDS epidemic, population increase is more moderate, with a total population in 2015 of 9.0 million, and population growth rates declining to about 1.8 percent by the end of the period. Thus the total population size in 2015 is about 0.5 million smaller with the epidemic than without. In terms of the subSaharan Africa region, these results would suggest that the total population of the region in 2015 could be reduced by as much as 50 million by the AIDS epidemic, compared with the no-AIDS scenario.

Figure 3. Projected Vital Rates, Total: 1990 to 2015



This decrease in population due to the AIDS epidemic is accomplished by increasing numbers of deaths and fewer births due to fewer women of childbearing age. Figure 3 shows the trends in birth and death rates in the total population. By 2015, the crude death rate with the AIDS epidemic is 15 compared to 10 with no epidemic. Thus, this AIDS epidemic, although concentrated in urban areas, has raised the crude death rate by nearly 50 percent in the country as a whole. The crude birth rate (CBR) is only slightly reduced by the epidemic and only the CBR with AIDS is shown on the graph.

Figure 4. Projected Urban Population: 1990 to 2015



Since, in this scenario the majority of the epidemic occurs in urban areas, the impact is also concentrated there. Figure 4 shows the increase in population with the epidemic and without. By the end of the projection period the urban population is approximately one-third smaller than was projected without the epidemic. The population growth rate for urban areas in the last 5-year period of the projection is nearly one percentage point lower than without the epidemic. Again, this decrease in growth has been brought about through increases in the number of deaths. At 22 per 1,000 population, the crude death rate in urban areas is more than twice the level expected without the epidemic. Figure 5 shows the trend in vital rates for urban areas.

Life Expectancy and Number of Deaths

As evidenced in the crude death rate, the AIDS epidemic makes its presence known in increasing the number of deaths. Figure 6 shows the trend over time in the composition of deaths in the total population. Non-AIDS deaths initially grow with increasing population size, and then gradually decline as projected improvements in non-AIDS mortality overcome the

Figure 5. Projected Vital Rates, Urban: 1990 to 2015

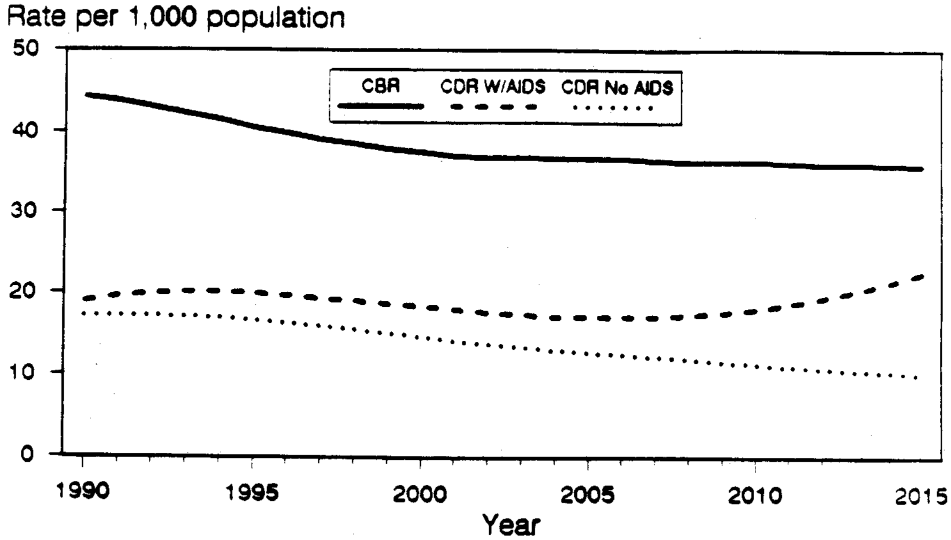
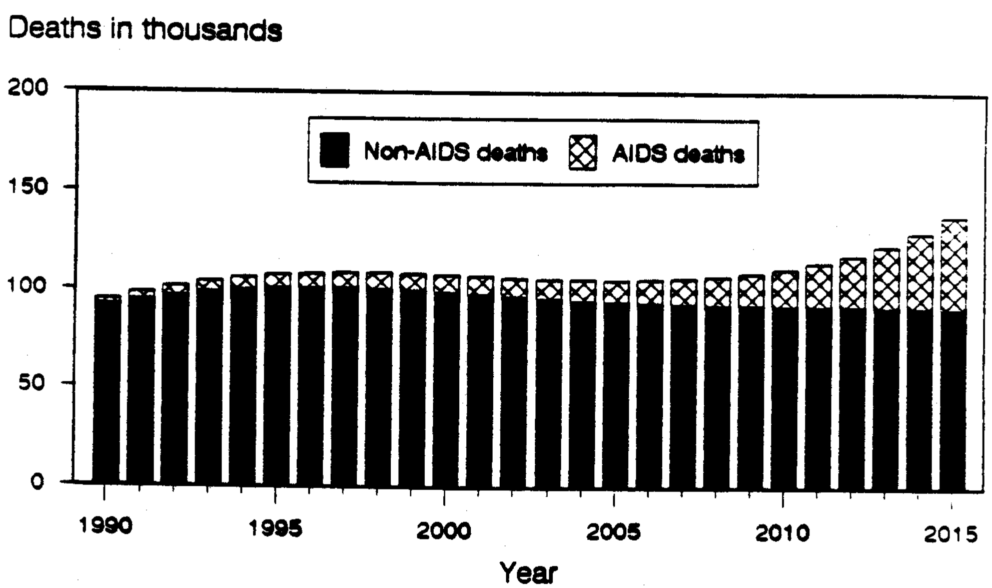


Figure 6: Projected Deaths, Total: 1990 to 2015



population-size effect. AIDS deaths, on the other hand, steadily increase in the projection period, as noted above. This results in an increase of more than one-third in the number of deaths. By 2015 the model shows a total of nearly 138 thousand deaths occurring (13.8 million in subSaharan Africa) annually—nearly 46 thousand (4.6 million) of these are AIDS deaths.

Initially, approximately two-thirds of the AIDS deaths are occurring in urban areas compared with 20 percent of the non-AIDS deaths. By 2015, 57 percent of AIDS deaths occur in urban areas. At this time, 58 percent of the urban deaths are AIDS deaths (see Figure 7).

What impact do these deaths have on levels of life expectancy of the population? Figure 8 graphically shows the impact of AIDS in urban areas on projected levels of life expectancy. With no AIDS, life expectancy at birth increases from around 50 years in 1990 to 58 years in 2015. Urban life expectancy is already affected by the AIDS epidemic in 1990 when life expectancy is about 47 years. The impact of AIDS on urban life expectancy increases with the increase of the epidemic. By 2005, when urban seroprevalence is 6 percent, the deficit in life

Figure 7. Projected Deaths, Urban: 1990 to 2015

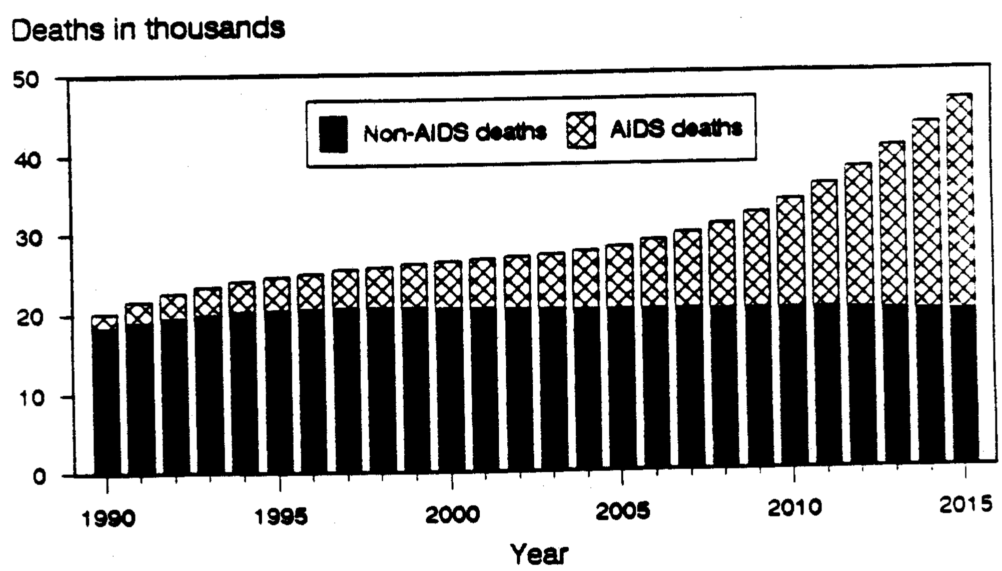
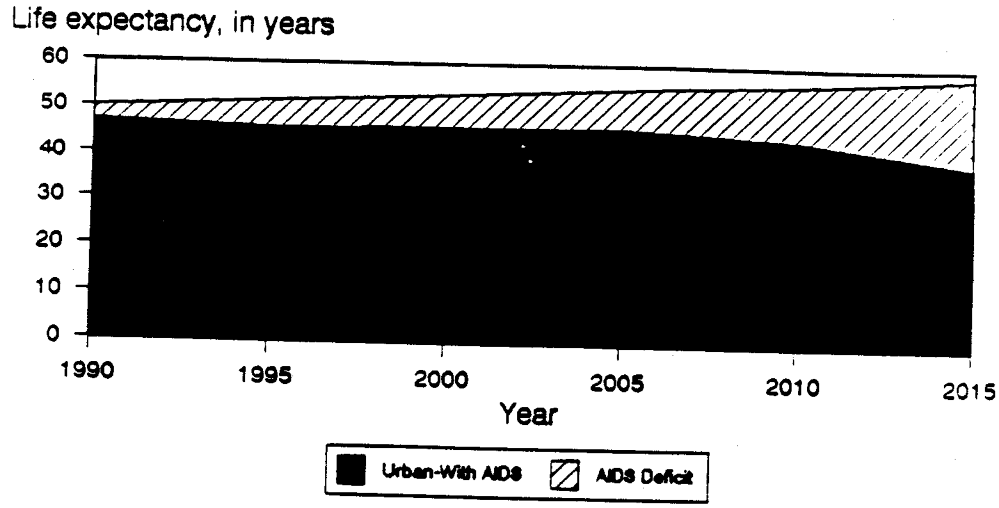


Figure 8. Urban Life Expectancy at Birth With and Without AIDS: 1990 to 2015



expectancy due to AIDS is 9 years. At the end of the projection period, when urban seroprevalence is 17 percent, urban life expectancy is 19 years lower than that projected in the absence of AIDS. This is a significant loss in life expectancy and is due to the fact that people are dying at younger ages. Age patterns of the mortality impact will be discussed further below.

Infant and Child Mortality

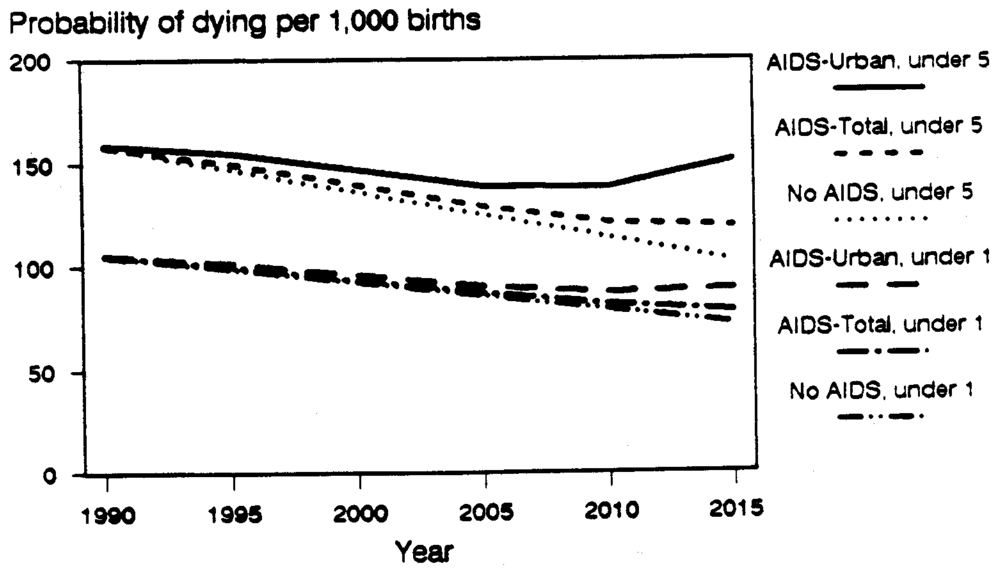
A major concern in discussions of the demographic impact of AIDS has been the impact on levels of infant and child mortality. Major international health programs over the past several decades have addressed the need to improve the survival chances for newborns. Since the AIDS epidemic in the African setting is predominantly heterosexual, with large numbers of women of reproductive age infected, many (nearly two-fifths) of the births will result in HIV infection of the newborn. Available studies show that the survival chances for these infected infants declines rapidly after the first year. Thus, the impact of the AIDS epidemic will be observed both in increased levels of infant mortality and also in levels of child mortality or mortality under age 5. An AIDS epidemic also has an indirect impact on infant and child survivorship through the creation of AIDS orphans.

Probabilities of survival from birth to 1 year of age (infant mortality, or ${}_1q_0$) and from birth to age 5 (${}_5q_0$) were chosen as the principal indicators, since they are both strictly probabilities of survival and can be readily compared. Figures on infant and child mortality for the total country and urban areas with the AIDS epidemic, and levels for the country without an epidemic are shown in Figure 9.

Infant mortality (IMR) in all three series begins at about 105 infant deaths per 1,000 live births and in the no-AIDS scenario declines to an IMR of about 73. In urban areas, there is also overall evidence of a decline, although IMRs are beginning to increase toward the end of the period. Infant mortality for the total country given the AIDS epidemic is slightly elevated relative to the norm.

When mortality under age 5 is examined, in contrast, the full impact of the epidemic on infants and children is evident. Mortality was expected to decline from about 159 deaths under age 5 per 1,000 live births to 102 with no AIDS. Instead, in urban areas, mortality levels off after about 15 years and increases in

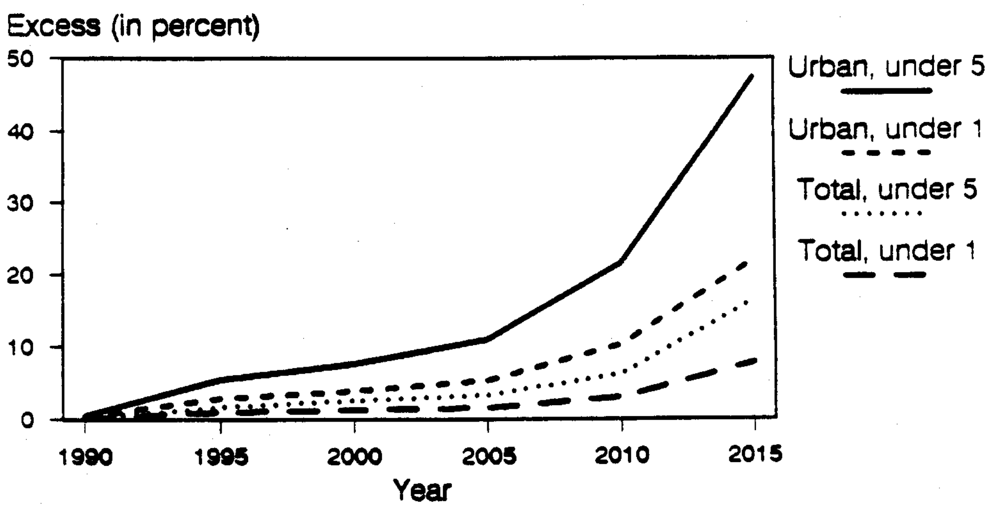
Figure 9. Impact of AIDS on Infant and Child Mortality, Total and Urban: 1990 to 2015



the last 5-year period, ending the projection period at 151 deaths under age 5 per 1,000 live births. The impact of the largely urban epidemic on the overall survival of infants and children in the total country is also evident.

Figure 10 shows the mortality rates for infants and children in the total country and urban AIDS scenarios relative to the level without AIDS. By the end of the projection in 2015, urban infant mortality levels are 22 percent elevated relative to the norm. Overall mortality under age 5 is even more affected, reaching a level 47 percent above the non-AIDS scenario. Nationally, infant mortality increases 8 percent due to AIDS while child mortality is elevated by 16 percent.

Figure 10. Relative Excess of Infant and Child Mortality Due to AIDS, Total and Urban: 1990 to 2015

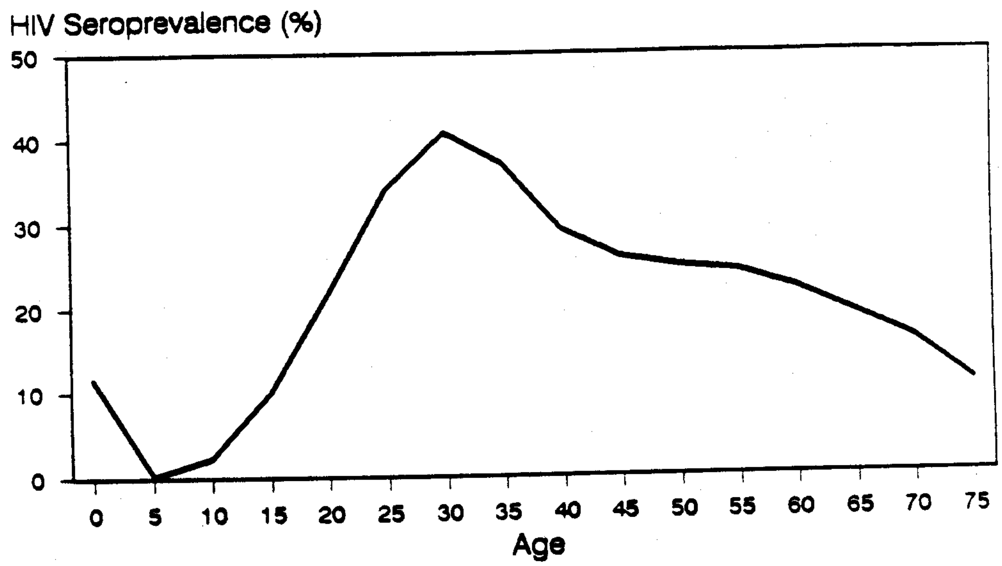


Age Patterns

An important consideration in the examination of the impact of the AIDS epidemic on the population of a country is the effect on different age groups in the population. Given the predominant transmission of the virus through sexual contact and from mother to infant, *new* infections will tend to be concentrated among young adults and children. The long period of incubation, on the other hand, will mean that the age patterns of *current* infection and mortality will be somewhat shifted from these points and will be more diffused through the age distribution.

HIV Seroprevalence. Figure 11 shows the age pattern of HIV seroprevalence in the population at the end of the projection period (2015). Whereas the overall level of infection in the population is almost 17 percent by this point in time, infection is well over 30 percent in those aged 25 to 39 years in urban areas and the overall infection level for the urban population 15 to 45 years of age is 26 percent. At ages over 30, infection levels decline due to differences in behavior in these ages and the cumulative impact of AIDS mortality on those infected at younger ages.

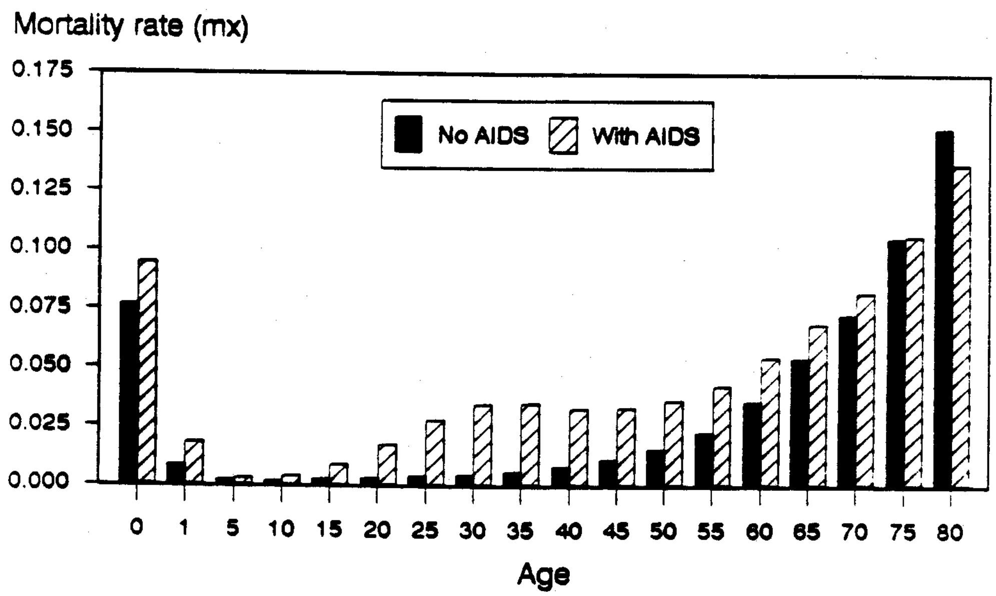
Figure 11. Percent Infected, by Age, Urban: 2015



Infection levels for those under 5 years of age are elevated relative to older children. Infection is passed to 39 percent of the infants born to infected mothers, but most of these infected infants do not survive to their fifth birthday. Thus, in urban areas, nearly 12 percent of the children under 5 years are infected, reflecting the infection levels among women of childbearing age. In the country as a whole, infection levels for children under 5 years are around 4 percent.

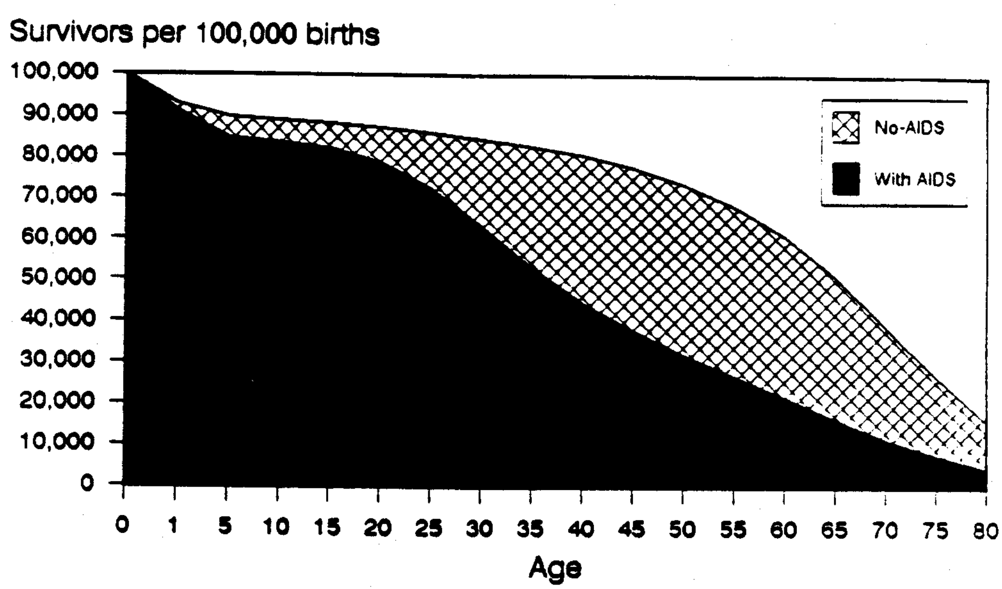
Age Patterns of Mortality. The impact of the epidemic on levels of infant and child mortality and life expectancy have already been discussed above. Figure 12 shows the impact of AIDS on mortality rates for the year 2015 across the entire age spectrum. Again we see that the epidemic strikes hardest the youngest and those in the middle adult years. Levels of mortality for those under 1 and under 5 years are elevated, as has been discussed above. In the middle adult years, the effect of the epidemic can be seen in increasing the expected mortality levels by a factor of 6 or more in some ages. Across the adult ages, mortality increases rapidly and then plateaus through the ages from 30 to around 50 years. In contrast, mortality expected in the absence of AIDS in these ages is a low and slowly increasing level. Approximately 12 percent of the population would be expected to die between their 15th and 45th birthdays. Instead, with the level of AIDS found in urban areas in 2015, over 54 percent of those reaching age 15 will not live to their 45th birthday.

Figure 12. Urban Age-Specific Mortality Rates, AIDS and No-AIDS Scenarios: 2015



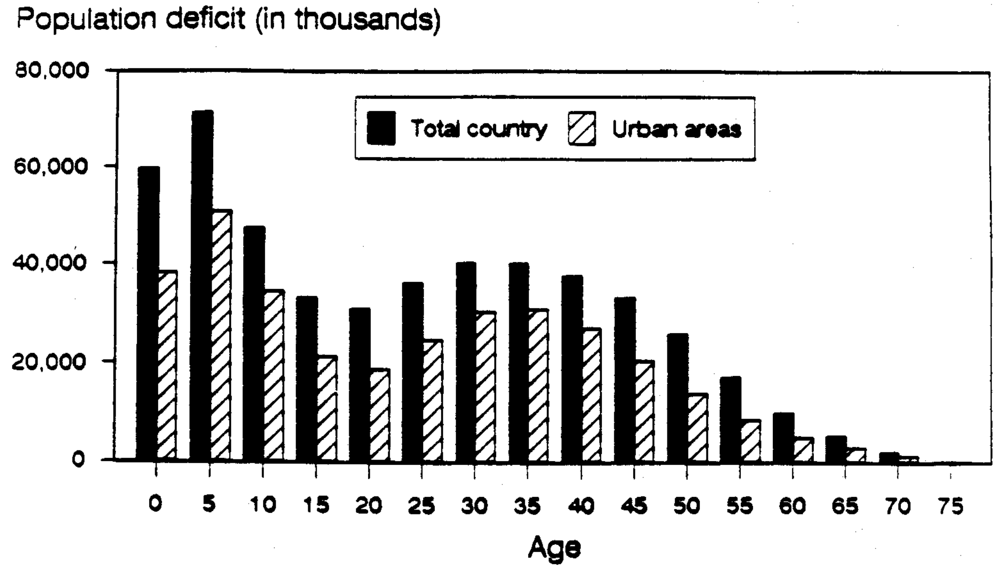
The age pattern of mortality in Figure 12 is, in fact, the reason for the substantial impact of the epidemic on expected levels of life expectancy by the end of the projection period. Deaths occurring to children and young adults have a much stronger influence on overall levels of life expectancy than do deaths at the upper range of the age distribution. By cutting a broad swath through the survival curve from birth to the oldest ages, the impact of AIDS is to greatly reduce the aggregate number of years of life expected in a population. Figure 13 graphically portrays the cumulative impact of AIDS mortality. By age 45, the number of survivors is less than one-half that expected without AIDS.

Figure 13. Urban Survivors per 100,000 Births, AIDS and No-AIDS Scenarios: 2015



Deficit of Population Due to AIDS. An adjunct consideration to the discussion of the impact of AIDS on the size of the population at the end of the projection period is the comparison of the final population, in terms of age, with that projected without AIDS. The age-specific differences represent the deficit of population due to the AIDS epidemic. Figure 14 shows this deficit for the country as a whole and for urban areas in the year 2015. In general, these deficits resemble a graph of the population itself. A moment's consideration suggests why this is so. Since the epidemic is protracted in time, with deaths

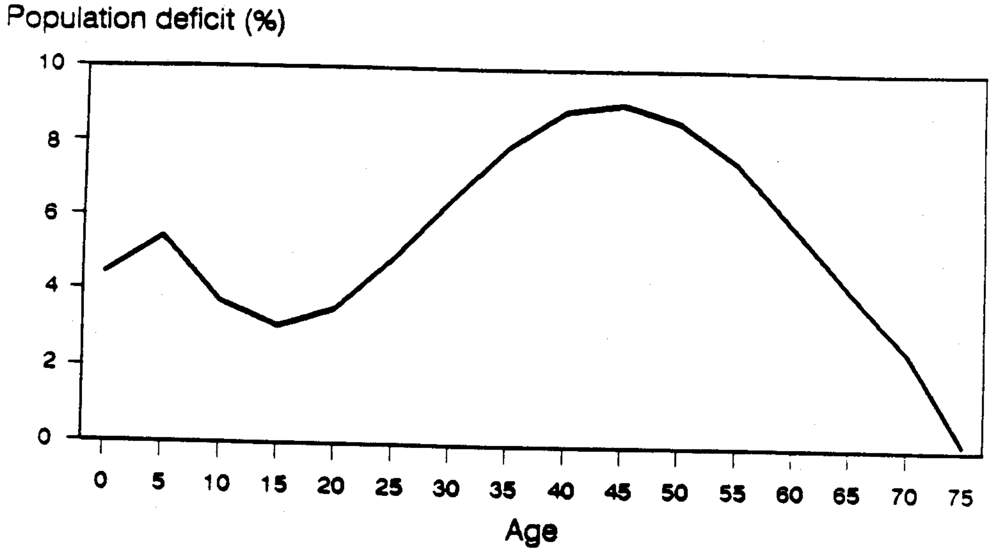
Figure 14. Deficit of Population Due to AIDS, by Age, Total and Urban: 2015



occurring across time and across all age groups, the impact after 25 or more years has also been distributed across these ages. There are fewer children due both to AIDS mortality and to the reductions in the numbers of potential mothers in the absence of AIDS. In addition, there are fewer adults overall, due to both the reduced survival of births and due to adult AIDS mortality.

The lack of any dramatic and concentrated age impact is perhaps one of the initial surprises of the impact of AIDS, particularly in relation to other epidemics which may have a more pronounced effect. For example, the effect of the widespread influenza epidemic of 1918 can still be seen in the population pyramids of many countries. The difference with the AIDS epidemic will be its more protracted time scale and the increase of mortality rates across a broad age spectrum. The deficit of total population due to AIDS expressed as a percent of the expected population is shown in Figure 15. We see the broad impact of AIDS on the population with some concentration of impact on the middle adult ages.

Figure 15. Percentage Population Deficit Due to AIDS, by Age, Total: 2015



Indeed, reflecting the broad deficit of population shown in these figures, gross measures of population age distribution, such as the dependency ratio, show very little impact of the AIDS epidemic. The dependency ratio in 2015 with the AIDS epidemic is virtually identical to that without AIDS. Overall, there are 77.5 persons under 15 or over 65 years per 100 persons 15-64 years of age with the AIDS epidemic. Without AIDS, this figure is 76.5. The epidemic in urban areas raises the dependency ratio to 79.0; still a modest increase considering the size of the epidemic.

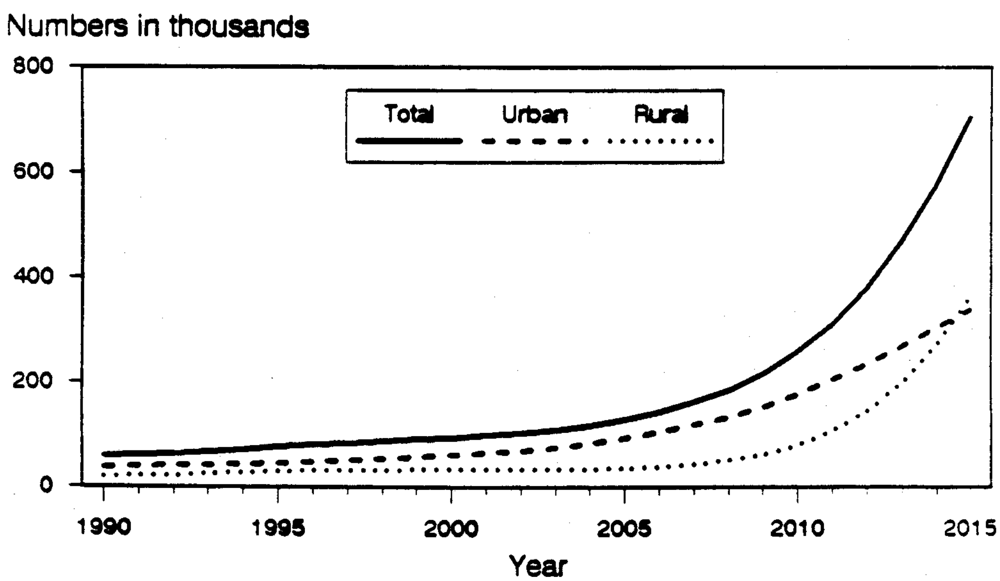
Epidemic Measures

Beyond the results already discussed, another aspect of the AIDS epidemic in this typical African country is the outcome in terms of numbers infected, numbers of new infections, and numbers of AIDS cases. These measures are important in understanding the potential impact of an AIDS epidemic on the health system, for example, and for grasping the sheer size of this epidemic. In order to maintain the linkage to the projection for the entire subSaharan region, the inflated regional figures are shown in parenthesis.

Number Infected. The level of infection in the population has already been discussed in terms of the percent of population infected. In this typical African country of 5.4 million (543 million) population in 1990, the initial seroprevalence level corresponds to about 59 thousand (5.9 million) persons, two-thirds of whom are in urban areas (see Figure 16). Over the 25-year projection period, the number infected increases by a factor of over 12—to over 700 thousand (70 million) infected in the year 2015. The doubling time for the infected population is 7 years. Due to the acceleration of the epidemic in rural areas in the latter part of the projection, by the year 2015 the infected population is about equally divided between urban and rural areas.

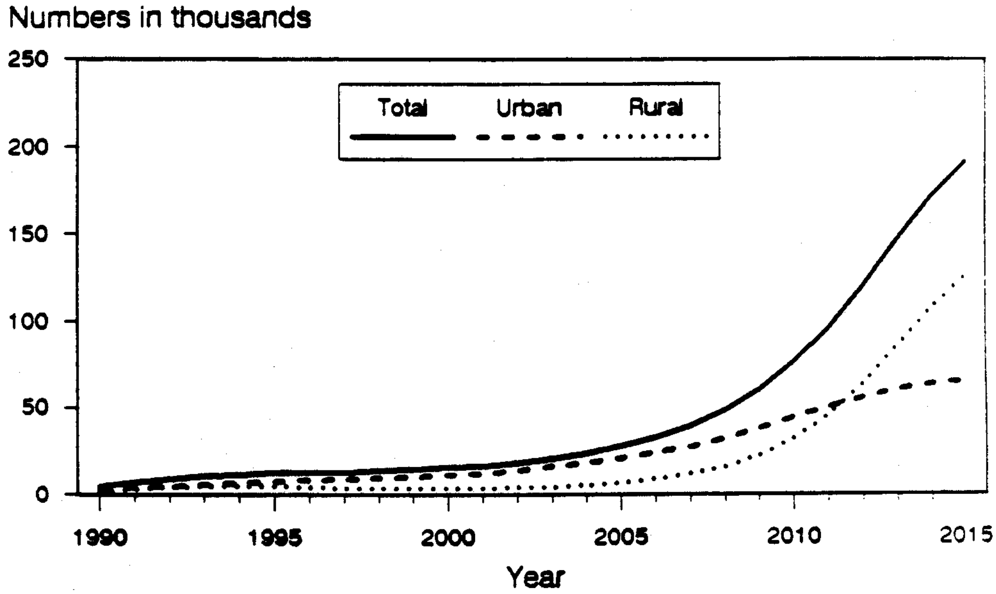
Number of New Infections. New infections "feed" the epidemic, replacing those who die and contributing to growth in the number infected. The number of new infections, then, is a measure of the growth of the epidemic. More importantly, however, this number is an indication of the potential target for reducing the epidemic. Those already infected are beyond measures aimed at prevention. But the annual number of new infections represents ineffective prevention, and thus can provide a target for prevention measures.

Figure 16. HIV-Infected Population, by Region: 1990 to 2015



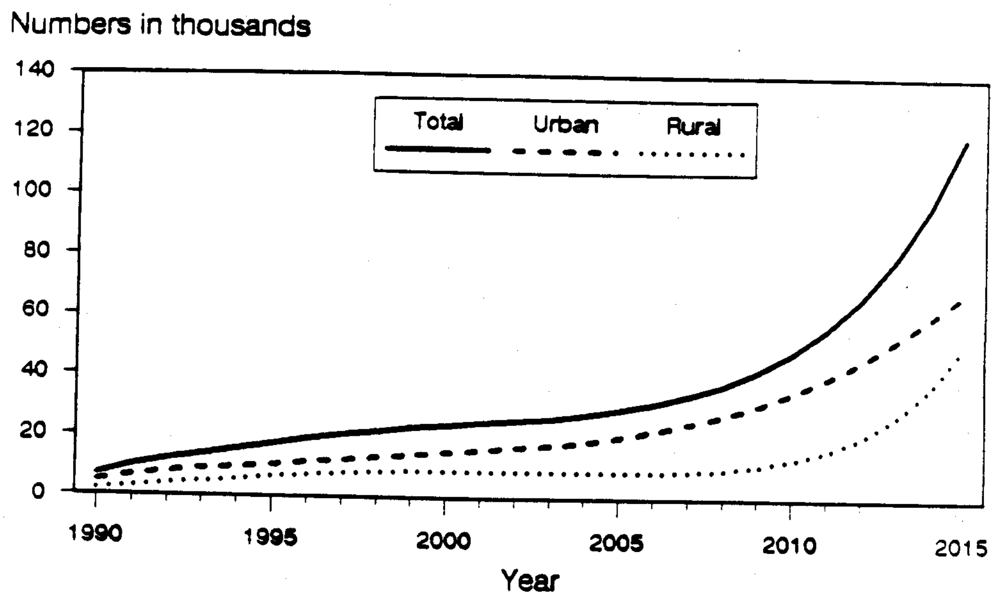
At the beginning of the projection period in 1990, over 5 thousand (500 thousand) new infections are shown in the results of the model; two-thirds of these are in urban areas (Figure 17). At this early point, the strength of the epidemic growth in urban areas is evident. Infections continue to grow over the 25 years of the projection, but in urban areas new infections are leveling off by the end of the period, while new infections in rural areas are increasing strongly. By 2015, nearly 200 thousand (20 million) new infections are occurring annually, and two-thirds of these are in rural areas. By 2015, 125 thousand (12.5 million) new infections a year are occurring in rural areas.

Figure 17. New HIV Infections, by Region: 1990 to 2015



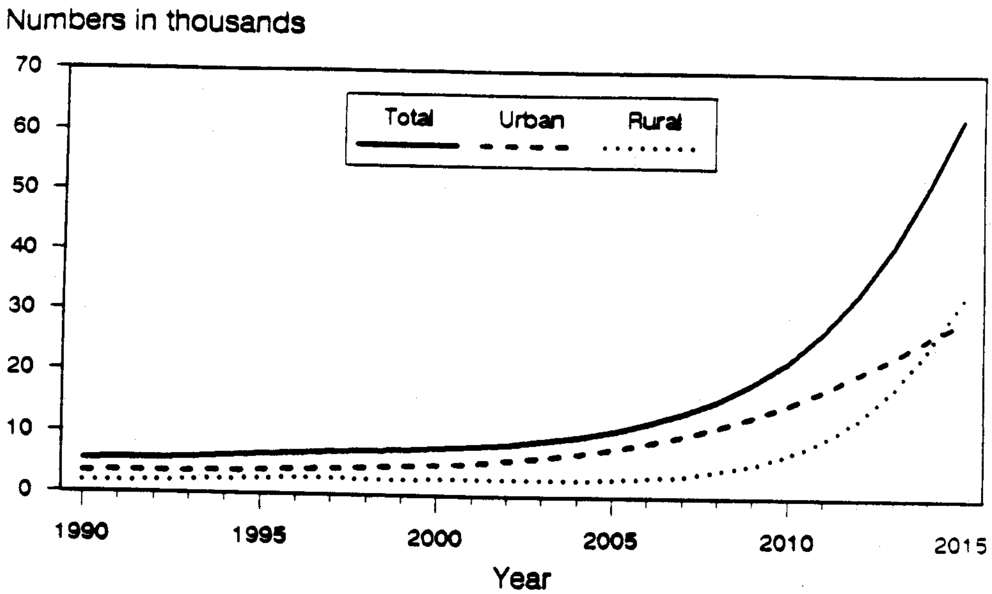
Number of AIDS Cases. The final measures of the epidemic to be discussed are the number of new AIDS cases in the population and the population currently with AIDS. These measures are perhaps the best by which to gauge impact on the health care system, since these persons are the most likely to seek and to need attention by the health care system.

Figure 18. Current AIDS Cases, by Region: 1990 to 2015



In 1990, the model shows 7 thousand (700 thousand) AIDS cases in the population. Nearly 5 thousand (500 thousand) of these are in urban areas (See Figure 18). The number of AIDS cases increases over the projection period to over 120 thousand (12 million) AIDS cases in the country in 2015. At this point in time about three out of every five are in urban areas reflecting again the stronger urban epidemic, particularly in the early years of this scenario. In rural areas the number of AIDS cases increases and then declines as a result of declining numbers of new infections during the early years of the projection. In the last decade of the projection, rural AIDS cases are increasing rapidly, reaching 51 thousand (5.1 million) in 2015. The lag resulting from the extended incubation period can be seen in a comparison of the timing of rural increases in new infections (see Figure 17) and AIDS cases (see Figure 18).

Figure 19. New AIDS Cases, by Region: 1990 to 2015



Given the short life expectancy following the development of AIDS, the relationship between new AIDS cases and the current population with AIDS is quite direct and exhibits little of the lag seen previously with new infections and infected populations (see Figure 19). The population with AIDS tends to be about twice the number of new infections. Since the epidemic is growing more rapidly in rural areas, by the end of the period, more new AIDs cases are occurring in rural areas than in urban areas.

PROGRAM INTERVENTIONS

A number of interventions can halt or decrease the spread of HIV infection. Information, education, and communication (IEC) programs that promote behavioral changes and increased condom use are important tools in the control of HIV spread. On the medical side, blood screening and the control of sexually transmitted diseases (STD) can also help prevent the spread of HIV infection.

What interventions are most cost effective for countries with very limited budgets? The following is a description of four different possible interventions to be implemented in the 1990-95 period to stop or decrease the spread of HIV infection in the population. They are:

- The promotion of condom use that results in the participation of a certain percentage (5 to 25 percent) of urban women by 1995;
- An STD control program that reduces the duration of STDs (5 to 25 percent) in the urban population by 1995;
- An information, education, communication (IEC) program that reduces the amount of casual sex in the urban population (5 to 25 percent); and
- A 100-percent blood screening program that becomes completely operational by 1995.

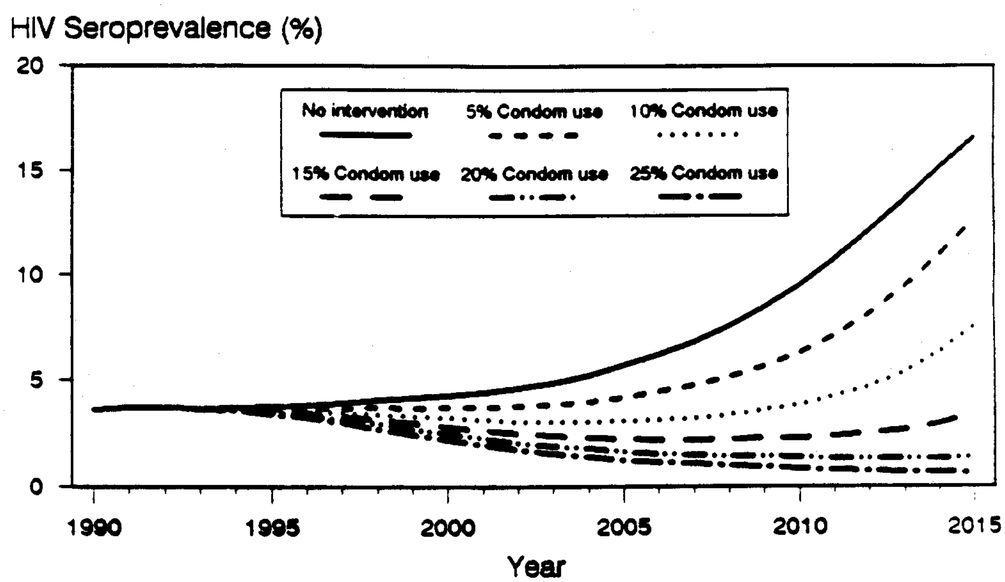
Condom Use

One of the interventions that can be used by a country is the promotion of the use of condoms. Condom distribution provides a means of HIV prevention for individuals who are at risk of contracting and transmitting HIV infection because of their sexual or drug-using behavior. Condom use is very low at present in African countries (See Appendix A).

In this example, we have modeled a 5-year program of condom promotion which begins in 1990 and is fully operational by 1995. We look at various program goals of condom use by 5 to 25 percent of urban women. In 1990, 0.4 percent of the urban women and men use condoms.

With no intervention, the model projects the prevalence rate of HIV infection by the year 2015 to be about 17 percent in the urban areas. With increased use of condoms by the urban population we see a decrease in the epidemic (See Figure 20). Starting with an intervention program that results in the use of condoms by 5 percent of urban women, the model projects an overall prevalence rate of less than 13 percent in the urban areas. An intervention that results in condom use by 25 percent of the urban women results in a declining epidemic with an urban prevalence rate of 0.6 percent by the year 2015.

Figure 20. Projected Urban HIV Seroprevalence Rate--Condom Intervention: 1990 to 2015



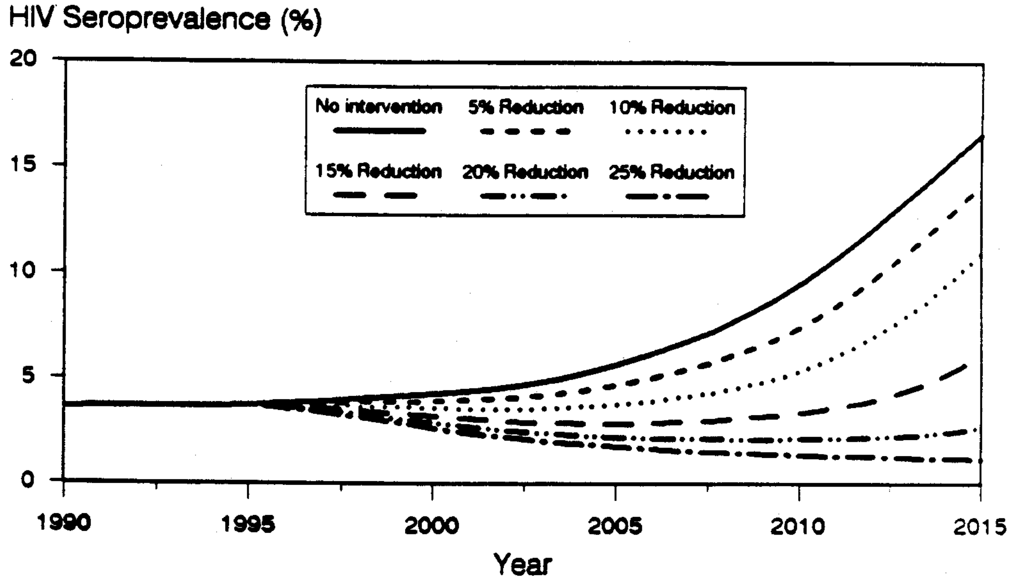
STD Control

The second intervention modeled is a program to control STDs. It has been shown that infection by an STD increases the risk of HIV infection. In an attempt to reduce the risk of HIV infection, an intervention program could be put in place to reduce the duration of STD infection. (This would come about through earlier treatments of STDs and an adequate supply of medications.)

In this example, we examine the impact of reducing the duration of urban STD infection from 5 to 25 percent from the initial levels of 2 months for urban males and 2.5 months for urban females.

A 5-percent reduction in the duration of STDs in urban areas results in a 2-percentage point drop in urban seroprevalence levels in 2015—from 17 to 15 percent (see Figure 21). Larger reductions in STD duration result in progressively larger decreases in seroprevalence levels in 2015. However, even with a 20-percent reduction in the duration of urban STDs, the urban AIDS epidemic shows signs of growth toward the end of the projection period.

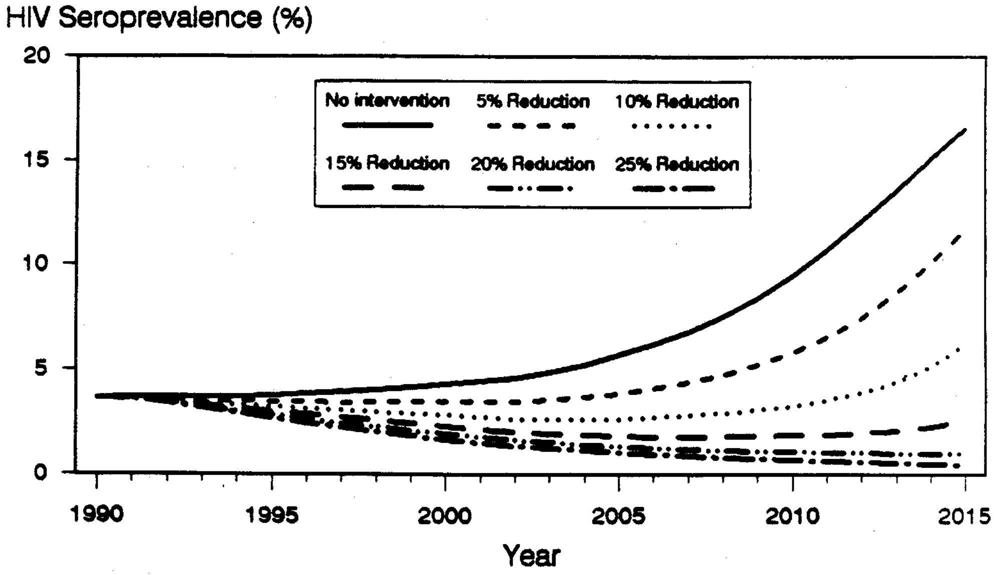
Figure 21. Projected Urban HIV Seroprevalence Rate--STD Duration Intervention: 1990 to 2015



Reduction in Casual Sex

Another potential intervention is an information, education, and communication (IEC) program with the goal of reducing the amount of casual sex. The model defines casual sex as the number of sexual contacts outside of marital sex. In this example we reduce the amount of casual sex in the urban areas by a range from 5 to 25 percent.

Figure 22. Projected Urban HIV Seroprevalence Rate--Casual Sex Intervention: 1990 to 2015



An IEC program with the effect of reducing casual sex in urban areas by 5 percent would result in a prevalence rate reduction for the year 2015 of nearly five percentage points. In the urban areas, instead of a rate of 17 per 100 population, the model projects a prevalence rate of around 12 for the year 2015 (see Figure 22). Under these model assumptions, a reduction of 15 percent or more in casual sex would be required to see a decline in the epidemic.

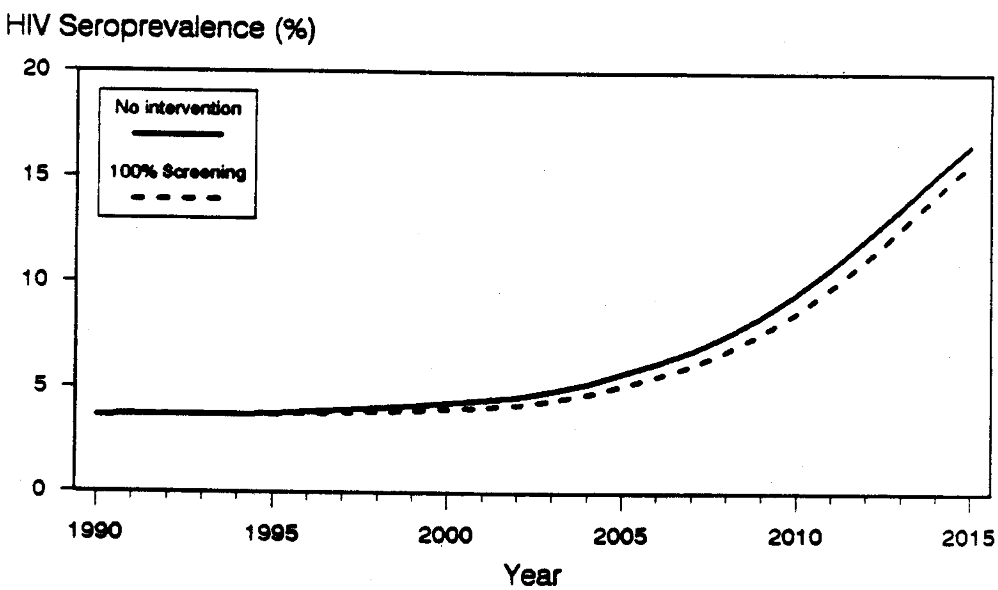
A comparison of the results of the condom, STD, and casual sex interventions suggests that all three of these interventions have the potential to dramatically change the course of the epidemic, at least in the scenario presented here. The relative payoffs for a given level of change differ somewhat among the three alternatives, with changes in the level of casual sex appearing to have a slightly higher impact. However, a balanced program of interventions will likely include projects aimed at all three of these areas. Different populations may be reached by each of the interventions and the cost and feasibility of achieving a target level of change may well differ.

Blood Screening

What are the costs associated in establishing a national blood screening program; constructing laboratories, training the staff and establishing the infrastructure to screen 100 percent of blood? What would be the results of a 100-percent blood screening program? Would the money that is available to these countries be better spent in another intervention?

Using the iwgAIDS model, an intervention to screen 100 percent of the blood is introduced in 1990 and will be completely operational by 1995. The model shows little impact on the growth of the epidemic (see Figure 23). With a 100-percent blood screening program in place by the year 1995, the urban prevalence rate for the year 2015 is projected to be reduced by less than 1 percentage point. Therefore, for the amount of money spent to develop the blood screening program, very little impact is projected.

Figure 23. Projected Urban HIV Seroprevalence Rate--Blood Screening Intervention: 1990 to 2015



This is not to say that countries should not institute procedures to protect their blood supplies. There are particular age groups that are at greater risk for HIV infection because they receive high levels of transfusions such as children less than 15 years of age for malaria treatments. This group is not yet at risk for HIV infection through sexual transmission. Medical centers should review their blood screening practices and strengthen blood donor recruitment programs in order to discourage those practicing high-risk behaviors from donating blood. They should review requests and treatment procedures that require blood transfusions in an effort to reduce the number of transfusions performed unnecessarily. However, putting all available health funds into establishing a 100-percent screening program may not be as cost effective as other types of interventions, as described above.

IMPLICATIONS

The results presented above have important implications for the majority of subSaharan African countries in which the AIDS epidemic can be considered a major concern. Whether current seroprevalence levels are 5, 10, or 20 percent among sexually-active adults, the results of the application of the iwgAIDS model to this typical African country suggest that HIV infection and AIDS are currently having substantial impacts on the populations of these areas. Furthermore, without considerable behavior change there is little reason to think that the epidemics in many countries will not continue to grow.

In this report we have only begun to examine the impact of AIDS on this typical country; much detail has been omitted in order to focus on the broad aspects of the demographic impact. Subsequent analyses will examine a number of these areas in more detail. In particular, an analysis of the economic impact of the epidemic is currently planned, based on the epidemic in the typical African country described in this report. A more detailed look at the impact of various interventions and an examination of the impact at higher levels of the epidemic are other possibilities.

Nevertheless, the results described in this report can be seen to have implications in a number of areas, including:

- Population growth and family planning;
- Infant and child mortality;
- Family structure and AIDS orphans;
- Provision of health care;

- Urbanization and migration; and
- Labor force and human resources.

The implications relate not only directly to these sectors of the economy and society, but also have relevance for those planning programs and policies that relate to these areas. AIDS epidemics will force policy planners and program planners in many areas to explicitly take the impact of the epidemic into account.

Population Growth and Family Planning

Population growth in African countries will continue to be a development issue into the foreseeable future. AIDS epidemics can cause huge increases in the death rate in affected areas. The urban crude death rate more than doubled in the current scenario, for example. However, the majority of African countries have large excesses of births over deaths. National death rates would have to increase by factors of three to four or more to raise death rates to the level of current fertility. In the scenario presented in this report, urban rates of natural increase continued to be positive despite HIV infection rates of over 30 percent in young adult ages. Furthermore, the epidemic pattern shown in virtually all African countries is for much lower rates of infection and likely slower epidemic growth in rural areas. Even in Uganda, a country hard hit by the AIDS epidemic, average infection levels outside the capital are less than half those recorded in Kampala.

Thus, African populations, particularly in rural areas, will continue to grow. And they will grow at relatively rapid rates; even those countries most affected by the AIDS epidemic will probably continue to grow at rates of 2 percent or more.

Family planning programs in developing countries have been promoted based on a number of benefits that accrue to the household as well as to the society at large. Important health benefits for both the mother and child, for example, result from increased birth intervals. Per capita family resources for food and education are increased through smaller family size. Parents should have the freedom and the means to choose to limit their family size. These and other important benefits to households will continue, even in the face of an AIDS epidemic.

Furthermore, in households in which one or both of the spouses are infected by HIV, family planning methods provide the means to decide not to have an additional (possibly HIV-infected) child, or the means to limit, through the use of a condom, the potential transmission of HIV. These choices are also important to maintain.

Clinics and other outlets where family planning information and supplies are available may also be places where information on other aspects of reproductive health, including AIDS, other STDs and the risk of perinatal transmission, should be made available.

Infant and Child Mortality

Throughout the developing world, programs and policies are in place to enhance the survival chances of infants and children. In a region in which the average infant mortality claims about 10 percent of births in the first year, African countries have devoted large amounts of resources to improving these conditions.

AIDS epidemics in Africa threaten to reverse the trend toward declining mortality levels for infants and children. In the scenario presented in this report, urban infant mortality was increased by 22 percent, and mortality under age 5 by over 47 percent. These increases correspond to more than a decade's effort to improve mortality levels.

The disproportionate amount of AIDS mortality concentrated in the ages 1 to 4 years should be noted. Strict measures of infant mortality may not capture the full impact of the AIDS epidemic on the survival of these children.

The AIDS epidemic may have indirect effects on infant and child mortality as well. Mothers who are suffering from HIV-related illnesses may not be able to care adequately for their young. Relatives and friends may be reluctant to assist, for fear of themselves becoming infected.

Many development programs in the areas of health and nutrition use as measures of program success the level of infant or child mortality. To the extent that AIDS mortality is increasing these levels, they will become less useful measures of program effectiveness in other areas.

Family Structure and AIDS Orphans

The integrity of the family will be severely taxed in an extensive AIDS epidemic. Mothers and fathers will fall victim to premature death and leave behind broken families and both the young and the elderly not able, perhaps, to care for themselves. Although the African family has traditionally adapted to these stresses through the extended family network, reports from some regions in Africa suggest that even these mechanisms are becoming overloaded by the extent of the AIDS problem. This may be true both in urban areas, where extended families may be less viable, as well as in hard-hit rural areas where several units of the same extended family may suffer AIDS losses.

The AIDS epidemic leaves orphans in its wake. Since two-thirds of births to infected mothers are themselves not infected, an infected mother may leave 2 to 3 surviving children when she dies. Again, traditional African fostering practices have provided in the past, but may not be able to cope with the problem in severely affected areas. Fear of infection and misinformation concerning HIV transmission may limit the attractiveness of caring for these AIDS orphans.

Provision of Health Care

The impact of an AIDS epidemic on the provision of health care in African countries may be difficult to gauge, since the coverage of the health care system is far from complete. Many of those in need of health care simply do not have access to it. There can be no doubt, however, that an AIDS epidemic can strain the ability of the system to function. Studies in several urban areas in Africa have shown already a large proportion of those in the hospital are AIDS patients.

Not all of the burden of health care in Africa falls on the formal sector. Family members are important health care providers to many, especially in rural areas. The presence of sick and dying household members will likely have large direct and indirect effects on household income. Direct costs include the cost of food and medication, while indirect costs result from lost earnings or production by the care giver.

In urban areas, not all of the sick and dying will be visible. Many of those who fall ill return to their rural homelands for family care. This may be particularly true of young urban migrants. To the extent that this occurs, the mortality of urban residents will be less visible, since many will actually die in rural areas. This will serve to mask some of the effect of the AIDS epidemic.

HIV infection and AIDS increases the susceptibility of the host to other diseases, including tuberculosis (TB). Dramatic increases have been recorded in those areas of Africa where TB reporting is good and where HIV infection is increasing. Increases in the incidence of other opportunistic infections will also result from elevated HIV infection levels.

Urbanization and Migration

Urbanization is an important population dynamic in developing countries, especially in Africa. The migration of rural population to the cities has been a critical factor in the growth and economic vitality of the cities of the region. Migrants tend to be better educated than their non-migrant rural counterparts and contribute their young, educated enthusiasm toward economic activities in the city.

This migration of young adults to urban areas, however, can be considered to be a contributor to the AIDS epidemics now evident in Africa. Young adults, without family ties, are more likely to have multiple sexual partners and are among the earliest population group to become infected in an AIDS epidemic.

A major AIDS epidemic in urban areas may affect the migration and urbanization process in several ways. To the extent that the epidemic increases mortality, the growth and development of urban areas may be slowed. The potential reaction to this change will depend to a great extent on the public perception of the cause and of the situation in urban areas. Increased demand for workers in cities may increase the flow of migration to the city—in effect to fill the spaces vacated by those taken by the epidemic. However there is also some risk that, as the epidemic increases and matures, rural populations may come to view the cities as "places where people get AIDS and die." This may reduce the propensity to migrate to the city and create localized labor shortages despite excess population in rural areas.

Currently, most urban areas in Africa are characterized by an excess supply of labor, resulting in substantial levels of underemployment. This excess population is available to compensate for AIDs deaths in urban areas, at least initially.

Labor Force and Human Resources

The broad impact of an AIDS epidemic on the age structure has been examined above. The net loss of population by the end of the projection interval, compared with the non-AIDS situation, was distributed across age groups. This is due to the variation in the age at the time of infection and the long incubation period for the virus. The effect on labor force and the human resources situation in a country is in some ways very simple and in others rather subtle.

The simple impact results from the loss of population—0.5 million in our scenario. This loss results from actual AIDS deaths and the loss of births due to the death of their potential mothers.

The more subtle impact of the AIDS epidemic on labor force and human resources comes from an examination of who dies and where. Our discussion of AIDS mortality has shown that the AIDS deaths are occurring to those in the most productive years of life—their 30's and 40's primarily. Thus, each death robs the society of these productive workers and also eliminates their potential future contributions. With an extended AIDS epidemic, the labor force will become less experienced.

DATA INPUT FOR THE IWGAIDS MODEL

This section describes the data and parameters used as input to the iwgAIDS model. In keeping with the approach of this paper, the inputs reflect regional levels (particularly of the demographic variables) are drawn from a variety of countries in the region, or are thought to be the best available parameters describing the transmission and natural history of HIV-related disease. The discussion of each particular input includes a description of the data, a review of available data, and the presentation of the particular values used in this application. Data are divided into demographic, behavioral, disease-related, and other parameters.

Demography

1. **Initial Population.** The initial population is input by age, sex, and urban/rural residence. This input provides the population base for the demographic and epidemiological processes of the model. Many subsequent parameters are input as proportions of the population, thus avoiding repeated calculations.

Modelers examining the potential impact of AIDS on populations in Africa have generally used a "stable" population age structure (e.g., Bongaarts, 1989). A stable population is one which has been characterized by an extended history of constant fertility and mortality, thus giving the age distribution a regular and predictable pattern. We know, however, that demographic parameters in Africa have not been constant over the past 40 years or more. Although fertility levels have not declined significantly in many areas, mortality conditions have been improving in most countries. Thus, a stable population assumption for the initial input may not be the best.

The population age structure used in this analysis is based on the projected 1990 midyear population for the entire subSaharan African region. This population is derived by aggregating individual national projections prepared at the U.S. Bureau of the Census (1990). The resulting population of 543 million persons was then scaled down to 5.4 million--1 percent of the total--while keeping the proportional distribution of population, by age and sex.

Urban and rural populations were derived using a figure of 20 percent urban. Among subSaharan African countries this proportion varies from 5 percent to over 50 percent in 1990, according to United Nations (1987) projections. Burkina Faso, Burundi, Malawi, Rwanda, and Uganda all have less than 15 percent of their population in urban areas, while Cameroon, Central African Republic, Congo, Cote d'Ivoire, and Zambia are more than

40 percent urban. The potential impact of internal migration on the urban age distribution was examined in a preliminary demographic projection of the population, using the urban-rural migration levels described below. The resulting proportional urban age distribution was affected to such a minor extent that it was decided to use the same input proportional age distribution for both urban and rural areas. The resulting population for each area, by age and sex, is presented in Table A-1.

2. **Levels and Trends in Fertility.** The iwgAIDS model, like most demographic models, requires the input of current and projected levels of fertility. Initial fertility levels are specified as age-specific fertility rates (ASFRs), per woman, for ages 15-19 through 45-49. Subsequent input specifies the total fertility rate for particular years of the projection. Initial ASFRs are adjusted to reproduce the desired total fertility rate level. By this method, the user may determine the exact pattern of fertility change, following a linear or other pattern of change to its ultimate level.

Input fertility patterns and levels were determined based on the aggregate total fertility rates from Census Bureau projections for subSaharan Africa. A standard age pattern of fertility was adjusted to reproduce the total number of births projected, based on the female population and the ASFRs. The age-specific fertility rates for 1990 and the projected total fertility rates for the 1990 to 2015 period are shown in Table A-2. No urban-rural differentials in fertility were assumed for the projection. Although, in reality, there is usually some difference.

3-4. **Initial and Projected Mortality Rates and Life Expectancy at Birth.** Input to the model for non-AIDS mortality is in the form of age-specific mortality rates (${}_nm_x$), by sex and urban/rural residence, for the initial and the terminal years of the projection. Thus, the user can allow for the expected change in the age pattern of mortality with increasing levels of life expectancy. Within the model, expected deaths based on these mortality rates are combined with those resulting from AIDS to give the total deaths in the country. AIDS deaths are determined by the model based on the infected population, time since infection, progression to AIDS, and survival after development of AIDS.

Life expectancy, by sex, for all of subSaharan Africa for 1990 as projected at the U.S. Bureau of the Census was used for the non-AIDS level of mortality. These projections do not take into account the possible impact of AIDS on mortality. The age pattern of mortality was determined by a comparison of the total deaths projected without AIDS and the number that would have been expected based on the projected level of life expectancy and several different "model" life tables. These model life tables include those originally developed by Coale and Demeny (1967) and life tables more recently developed by the United Nations (U.N.)(1982). An examination of the total deaths, infant mortality levels, and life expectancy suggested that the United Nations "general pattern" life table best conformed to the pattern of deaths projected for subSaharan African countries. Therefore, the U.N. general pattern life table with life expectancy levels of 50.4 years for males and 53.5 years for females was used for the initial mortality input. No urban-rural differentials in mortality were assumed for the projection.

Mortality for the terminal life table input (for the end of the projection period) was also based on the Census Bureau projections of life expectancy and the U.N. general pattern. Expected levels of life expectancy in the absence of AIDS was projected at 59.9 years for males and 64.5 years for females for 2015. Age-specific mortality rates, by age and sex for 1990 and 2015 as input to the iwgAIDS model are shown in Table A-3. Patterns of change in life expectancy, by sex, for the entire projection period are shown below:

YEAR	MALE	FEMALE
1990	50.4	53.5
1995	52.4	55.8
2000	43.3	58.0
2005	56.2	60.2
2010	58.1	62.4
2015	59.9	64.5

These expected levels of mortality will form the basis of comparison for examining the impact of the AIDS on mortality.

5. **Proportion Married (in Union).** The iwgAIDS maintains the categories of "married" and "single" (i.e., those in long-term partnerships and those not). Within the model, each of these categories is characterized by differing patterns of (sexual) behavior. Clearly, conceptualizations of behavior may be difficult to measure empirically, and self-reported information on marital status is not an ideal measure of this status. This may be particularly true in Africa where informal unions may be common and patterns of "trial marriages" prior to formalizing a union may be widespread. Nevertheless, reported information from censuses and demographic surveys provides the best available source of information on marital status and partner formation. It should be noted that official statistics on marriages conducted are not collected in many African countries, and may be of questionable completeness where collected.

For this study, marriage patterns, by age and sex, in three African countries (Burkina Faso, Malawi, and Liberia) were averaged to form a composite pattern of partner formation. Those in both formal and consensual unions were considered married. The median age at marriage for males in this composite pattern is around age 25 years, while, for females, it is approximately age 20. This pattern was used for rural populations. For the urban population, the proportion married was shifted 2.5 years older, corresponding to the generally observed pattern of later marriage in urban areas. Proportions married, by age and sex, based on this method are shown in Table A-4 for urban and rural areas.

6. **Spouse Age Preference.** Since the iwgAIDS model contains a dynamic marriage model, information must be provided on the preferred age difference between spouses and the distribution of this preference. During the projection run, new partnerships are formed based on these preferences and the availability of potential partners of the opposite sex.

Since the marriage information from various African censuses showed a 5-year difference in the median age at marriage, this 5-year differential was maintained in the preference function. Thus, males prefer a spouse on average 5 years younger than themselves. A standard deviation of 3 years was assumed for the distribution of preferences around this mean. This age differential was used for both urban and rural areas.

7. **Rates of Marital Disruption.** Rates of marital disruption, or divorce rates, are used by the iwgAIDS model to reflect the process of partnership dissolution. These data, however, are not readily available for subSaharan African countries. In fact, only Mauritius, Reunion, St. Helena, and Seychelles report the number of divorces to the U.N. (United Nations, 1989). These countries, however, are not typical of subSaharan Africa.

For purposes of this analysis, a modal divorce rate of 10 percent per year was assumed for both urban and rural areas. This figure is lower than levels reported for Egypt and Tunisia, although the religious and cultural differences between these two north African countries and subSaharan Africa are great. Divorce rates were assumed to decline with increasing ages over age 30. These figures are shown in Table A-5.

8. **Rates of Polygamy.** Many ethnic groups in Africa practice polygyny, that is, some men have more than one wife. Obviously, this practice affects the number of men and women in unions, as well as the rate of sexual contact between spouses. The iwgAIDS model allows for the user specification of levels of polygyny (or

polyandry) and adjusts the partnership formation and dissolution processes accordingly.

Based on the marital status data used as input, the rate of polygyny was estimated at approximately 1.3 wives per husband. This was derived as the simple average of the ratio, for each country, of the number of women in unions divided by the number of men in unions. For the three countries, the figures were 1.31 (Malawi), 1.44 (Burkina Faso), and 1.28 (Liberia).

9. Population Mobility. The iwgAIDS model incorporates several different aspects of the geographic mobility of the population. The first of these is the permanent (or semipermanent) migration of persons to and from the urban area. Since the characteristics of the migrant (including infection status) are important in determining the disease impact of the migrant on the destination, separate flows to and from urban areas are maintained. Most demographic models simplify this process by considering only net migration flows.

Rural-to-urban migration is the means by which levels of urbanization increase, since typically natural population increase in urban areas is no higher (and is often lower) than in the balance of the country. The initial demographic processes of births and deaths result in a population growth rate for this hypothetical country of slightly over 3 percent per year. Levels of migration between urban and rural areas were selected which resulted in an excess growth in urban areas of approximately 2 percent per year. Thus, the population growth rate in urban areas is about 5 percent per year, compared with around 3 percent for rural areas. The rates of migration which result in this growth are held constant over the projection period.

Migration to urban areas tends to follow a regular pattern by age, with peak rates in the young adult ages, followed by declines in the older ages. Rates for infants and young children are also elevated, since many migrants have offspring in these ages. Migration age patterns from urban to rural areas are typically less pronounced, and affect the population of older adults. Migration rate patterns from urban and from rural areas which corresponded to these overall trends were developed and were then adjusted to result in the desired level of net migration (approximately 2 percent per year) based on the initial input population. Rates of outmigration from urban and rural areas are shown in Table A-6.

The iwgAIDS model also allows for the specification of rates of circular migration. Circular migration, in concept, is the repeated seasonal migration of population from one area to the other, perhaps due to the need for agricultural labor in the rural areas and opportunities for cash income in the cities. It is potentially an important factor in the spread of infection between urban and rural areas. However, relatively few quantitative studies have been done on this type of population mobility, particularly in the African setting. For this reason, in this analysis the level of circular migration has been assumed to be virtually nil. Thus, the results do not consider the possible contribution of this factor.

For some countries, it is useful to include the effect of international migration on the size of the urban or the rural population. The iwgAIDS model allows for this demographic process, treating international migration as a net process. This assumes that the infection status and other characteristics of those entering or leaving the country are not known. Net international migration was assumed to be nil for this analysis.

The final migration process provided for in the iwgAIDS model is the adjustment of migration rates for those in different partnership status groups. Thus, the rural-urban migration rates for those, for example, currently in partnerships can be adjusted to be higher or lower, older or younger, than the norm. This allows for considerable flexibility in patterns of migration without the need to separately specify age-specific migration rates for each status group. For this analysis, migration rates were not adjusted for any status group.

Sexual Behavior

10. Proportions Engaging in Casual Sex. These proportions are used to estimate the population involved in high-risk behavior. These proportions are multiplied by the estimated population by age, sex and marital status. The rate of promiscuous behavior of the married female population is assumed to be low. This assumption is based on beliefs held by traditional societies that extramarital behavior of the wife is unacceptable.

The proportions input for this example are partly based on reported sexual behavior from a knowledge, attitudes and practices (KAP) study conducted in Kinshasa where 22.6 percent of the married men reported having extra-marital relations in the past 6 months and 1.4 percent of the married women reported the same (Bertrand et al.,1989). A survey of 711 currently married Zimbabwean men found that 40 percent of the men had sex partners in addition to their wife in the past year and that 29.4 percent had sex with a prostitute in the past year (Adamchak et al., 1990). The proportions were adjusted to maintain a balance between the number of high-risk male sex acts and the number of high-risk contacts for females (see Table A-7).

11. Numbers of Sexual Contacts per Partner. The number of sexual contacts is input by age, sex, risk group, and marital status. These figures are also partly based on the Kinshasa KAP study and partly on reports of the number of sexual contacts per day by prostitutes in Nairobi (3.7/day and 116-1042/year) (Simonsen et al., 1990; Kreiss et al.. 1986). These figures are then balanced with the proportions engaging in casual sex.

The figures used for the low-risk married group are for sexual contacts within the marriage, the figures for the high-risk married group are the number of sexual contacts outside the marriage (see Table A-8). Low risk married women average nearly six sexual contacts per month. This frequency is based on the Auvert, et al. (1988) estimate of 1.5 weekly sexual contacts with a regular partner and is consistent with other studies in the region (Ryder et al., 1990). A decline in sexual activity occurs with increasing age.

High-risk single males are assumed not to have a regular partner. The frequency of sexual contact is assumed to be four per month, while high-risk contacts for married males occur once per month for males less than 50 years of age.

Prostitutes are included in the high-risk single females category which has the highest frequency of sexual contacts. The average number of contacts per month is 22.5 and declines for this high risk group after the age of 35.

12. Proportions of the Population Engaging in Homosexual Contact. There is little documented homosexual activity in Africa. Therefore, the proportions of the population engaging in homosexual contact for this application of the model remain zero.

Recently some homosexual activity was reported from a survey of University of Kinshasa students, but these were very few in number and typically took place at a relatively young age (i.e., under age 15). A possible hypothesis is that these contacts took place in a gender-segregated boarding school situation.

13. Sexually-Transmitted Disease (STD) Parameters. The model requires the input of the average duration of infection, by sex, for an episode of STD. These figures, together with figures for the transmission of STDs and the susceptibility, are used to generate co-circulating STD infections in the population. Holmes et al. (1989) estimated a female to male transmission rate per contact of 25 percent for gonorrhea. Transmission from males to females would presumably be higher, perhaps by a factor of 2 or more. Other studies cite transmission rates ranging from 15 percent for syphilis and chancroid to 60-80 percent for gonorrhea (Over and Piot, 1990).

Duration of infections is longer in developing countries than in developed countries where access to medications and medical services is better. The duration of an STD episode also varies by disease, sex and by individual.

For this example, an STD transmission rate of 40 percent was used. Estimated duration of disease for urban areas was 2 months for males and 2.5 months for females. In rural areas the duration was assumed to be 2.5 months for males and 3.5 months for females.

14. Prevalence of Condom Use. Several studies have reported very low use of condoms in Africa. The 1989 Kenya Demographic and Health Survey (National Council for Population and Development and Institute for Resource Development, 1989) reported that 0.4 percent of women and 0.5 percent of married women used condoms for contraceptive purposes. In the 1988 Contraceptive Prevalence and KAP for AIDS survey of the University of Kinshasa students, 0.3 percent of married men, 1.2 percent of single men, 0.7 percent of married women, and 0.04 percent of single women used condoms. For our application a condom use rate of 0.4 percent was input for the low risk married males and females.

Increased condom use is one intervention that is explored in this analysis.

Disease Parameters

15. Seroprevalence of HIV. Although many seroprevalence studies have been carried out in Africa on various population groups, they do not provide a complete picture of seroprevalence status at a particular point in time. Representative data on rural areas is particularly lacking.

The pattern of seroprevalence by age used for this analysis is based on the Uganda National Serosurvey (Berkley et al. 1989). The study began in 1987 and continued in 1988. Cluster sampling methodology was used and the data presented here is based on 3,553 adults, 62 percent female and 38 percent male. The seroprevalence is highest for women in the age group 20-24 and for men in the age group 25-29 (see Table A-9). This pattern is typical of age patterns seen of the infection in Africa.

This observed age and sex pattern was used with an adjustment for the age groups 40-44 and above in order to smooth the curve. Using this age/sex pattern, the level of infection was then adjusted in order to obtain an overall level of seroprevalence comparable to the World Health Organization (1990) estimate of approximately 5 million infected adults in 1990. This corresponds to an urban seroprevalence for the 15-49 age group of 6.7 percent and 0.7 percent for the rural area.

In the urban population, the highest HIV seroprevalence rate among women is 17.5 percent in the high-risk group for the age group 20-24, for men the highest HIV seroprevalence rate is 19.1 percent in the high-risk group, ages 25-29. For the low-risk populations, the seroprevalence rates peak in the same age categories, 10.2 percent for females and 11.5 percent for males.

In the rural areas, the seroprevalence rate for high-risk males 25-29 years of age is 1.7 percent and for the low-risk males in the same age group the rate is 1.1 percent. For females in the age groups 20-24, the high-risk group has a seroprevalence rate of 1.5 percent and the low-risk group has a rate of 0.9 percent.

16. Standard Rate of Infectivity per Sexual Contact. The risk of heterosexual sexual transmission of the AIDS virus is well accepted. However, there are few estimates on the rate of infectivity per sexual contact. The estimates that are found in the literature are usually a partnership rate and not a per-contact rate. Variability in transmissibility remains the most significant unexplained aspect of HIV infection.

Recent reviews suggest that the average transmission probability for heterosexual partnerships is around 0.1-0.2, 0.1 for homosexual partnerships. Per sex act the probability of transmission has been estimated at less than .001 to 0.01 (Anderson and Medley, 1988). But Cameron, et al., (1989) estimate a per-contact female to male transmission rate of 3 percent, based on a study in Nairobi. Over and Piot (1990) in modelling the epidemic use a transmission rate of 0.03 for males and 0.01 for females without ulcers and 0.10 for males and 0.05 for females with ulcers.

For this application we use a male to female per contact transmission rate of 0.0030 and for females to males of 0.0015.

17. Relative HIV Infection Risk Associated with STD Infection. Sexually transmitted diseases (STDs) have a well-documented affect on increasing the likelihood of HIV transmission. This enhancement has now been demonstrated both with STDs traditionally considered ulcerative as well as with non-ulcerative STDs.

The prevalence rates for the various STDs range a great deal between countries as well as within countries. Depending on the relative prevalence within a country of the various STDs the risk factor for HIV infection may also vary. The risk factor for HIV infection calculated from several studies in Africa ranges from

1.0 to 12.3. However, this relative risk is typically calculated based on an examination of the seroprevalence of those in the sample and self-reported episodes of an STD at some point in the recent part. Since it is likely that they had the STD for only a fraction of the period of exposure to HIV infection, the per contact risk is likely to be much greater than the observed relative risk. For this application of the model we use a relative risk of 50 for both males and females.

18. Progression from HIV Infection to AIDS. The incubation period is defined as the time between infection and the diagnosis of disease. With AIDS the incubation period seems to be long and variable. Estimates of the incubation for transfusion-associated AIDS patients period ranges from 4.5 years to 15 years (Lui et al., 1986; Rees, 1987).

In the U.S., the San Francisco General Hospital Cohort Study has seen a progression rate of 54 percent at 10 years after infection. The median incubation period has been estimated to be 9 to 10 years.

Other estimates of the mean incubation period from adult U.S. transfusion-associated AIDS cases reported through April 1988 are 7.43 years (based on a Weibull distribution) and 14.33 years (based on a Gamma distribution). The incubation period for perinatal infected children appears to be shorter (less than 1 year). (Anderson and Medley, 1988) In another study based on transfusion-associated AIDS patients in the U.S., Medley, et al. (1987) suggest the following age-related incubation periods: 1.97 years for children (0-4 years old at infection), 8.23 years for adults (5-59 years old), and 5.50 years for elderly patients (60 yrs and older). Analysis by sex shows the incubation period for females to be longer than for males. The means for the females and males are 8.77 years and 5.62 years, respectively.

We have used a distribution of the incubation period based on a Weibull distribution with parameters proposed by Medley et al. (1987) with means of 7.8 years for adults and 1.9 years for children.

19. Progression from AIDS to Death. The mortality rate for diagnosed cases of AIDS is virtually 100 percent. The 2-year rate of progression from symptomatic HIV disease to AIDS in the San Francisco General Hospital Cohort Study is 50 percent (AIDS Knowledge Base, 1990).

Median survival times for AIDS patients in developed countries ranges from 9 to 13 months (Anderson and Medley, 1988). The progression from AIDS to death for adults has been reported as 1 year (Piot et al., 1988), infants and children 8 months (Piot et al., 1988).

The progression to AIDS of HIV infected newborns is much quicker than in adults. In the Newborn French Collaborative study, 59 percent of the infants in the study who had HIV infection by the age of 18 months had severe disease (Blanche et al., 1989). Whereas, in a study of 288 HIV seropositive men at the San Francisco General Hospital found a 33 percent progression to AIDS at 4.5 years.

20. Rate of Perinatal Transmission between Mothers and Infants. Maternal transmission of HIV is the primary cause of pediatric AIDS particularly in countries which have established blood donor screening.

It is difficult to identify at birth the actual status of HIV infection. Maternal antibodies may persist in the child for more than a year. Time is needed for the passively transmitted maternal antibodies to disappear from the infants. Maternal IgG antibodies readily cross the placenta and are present in the neonate's blood in approximately the same concentration as in the mother's.

There are other difficulties in determining HIV infection in the first and second year of life. The mother may transmit other congenital infections or, if the mother is a drug abuser, the HIV-uninfected baby may exhibit a transient immune deficiency (Holmes et al., 1989). However, in Africa the IV-drug abuse is not prevalent.

The European study reported an infection rate after 15 months of 24 percent. The authors, however, feel that this is an underestimate due to the insensitivity of virus and antigen tests (European Collaborative Study, 1988). The Italian study reports 33 percent transmission from mother to child among the 89 infants followed for at least 15 months (Italian Multicenter Study, 1988). In Zaire, 39 percent of infants born to seropositive mothers had evidence of HIV-1 infection 1 year later (Ryder, et al., 1989). The relative risks associated with various modes of vertical transmission have not been measured. For this application, a transmission rate of 39 percent is used.

Table A-10 summarizes a number of the miscellaneous projection parameters used in this application of the iwgAIDS model.

21. Proportion of Blood that is Screened for HIV Infection. Blood transfusions represent the third major route for transmission of HIV; sexual contact and perinatal transmission being the other two. Blood donation parameters used with the model are shown in Table A-11.

The distribution of blood donors by age and sex is based on HIV seroprevalence studies of blood donors in Mozambique and Côte d'Ivoire. In these studies, 75 to 87 percent of the blood donors were male. For this projection, it was assumed high risk males were as likely to donate blood as low risk males; however, blood donations from high risk females were assumed not to occur.

The likelihood of receiving a blood transfusion is related to diagnosis of disease and residence. If diagnosis suggests a blood transfusion, a patient in an urban hospital is more likely to receive a transfusion than a patient in a rural health facility. Thus, we have assumed that those in the urban areas are ten times more likely to receive a blood transfusion than those in the rural areas. Children have a higher frequency of blood transfusions than adults because of their lack of immunity to malaria and sickle cell disease. The exception is females in the reproductive ages. The frequency of transfusion is slightly higher in this group because of factors related to childbirth.

Table A-1. Population, by Age and Sex, for Urban and Rural Areas: 1990 (Population in thousands)

	Urban			Rural		
Age	Both sexes	Male	Female	Both sexes	Male	Female
All ages						
0-4 years	200	100	99	798	401	397
5-9 years	161	80	80	642	322	321
10-14 years	135	68	68	540	270	270
15-19 years	114	57	57	457	229	228
20-24 years	96	48	48	383	192	191
25-29 years	78	39	39	311	155	156
30-34 years	64	31	33	256	126	130
35-39 years	54	26	28	215	104	111
40-44 years	46	22	24	182	88	94
45-49 years	37	18	19	150	73	77
50-54 years	31	15	16	123	59	63
54-59 years	25	12	13	98	48	51
60-64 years	19	9	10	75	36	39
65-69 years	13	6	7	52	26	27
70-74 years	8	4	4	34	16	18
75-79 years	5	2	2	19	9	10
Over 80 years	3	1	2	12	5	6

Source: Based on 1990 population projected at the U.S. Bureau of the Census and aggregated across all subSaharan African countries. This population distribution, by age and sex, was adjusted to the totals for urban and rural areas shown here.

Table A-2. Age-Specific Fertility Rate, per Woman, for 1990 and Projected Total Fertility Rates for 1990 to 2015

Age	Age Specific Fertility Rates	Year	Projected Total Fertility Rate
15-19 years	.1163	1990	6.53
20-24 years	.3015	1995	6.26
25-29 years	.3126	2000	5.89
30-34 years	.2654	2005	5.47
35-39 years	.1892	2010	5.01
40-44 years	.0832	2015	4.55
45-49 years	.0323		

Source: Based on 1990 to 2015 fertility levels projected at the U.S. Bureau of the Census and aggregated across all SubSaharan African Countries.

Table A-3. Age-Specific Mortality Rates, by Age and Sex: 1990 and 2015

Age	1990 Male	1990 Female	2015 Male	2015 Female
Under 1 year	.12499	.10117	.07641	.06155
1-4 years	.01498	.01559	.00691	.00649
5-9 years	.00369	.00367	.00179	.00150
10-14 years	.00233	.00219	.00120	.00092
15-19 years	.00343	.00336	.00184	.00135
20-24 years	.00488	.00463	.00263	.00185
25-29 years	.00553	.00540	.00303	.00228
30-34 years	.00660	.00624	.00362	.00281
35-39 years	.00824	.00732	.00472	.00355
40-44 years	.01068	.00853	.00646	.00460
45-49 years	.01425	.01071	.00918	.00629
50-54 years	.01953	.01457	.01347	.00908
55-59 years	.02702	.02077	.01982	.01357
60-64 years	.03883	.03030	.02985	.02076
65-69 years	.05682	.04508	.04499	.03256
70-74 years	.08202	.06797	.06673	.0510[illegible]
75-79 years	.11485	.10170	.09645	.07834
80 years and over	.18332	.17715	.16670	.1551[illegible]

Source: Based on 1990 and 2015 mortality levels projected at the U.S. Bureau of the Census and aggregated across all subSaharan African countries. The age pattern of mortality is based on the United Nations General pattern of mortality.

Table A-4. Percent Married, by Age, Sex, and Urban/Rural Residence

Age	Urban		Rural	
	Male	Female	Male	Female
15-19 years	2.14	23.60	4.28	47.20
20-24 years	18.35	67.42	32.42	87.63
25-29 years	48.13	89.35	63.85	91.06
30-34 years	71.57	91.09	79.29	91.12
35-39 years	82.43	90.05	85.58	88.98
40-44 years	86.61	87.60	87.65	86.21
45-49 years	88.46	83.95	89.26	81.69
50-54 years	89.00	79.02	88.74	76.34
55-59 years	89.00	72.09	89.26	67.84
60-64 years	87.69	62.37	86.12	56.89
65-69 years	85.48	53.35	84.85	49.81
70-74 years	82.86	44.95	80.88	40.10
75-79 years	78.52	35.18	76.15	30.25

Source: Rural figures calculated as the average of data reported in United Nations Demographic Yearbook, 1982, table 40, for Malawi, Burkina Faso, and Liberia. Urban figures were shifted 2.5 years older.

Table A-5. Annual divorce Rates for Males, by Age, for Urban and Rural Areas

Age	Urban	Rural
15-19 years	.10	.10
20-24 years	.10	.10
25-29 years	.10	.10
30-34 years	.08	.08
35-39 years	.05	.05
40-44 years	.04	.04
45-49 years	.03	.03
50-54 years	.02	.02
55-59 years	.02	.02
60-64 years	.02	.02
65-69 years	.02	.02
70-74 years	.02	.02
75-79 years	.02	.02

Source: Derived at the U.S. Bureau of the Census based on a comparision of available data from the African region. See text for discussion.

Table A-6. Out-Migration Rates per 1,000 Population, by Age and Sex, for Urban and Rural Areas

Age	Urban		Rural	
	Male	Female	Male	Female
0-4 years	4.38	4.38	6.57	6.57
5-9 years	4.38	4.38	4.93	4.93
10-14 years	4.38	4.38	3.29	3.29
15-19 years	6.57	6.57	9.86	9.86
20-24 years	9.86	9.86	13.14	13.14
25-29 years	9.86	9.86	13.14	13.14
30-34 years	9.86	9.86	9.86	9.86
35-39 years	9.86	9.86	6.57	6.57
40-44 years	9.86	9.86	3.29	3.29
45-49 years	9.86	9.86	1.64	1.64
50-54 years	9.86	9.86	1.64	1.64
55-59 years	6.57	6.57	1.10	1.10
60-64 years	4.38	4.38	.55	.55
65-69 years	2.19	2.19	.00	.00
70-74 years	1.64	1.64	.00	.00
75-79 years	.00	.00	.00	.00
80 years and over	.00	.00	.00	.00

Source: Derived at the U.S. Bureau of the Census based on an assumed age pattern of migration and a target net migration to urban areas of approximately 3 percent.

Table A-7. Proportion of the Population in the High-Risk Group, by Age, Sex, and Marital Status, for Urban and Rural Areas: 1990

	Married		Single	
Sex and age	Urban	Rural	Urban	Rural
Male				
15-19 years	.13	.10	.60	.30
20-24 years	.25	.20	.75	.60
25-29 years	.25	.20	.75	.60
30-34 years	.25	.20	.75	.60
35-39 years	.25	.20	.75	.60
40-44 years	.25	.20	.75	.60
45-49 years	.25	.20	.75	.60
50-54 years	.19	.15	.60	.45
54-59 years	.13	.10	.50	.30
60-64 years	.06	.05	.25	.20
65-69 years	.00	.00	.00	.00
70-74 years	.00	.00	.00	.00
75-79 years	.00	.00	.00	.00
80 years and over	.00	.00	.00	.00
Female				
15-19 years	.03	.03	.25	.20
20-24 years	.05	.04	.50	.45
25-29 years	.05	.04	.50	.45
30-34 years	.05	.04	.50	.45
35-39 years	.04	.04	.30	.45
40-44 years	.03	.03	.25	.35
45-49 years	.01	.02	.13	.25
50-54 years	.00	.01	.00	.10
54-59 years	.00	.00	.00	.00
60-64 years	.00	.00	.00	.00
65-69 years	.00	.00	.00	.00
70-74 years	.00	.00	.00	.00
75-79 years	.00	.00	.00	.00
80 years and over	.00	.00	.00	.0

Note: High Risk refers to those with casual sexual contacts.

Source: Derived at the U.S. Bureau of the Census based on available data for selected populations and assumed age pattern. See text for discussion.

Table A-8. Frequency of Sexual Contact per Month, by Age, Sex, and Risk Group, for Urban and Rural Areas

Sex and age	Low-risk married		High-risk single		High-risk married	
	Urban	Rural	Urban	Rural	Urban	Rural
Male						
15-19 years	8	8	4	3	1	1
20-24 years	8	8	4	3	1	1
25-29 years	8	8	4	3	1	1
30-34 years	8	8	4	3	1	1
35-39 years	8	8	4	3	1	1
40-44 years	8	8	4	3	1	1
45-49 years	8	8	4	3	1	1
50-54 years	8	8	3	2	.5	.5
54-59 years	6	6	3	2	.5	.5
60-64 years	4	4	2	1	.5	.5
65-69 years	2	2	2	1	.5	.5
70-74 years	1	1	1	1	.5	.5
75-79 years	0	0	0	0	0	0
80 years and over	0	0	0	0	0	0
Female						
15-19 years	5.75	5.75	10	10	1	[illegible]
20-24 years	5.75	5.75	22.5	22.5	1	[illegible]
25-29 years	5.75	5.75	22.5	22.5	1	[illegible]
30-34 years	5.75	5.75	22.5	22.5	1	[illegible]
35-39 years	5.75	5.75	22.5	22.5	1	[illegible]
40-44 years	5.75	5.75	15	15	.5	.5
45-49 years	5.75	5.75	10	10	.5	.5
50-54 years	4	4	0	0	.5	.5
54-59 years	3	3	0	0	.5	.5
60-64 years	2	2	0	0	.5	.5
65-69 years	1	1	0	0	.5	.5
70-74 years	0	0	0	0	.5	.5
75-79 years	0	0	0	0	0	0
80 years and over	0	0	0	0	0	[illegible]

Note: High Risk refers to those with casual sexual contacts.

Source: Derived at the U. S. Bureau of the Census based on available data for selected populations and an assumed age pattern of behavior. See text for discussion.

Table A-9. HIV Seroprevalence, as a Proportion of the Population, by Age, Sex, and Risk Group, for Urban and Rural Areas: 1990

Sex and age	Urban Population		Rural Population	
	High Risk	Low Risk	High Risk	Low Risk
Male				
Under 5 years	--	.011	--	.001
5-9 years	--	.003	--	.000
10-14 years	--	.000	--	.000
15-19 years	.051	.031	.005	.003
20-24 years	.119	.072	.010	.006
25-29 years	.191	.115	.017	.011
30-34 years	.131	.078	.012	.008
35-39 years	.103	.062	.009	.006
40-44 years	.091	.055	.008	.005
45-49 years	.087	.052	.008	.005
50-54 years	.083	.050	.007	.004
54-59 years	.040	.024	.003	.002
60-64 years	.032	.019	.003	.002
65-69 years	.000	.000	.000	.000
70-74 years	.000	.000	.000	.000
75-79 years	.000	.000	.000	.000
80 years and over	.000	.000	.000	.000
Female				
Under 5 years	--	.010	--	.001
5-9 years	--	.003	--	.000
10-14 years	--	.000	--	.000
15-19 years	.110	.066	.010	.006
20-24 years	.175	.105	.015	.009
25-29 years	.117	.070	.010	.006
30-34 years	.083	.050	.007	.004
35-39 years	.075	.045	.007	.004
40-44 years	.072	.043	.006	.004
45-49 years	.068	.041	.006	.004
50-54 years	.065	.039	.006	.004
54-59 years	.061	.037	.005	.004
60-64 years	.041	.025	.004	.002
65-69 years	.000	.000	.000	.000
70-74 years	.000	.000	.000	.000
75-79 years	.000	.000	.000	.000
80 years and over	.000	.000	.000	.000

Note: High Risk refers to those with casual sexual contacts, while Low Risk refers to the balance of the population.

Source: Based on the age-sex-specific patterns of seroprevalence for Uganda in 1987-88. This pattern was adjusted downward to reproduce the World Health Organization estimate of infected African population in 1990.

Table A-10. Miscellaneous AIDS Projection Parameters, for Urban and Rural Areas

Parameter	Urban	Rural
Condom Use		
Ages 15-49	.004	.000
Sexual transmission per contact		
Male to female	.0030	.0030
Female to male	.0015	.0015
Sexually Transmitted Diseases (STDs)		
Risk factor for HIV transmission		
Male	50	50
Female	50	50
STD transmission rate per contact	.4	.4
Duration of STD infection		
Male	2.0	2.5
Female	2.5	3.5
Vertical transmission (mother to child)	.39	.39

Source: See text for source of individual parameters.

Table A-11. Blood Donor and Transfusion Recipient Parameters, by Age and Sex, for Urban and Rural Areas

Parameter and age	Urban		Rural	
	Male	Female	Male	Female
Percent distribution of blood donating population within region				
Under 15 years	0	0	0	0
15-19 years	15	3	15	3
20-24 years	20	3	20	3
25-29 years	25	3	25	3
30-34 years	10	2	10	2
35-39 years	5	1	5	1
40-44 years	5	1	5	1
45 years and over	5	2	5	2
Proportion of population receiving a transfusion per year				
Under 5 years	.0100	.0100	.00100	.00100
5-14 years	.0075	.0075	.00075	.00075
15-45 years	.0015	.0030	.00015	.00030
45 years and over	.0020	.0020	.00020	.00020
Average number of units received per transfusion				
Under 5 years	1	1	1	1
5-14 years	1	1	1	1
15-45 years	1	3	1	3
45 years and over	1	1	1	1

Source: Blood donor data -- Barreto, J., et al., 1988 (Mozambique); Odehouri, K, et al., 1988 (Côte d'Ivoire).
Frequency of transfusion -- Auvert, B., et al., 1988.

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