# ADDIS ABABA UNIVERSITY

# SCHOOL OF GRADUATE

# STUDIES



## DEMOGRAPHIC IMPACT OF

## HIV/AIDS IN ADDIS ABABA

A THESIS PRESENTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY

IN PARTIAL REQUIREMENT OF THE DEGREE OF MASTER OF PUBLIC HEALTH

BY:AHMED ABDUREHMAN,MD.

DECEMBER,1998

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## Acronyms and Abbreviations

| | |
|---|---|
| AGR | Annual Growth Rate |
| AIDS | Acquired Immune Deficiency Syndrome |
| AIM | AIDS Impact Model |
| CBR | Crude Birth Rate |
| CDR | Crude Death Rate |
| CMR | Child Mortality Rate |
| CWR | Child Woman Ratio |
| Demproj. | Demographic projection Model |
| GRR | General Reproduction Rate |
| HIV | Human Immunodeficiency virus |
| IMR | Infant Mortality Rate |
| LE | Expectation of Life at Birth |
| MOH | Ministry of Health |
| NNR | Net Natural Reproduction |
| PTR | Perinatal Transmission Rate |
| RNI | Rate of Natural Increase |
| STD | Sexually Transmitted Disease |
| TFR | Total Fertility Rate |
| UN | United Nation |
| US | United States |
| WHO | World Health Organization |

## GLOSSARY OF TERMS

Adult — an adult is defined as a person aged 15 or older

AIDS — The abbreviation for the acquired immunedeficiency syndrome, a disabling and fatal disease caused by the human immunodeficiency virus (HIV)

Child mortality rate — the number of children who die before reaching their fifth birth day per 1000 live births

Crude Birth Rate — refers to the total number of births occurring in a given year per 1000 mid-year population

Crude Death Rate — refers to the total number of deaths occurring in a given year per 1000 mid-year population

Dependency Ratio — is defined as the number of the dependent people in the population (usually the population below the age of 15 and over the age of 64) per 100 adults of productive age (usually 15-64)

Epidemiology the study of the incidence, distribution, and determinants of an infection, disease, or other health-related event in population

Expectation of life at birth
refers to the average number of years a new born baby is expected to live if he/she is exposed throughout its life to the prevailing pattern of age specific death rates

Incubation period the time interval between infection and the onset of AIDS

Infant Mortality Rate the number of infants who die during the first year of life per 1000 live births during the year

Perinatal and perinatal transmission
Pertaining to or occurring during the periods before, during, or shortly after the time of birth; that is, before delivery from the 28Th week of gestation through to the first seven days after delivery. The transmission of HIV from an infected woman to her fetus or newborn child is referred to as perinatal transmission.

| | |
|---|---|
| Prevalence | the proportion of a defined population with the infection, disease, or other health- related events of interest at a given point or period of time |
| Seroprevalence (HIV, STD) | the percentage of a population from whom blood has been collected that is found, on the basis of serology, to be positive for HIV or other STD agents at any given time |
| Sex Ratio | the number of male births per every 100 female births |
| Total Fertility Rate | refers to the number of children a woman is likely to produce at the end of her reproductive period given the current age-schedule of fertility rate |

## ABSTRACT

A mathematical modeling was done to determine the demographic impact of HIV/AIDS epidemic in Addis Ababa.

It was found that:- a) the adult HIV prevalence will reach a plateau level of 10.78% in the year 2001 and then declines to 10.28% in the year 2004. b) AIDS will slow the decline in infant mortality rate and under 5 mortality rates and will increase crude death rate and lowers the life expectancy at birth. c) AIDS will reduce the size of the Addis Ababa population by about 160,000 people in the year 2004, but will not stop or make its growth negative. d) AIDS will also reduce fertility but, e) it will not worsen the traditional dependency ratio (i.e., the population under age 15 and over age 64, as a proportion of the population of age 15-64). Similar trends were reported by studies conducted in other sub-Saharan African countries.

Based on the above findings, preventive measures such as STD control, condom promotion, IEC and blood screening, approaching the problem multisectorally, incorporating the HIV/AIDS epidemic in the demographic projection, and establishing HIV/AIDS data base were recommended.

## INTRODUCTION

Recognized as an emerging disease only in the early 1980s, AIDS has rapidly established itself throughout the world, and is likely to endure the persist well into the 21st century and probably beyond. It has evolved from mysterious illness to a global pandemic which has infected tens of millions in less than 20 years. It is now prevalent in virtually all parts of the world (1).

As of January 1, 1998 an estimated 30.6 million adults and children world wide were living with HIV/AIDS and 5.8 million (19.0% of total HIV prevalence) new infections occurred in 1997. More than 90% of HIV-infected people live in less developed world, and most do not know they are infected. Since the beginning of the epidemic there have been an estimated 11.7 million deaths from AIDS, 2.3 million of them in 1997. The total number of AIDS orphans (HIV-negative children who lost their mother or parents to AIDS when they were under the age of 15), is near 8 million since the beginning of the epidemic (1).

The infection is caused by two main types of viruses, HIV-1 and HIV-2 (2).

HIV, probably started to spread in Ethiopia in the early 1980s. The first two seropositive cases were reported in 1984(3), and the first AIDS cases were reported in 1986(4). Although HIV prevalence was very low in Ethiopia during the early 1980s, it has been increasing rapidly in the past few years.

It was estimated that by 1993, adult HIV prevalence had increased to 3.2% (5). A community based seroprevalence study conducted in Addis Ababa, in 1994, revealed a prevalence of 6.0 percent for men and 6.9 percent for women (6). By 1997, it is estimated that adult prevalence has increased to 7.4 percent, and it is estimated to be higher in urban areas, about 21 percent and lower in rural areas, which is about 4.5 percent (7).

Since the early 1980s, when AIDS was first recognized, there has been uncertainty about the future trends and ultimate dimensions of this pandemic. Uncertainty persists because of the difficulties in measuring, with any substantial degree of precision, the prevalence and more particularly the incidence of AIDS cases and HIV infections in any given population.

As a result, many HIV/AIDS models have been developed in an attempt to:

1) understand the dynamics and interrelationships of the major determinants of HIV transmission; and/or

2) develop reliable estimates and projections of HIV/AIDS.

Modelling is one way to help stimulate awareness among policymakers to the potential impact of HIV/AIDS on society. Modelling can help shape prevention strategies and programs that will slow the epidemic(8).

Ever since AIDS was recognized as a critical global health problem that would lead to increased adult and child mortality there have been debates about the demographic impact of AIDS. There has been speculation that the impact of AIDS might be so large as to cause negative population growth rates in some countries(9). In the contrary others reported that population growth rates are unlikely to turn negative in central Africa (10). Much of this debate has centered on Africa, where HIV prevalence rates are the highest. A review of the different approaches to estimate the demographic impact of AIDS conducted in 1993 (11) reported that the opposite conclusions were mainly due to different views about future levels of HIV prevalence in Africa.

With a continued AIDS epidemic, it was reported that AIDS will have significant impact on size of the Ethiopian population, but the population will still grow by almost 70 percent by the year 2014 (7).

This study was conducted with the general objective of determining the demographic impact of HIV/AIDS in Addis Ababa.

## LITERATURE REVIEW

The HIV (Human Immunodeficiencey Virus) and AIDS epidemic, which emerged in the last quarter of the twentieth century, has within less than two decades spread to over 190 countries in all continents. (1).

The infection is caused by two main types of viruses, HIV-1 and HIV-2. Globally, HIV-1 accounts for the great majority of HIV-infections; HIV-2 appears largely confined to west Africa; with foci in Angola and Mozambique and some cases in Europe, the Americas, and India (2).In vitro studies have shown important differences in the biological properties of HIV-1 subtypes (12), but very little is known about possible differences in the transmissibility of these sub types. The epidemiologic pattern of HIV transmission in Africa is characterized by a predominance of viral spread through sexual intercourse between partners of opposite sexes (13).

As of January 1,1998 an estimated 30.6 million adults and children world wide were living with HIV/AIDS, and 5.8 million (19.0% of total HIV/prevalence) new infections occurred in 1997. More than 90 percent of HIV infected people live in less developed world, and most do not know they are infected. Since the beginning of the epidemic there have been an estimated 11.7 million deaths from AIDS, 2.3 million of them in 1997. The total number of AIDS orphans (HIV-negative children who lost their mother or parents to AIDS when they were under the age of 15) is near 8 million since the beginning of the epidemic. (1)

Although HIV prevalence was very low in Ethiopia during the early 1980s, it has been increasing rapidly in the past few years. It was estimated that by 1993, adult HIV prevalence had increased to 3.2 percent (5).
By 1997, it is estimated that adult prevalence has increased to 7.4 percent. In urban areas adult prevalence is estimated to be higher, about 21 percent, and in rural areas it is estimated to have reached 4.5 percent in 1997 (7).
A community based seroprevalence study conducted in Addis Ababa, in 1994, revealed a prevalence of 6.0 percent for men and 6.9 percent for women (6).

Ever since AIDS was recognized as a critical global health problem that would lead to increased adult and child mortality there have been debates about the demographic impact of AIDS.
There has been speculation that the impact of AIDS might be so large as to cause negative population growth rates in some countries. Much of this debates has centered on Africa, where HIV prevalence rates are the highest.
Anderson et al. Concludes that in the most afflicted ares AIDS is likely to change population growth rates from positive to negative (9).

Bongaarts found that the population growth rates are unlikely to turn negative in central Africa.More likely, the population growth rates in central Africa will not drop below half of their current values (10).

The expected impact of AIDS on population growth and structure differs in significant way among the Geographic areas.Not only do current levels of HIV vary from negligible to substantial, but the dominant modes that distinguish the areas of affinity are highly relevant to demographic impact. The demographic impact of AIDS is most immediate and serious in Sub-Saharan Africa and in parts of the caribbean, where falling life-expectancy and increasing infant and child mortality have already been observed. Given the high proportion of the population already infected upto 30% young adults in some urban areas and the high mortality resulting from the disease,a demographic impact may eventually become as serious in several other geographic areas of affinity, but this will depend for most on whether the spread of HIV can be contained. From the perspective of population growth rate, not all individuals are equal: women starting their reproductive years have considerably more potential for affecting a population's growth and structure than do women past the reproductive years or men outside the reproductive process. In North America, for example, where the primary mode of HIV transmission so far has been through homosexual contacts, measurable demographic impact will be greatest on adult male mortality which will have little effect on population growth. But in areas where the dominant mode of transmission is through heterosexual contacts, as in Sub-Saharan Africa, women of child bearing age found to become infected and die before having the number of children they otherwise might have had. Also, pregnant women may infect their fetuses or new borns, causing increased infant and child mortality, with measurable impact on population growth (14).

In some urban centers of Sub-Saharan Africa, Western Europe, and the Americas, AIDS has already become the leading cause of death for both men and women aged 15-49. AIDS kills people in their most productive years and ranks as the leading cause of potential healthy life years lost in Sub-Saharan Africa (15).
For example, in two community based rural studies in Mosaka and Rakai districts of Uganda, (16,17) mortality among HIV infected adults was over 100 per 1000 person-years of observation (PYO), an order of magnitude higher than among adults not infected with HIV. In both districts, which have an adult prevalence of 8 and 13%, respectively, HIV was the leading cause of death in adults. Over 80% of deaths in the 20-39 age group occurred among those who were HIV infected.

AIDS will double or triple the adult mortality rates in Sub-Saharan African countries from levels that were already eight times higher than those in developed countries(15).

In addition to adult mortality, the HIV pandemic has already resulted in the death of over one million children world wide. A recent survey of the impact of AIDS on child mortality in ten central and eastern African countries (18), suggests that the death toll from AIDS in children under 5 years is likely to rise from 159 to 189 per 1000 by the year 2000. Overall infant and child mortality rates have exceeded previous projection by as much as 30 percent as a direct consequences of perinatal infection. Consequently, paediatric AIDS is now threatening much of the progress that has been made in child survival in developing countries during the past 20 years.

Life expectancy, which had been increasing in most of these countries, is now declining in many of them. In 2010, the projected life expectancy will be about 10-30 years lower in these countries than it would have been without AIDS.

Despite identification of only 55-85% of HIV related deaths, AIDS is the leading cause of death in males aged 25-44 in 66 U.S. Cities (19).

In some countries that are further into the epidemic in Africa, more than half of adult mortality is now attributable to HIV infection (16).

In Zambia crude mortality among employees of 33 factories and other businesses soared from 2.5 per 1000 in 1987 to

183 in 1993 an increase virtually wholly attributable to HIV related disease(20).

A report from MOH (7), in 1998 has shown that with a continued AIDS epidemic, the total population of Ethiopia would be 85 million by 2014, which is 7 million than the projection without AIDS. Thus, the combined impact of AIDS deaths and fewer births because of a smaller reproductive age population would result in almost 7 million fewer people by 2014. AIDS will have a significant impact on population size, but the population will still grow by almost 70 percent by 2014. The growth rate of the population will be less because of AIDS but it will still be 2.3 percent per year. Changes in the total fertility rate, due mostly to the use of family planning, will have much more impact on the population growth rate than will AIDS deaths.

Similarly the report indicated that, in the absence of AIDS, the infant mortality rate of Ethiopia, which is currently around 110 per 1000 live births, might be expected to decline to 79 per 1000 live births by 2014. However with AIDS, it would decline to only about 87 per 1000 live birth.The chiled mortality rate ,which is currently around 190 per 1000 live births,might be expected to decline to around 127 per 1000 live by 2014, because of child survival programs such as diarrhoea control and immunization. However, with AIDS it is likely to decline only to about 153 per 1000 live births.

A study conducted by region 14 health beuro(21),in 1998 showed that in the absence of AIDS the population of Addis Ababa would grow from about 2.2 million in 1995 to 2.9 million in 2004 and more than 3.7 million in 2014.But in the presence of AIDS the population would grow less rapidly to 2.7 million in 2004 and 3.0 million in 2014.This means by the year 2014, there would be 725,000 fewer people in Addis Ababa because of the AIDS epidemic.

Similarly the study reported that in the absence of AIDS the population would grow by more than 2.0 percent per year in 2014,but in the presence of AIDS the population would grow by

0 .7 percent per year in the year 2014.However,all of that growth

would be due to migration.The rate of natural increase would have turned negative as early as 2008.

Surveillance studies and AIDS projections indicated that women face increasing rates of HIV infection, prompting the world bank to estimate that AIDS may have a sizeable effect on population growth, one that will be increasingly evident overtime.

The reason is the multiplier effect of mortality of adults of reproductive age: the deficit of people (initially) is almost exclusively due to AIDS mortality, which is only a small proportion of all deaths. Two or three decades from now, the reduced number of people will be due both to AIDS mortality and to births that did not occur because of the additional mortality among women of reproductive age(22).

Gregson and colleagues have examined the question of the impact of HIV on fertility by examining potential changes in the proximate determinants of fertility. They found no clear evidence either way but concluded that the most likely result is that an HIV epidemic will slightly reduce fertility (23).

A recent study in Tanzania found weak evidence that adult mortality due to AIDS leads to reduced fertility rates(24). Two recent studies in Uganda found that HIV-infected women had lower fertility rates than HIV-negative women. One of these, in rural Rakai district(25), found that age-specific fertility rates for HIV infected women were 50 percent less than those for women who were not infected. Another study among a rural population in Masaka (26), found that fertility rates were 20 to 30 percent lower among HIV infected women. Since most women did not know their sero-status the reduced fertility rates were most likely due to biological rather than behavioral factors. This finding suggests that fertility might be 20 to 50 percent lower among HIV- infected women.

Contrary to those who argue that the epidemic's demographic impact will derive chiefly from its effect on mortality, Becker suggests that the impact on fertility is also significant. Deaths from AIDS will mean a smaller proportion of the population surviving to child bearing age and this, combined with increased use of condoms for prophylactic purposes, will lead to a noticeable, although by no means over whelming, impact on fertility rates(27).

The combined impact of AIDS on child and adult mortality can be captured by life expectancy at birth. There is only one community study that includes the full range of age specific mortality data by HIV status required to calculate life expectancy. The Masaka study in Uganda (28), where adult seroprevalence was 8%, reported a life expectancy at birth of 42.5 years (41.4 for men and 43.5 years for women), in the study area at any time between 1990 and 1995. For those known to be seronegative, life expectancy was 58.6 years (56.5 and 60.5 years in men and women, respectively).

A study in Thiland has estimated that 1 million Thais will be infected with HIV by the year 2000 and an almost equal number will have died of AIDS by the year 2014.
Although these numbers seem high, their direct and indirect effects on the demographic structure of the Thai population are small. However, at a regional level, for example in the northern region, the effect of the HIV- epidemic may be more severe(29).

A review of the different approaches to estimate the demographic impact of AIDS conducted in 1993(11), found that most researchers used similar methodologies. The opposite conclusions were due to different views about future levels of HIV prevalence in Africa. Those who felt that prevalence would continue to increase to very high levels found severe demographic impacts, where as those projecting more moderate prevalence levels in the future found that the demographic impact would be significant but would not lead to negative population growth in the African context. Two major institutions, the united nations (UN) and the US Bureau of the census, prepare country specific population projections for most countries world wide. Since the early 1990s these projections have included the impact of AIDS. Neither of these studies projects negative population growth in Africa as a result of AIDS. However, other results are quite different, especially for certain countries.

The UN population Division included the impact of AIDS in its 1992 and 1994 editions of world population prospects (30,31) and its forthcoming 1996 projections(32). In the 1996 revision, the UN reported the following:

1. AIDS will reduce the projected population of 24 countries in Sub-Saharan Africa by 3.9% (13 million people) by 2005 and 5.5% (30 million people) by 2025.
2. The additional number of deaths due to AIDS will reach 9.7 million by 2005.
3. The most severely affected country, Zambia, will have

9.2% (one million) fewer people in 2005 than there would have been without AIDS. The projected populations of Botswana, Uganda and Zimbabwe in 2005 are also more than 8% less than they would be without AIDS.

4. The mean annual population growth rate in Zambia for the 2000-2005 period would be reduced from 3.0% without AIDS to 2.5% with AIDS.
5. Life expectancy in Botswana is projected to decline from 60.8 years in 1985-1990 to 50.3 years by 1995-2000 before recovering to 65.3 years by 2020-2025.

The us Bureau of the census included the impact of AIDS in its 1994 and 1996 global population projections (33,34) and its forth coming 1998 report. Its projections showed a much more dramatic impact of AIDS on population growth than those of UN. For the 1998 projections, the US census Bureau will report the following:

1. AIDS will reduce the projected population of 21 countries in Sub-Saharan Africa by 11.8% (59 million people) by 2005 and by 16.6% (120 million people) by 2025.
2. The most severely affected country, Zimbabwe will have 21% (3.1 million ) fewer people in 2005 than there would have been without AIDS. The projected population of Botswana, Malawi, Namibia and Swaziland in 2005 are also more than 15% less than they would be without AIDS.

3. Population growth rates will remain positive in all countries but will be reduced significantly due to AIDS. For all 21 countries, the annual rate of growth from 1990 to 2005 will be 2.2%, rather than the 2.6% that would be projected without AIDS.
4. By 2010, life expectancy in Botswana will be reduced by 42% from what it would have been in the absence of AIDS (from 66 to 38 years). For all 21 countries, life expectancy will be reduced by 27%, from 62 to 45 years.

The reasons for these differences were found to be due to differences in the input assumptions(35). The most important factors, in order of importance, were as follows:

1. The projection of HIV prevalence. The UN and US census Bureau used different methodologies and assumptions in projecting future levels of HIV prevalence, this accounted for 56% of the difference in projected mortality.
2. The base year HIV prevalence estimate. The estimates of HIV prevalence in 1990 were different in the two sets of projections. This accounted for 16% of the difference in projected mortality.
3. The length of the incubation period. The UN assumed that the median time from HIV infection until AIDS is 10 years, where as the US census Bureau assumed that it is only 7.5 years. This accounted for 14% of the difference in projected mortality.

4. The perinatal transmission rate: The UN assumed that HIV infected mothers would transmit the virus to 30% of their newborn children, whereas the US census Bureau used a figure of 39%. This accounted for 7% of the difference in projected mortality.

When all four of these factors are combined, 100% of the difference is explained.

From this review we can see that the demographic impact of HIV/AIDS has already been shown by studies conducted at different parts of the globe.

## OBJECTIVES OF THE STUDY

General Objective:

To determine the demographic impact of HIV/AIDS in Addis Ababa

Specific Objectives:

1. To estimate the predicted prevalence of HIV infection,AIDS cases and AIDS deaths in Addis Ababa
2 To Assess the impact of HIV/AIDS on mortality indicators (crude death rate, IMR U5MR and Life-expectancy) in Addis Ababa
3. To Assess the impact of HIV/AIDS on Fertility in Addis Ababa.
4. To Assess the impact of HIV/AIDS on population size and annual growth rate in Addis Ababa
5. To Assess the effect of HIV/AIDS on dependency ratio in Addis Ababa

## METHODS

Study Area:

Addis Ababa is the capital city of Ethiopia, which is administratively divided into six zones and twenty seven Weredas. The total number of urban kebeles is 305, while the number of rural farmers associations is 23.

According to the 1994 census (36), Addis Ababa's population was found to be 2,112,737; of which 1,023,452 were males and 1,089,285 were females.

The percentage shares of males was 48 percent while that of females was 51.6 percent. The urban residents of Addis Ababa number 2,084,588, while its rural residents number 28,149. The population of Addis Ababa according to the May 1984 census(37) was found to be 1,423,182 persons. The average annual rate of growth was 3.8 percent during the last 10 years.

The 1994 census result indicated that there were 410,443 households in Addis Ababa with an average of 5.1 persons per household.

Considering the age distribution of the residents of Addis Ababa, the proportion of children under the age of 15 is about 32 percent while the proportion of the population at the age group 15-64 years is about two thirds of the total population.

The total fertility rate was found to be 1.8, the estimated infant mortality rate was 78 deaths per year per 1,000 live births and the estimated expectation of life at birth was

58 years (57 years for males, 60 years for females).

Study design:

This study was conducted from January 1998 to November 1998, and it is quantitative in design.

It was based on secondary data obtained from various sources and certain assumptions made on future level of HIV prevalence,fertility rate,future level of the expectancy of life at birth and migration rates. The following are the secondary data used including their sources and the assumptions made on some of the parameters.

1. HIV/AIDS Inputs (6,7,38)

(a) Base year adult HIV prevalence of 6.8 percent

(b) The start year of the epidemic, which is 1984

(c) Perinatal transmission rate of 35 percent which is typical of African countries

(d) Proportion of infants with AIDS dying in the first year (67%).

(e) Life expectancy after AIDS onset, in years(one year).

(f) Reduction in fertility among women who are HIV positive (30%) (g) Incubation period for the cumulative percentage of adults and children developing AIDS, by number of years since infection.A median time of progression from infection to AIDS of approximately 8 years and 2.5 years for adults and children, respectively.

(h) Age and Sex Distribution of new infection.

2. Demographic projection Inputs (36-38)

(a) The number of people in the population by age and sex in the base year.

(b) Total fertility rate in the base year

(c) Age distribution of fertility

(d) Life expectancy at birth (base year estimate by sex)

(e) Coale- demney- south model life table was selected

(f) The number of migrants by sex and year

(g) The distribution of migrants by age for each sex

3. Assumptions based on the 1984 and 1994 census reports and the 1995 fertility survey of Addis Ababa (36,37,39)

a) Expectation of life at birth

The following assumption on yearly increment in expectation of life is based on the 1984 census result and the past trend.

Yearly increments in life expectancy were 0.2 year per year in the period 1984 to 1995 and 0.3 year per year during the 1995 to 2004 period for both sexes.

(b) Fertility

The total fertility rate is assumed to decline by 0.14 per year and 0.06 per year for the periods 1984-1994, and 1994-2004, respectively. This assumption is based on the 1984 census result, the 1994 census result, the 1995 fertility survey of Addis Ababa and, as well as the past trend.

(c) Migration

The 1984 census result showed the net migration rate to be 17.5 per 1000 population and the assumptions for net migrations were 17.0 in the periods 1984-1989, 16.0 for 1990-1994, 15.0 for 1995-1999 and 14.0 for 2000-2004 per 1000 population respectively.

Data Analysis

(a) Preparation of Demographic Projection

To Assess the demographic impact of HIV/AIDS using AIM (AIDS Impact Model), which is part of the spectrum system of policy models, a demographic projection was required. Demproj., a computer programme for making population projection which is also part of the spectrum system of policy Models was used for this purpose (38). The projection was prepared for a duration of 20 years (1985-2004), using the demographic projection inputs and the assumptions made on life expectancy at birth, total fertility rate, and migration rate which were mentioned previously. The detailed methodology of Demproj., is described in annex I.

(b) Projection of HIV Prevalence

An adult HIV prevalence of 6.8 percent in the year 1994, obtained from a community based sero-prevalence study conducted in Addis Ababa in 1994, was used as reference year estimate. Future levels of HIV prevalence was projected using Epimodel computer programme (see annex II). The three key assumptions were: the year in which HIV infection first became wide spread, the number of people alive with HIV infection in a recent year, and the shape of the infection curve.

In our case, it was assumed that:

i) HIV infection first became widespread in Ethiopia in 1984

ii) In the year 1994, about 96840 people were living with HIV infection

iii) Gamma curve(a type of s-shaped curve) was assumed to be the shape of the epidemic curve.

It was also assumed that HIV incidence is currently at its peak.

(c) Projection of the demographic impact of HIV/AIDS

After preparing the demographic projection without and AIDS future level of adult HIV prevalence, the computer program AIM was applied. The complete methodology of AIM is described in annex III.

## RESULTS

Table 1 shows that adult HIV prevalence increases linearly to about 10.69 percent and 10.28 percent in the years 2000 and 2004, respectively and a cumulative total of about 231,560 and 253,770 HIV infected people by the years 2000 and 2004, respectively. There will also be, according to this model, about 16,450 and 23,220 new AIDS cases by the years 2000 and 2004, respectively.The adult HIV prevalence reaches a plateau level of 10.78% in the year 2001 and then declines to 10.28% in the year 2004(table 1 and figure 1).According to this model there will be about 23220 new AIDS cases and 21990 annual AIDS deaths in the year 2004(table 1 and figure 2).

The projected cumulative burden of AIDS deaths, would be 56,460 by the year 2000 and 133,890 by the year 2004 (table 1).

Figures 3-6 show four indicators of mortality in the absence of AIDS and with AIDS.

These indicators include crude death rate (figure 3), infant mortality rate (figure 4), under five mortality rate (figure 5), and life expectancy at birth (figure 6).

In the absence of AIDS, the indicators show a projected steady decline in mortality.

The presence of AIDS slows this decline, and infact reverses it in some cases. Crude death rate increases and life expectancy declines in the presence of AIDS.

In the absence of AIDS crude death rate is expected to decline from 7.3 per 1000 in 1984 to 6.1 per 1000 and 5.3 per 1000 in the years 1994 and 2004, respectively. But in the "with AIDS" scenario it is expected to increase from 7.3 per 1000 in 1984 to 7.0 per 1000 in 1994 and to 12.3 per 1000 by the year 2004, which is larger by 7.0 per 1000 population as compared to the "No AIDS" scenario.
Infant mortality rate is expected to decline in "No AIDS" scenario from 80.4 per 1000 in 1984 to 72.7 per 1000 live births in 1994 and to 61.1 per 1000 live births in the year 2004, but in the "with AIDS" scenario it is expected to decline from 80.4 per 1000 in 1984 to 76.5 per 1000 live births in 1994 and 68.0 per 1000 live births, which exceeds the "No AIDS" scenario by 6.9 per 1000 live births.

In "No AIDS" scenario under 5 mortality rate is expected to decline from 144.8 per 1000 in 1984 to 129.8 per 1000 live births in 1994 and to 108.6 per 1000 live births by the year 2004. But in the "with AIDS" scenario it is expected to decline from 144.8 per 1000 live births in 1984 to 138.3 per 1000 live birth and to 134.8 per 1000 live births in the years 1994 and 2004, respectively. This is larger than the "No AIDS" scenario by 26.2 deaths per 1000 live births.

In the absence of AIDS life expectancy at birth is expected to rise from 62 years in 1984 to 64 years in 1994 and to 66.9 years by the year 2004, but in the presence of

AIDS it is expected to decline from 62 years in 1984 to 59.9 years in 1994 and to 51.5 years by the year 2004. When compared to the "No AIDS" scenario it is lower by 15.4 years.

The changes in mortality indicators is depicted also in Table 2.

In the "No AIDS" scenario as depicted in table 3 and figure 7, the total population would increase from about 1.43 million in 1984 to about 2.31 million in 1994 and to about 2.91 million by the year 2000 and 3.32 million by the year 2004.

When the "No AIDS" scenario is compared to the one in which the impact from HIV/AIDS is taken into account, the situation emerging is quite different.

"With AIDS" the total population is expected to rise to 2.31 million in 1994 and to 2.82 million in the year 2000 and to 3.16 million by the year 2004, there by resulting in almost 160000 fewer people when compared to the "No AIDS" scenario.

In the absence of AIDS the population growth rate is expected to decline from 5.43 percent in 1984 to 3.89 percent and 3.01 percent in the years 1994 and 2004, respectively. But, in the "with AIDS" scenario the population growth rate is expected to decline from 5.43 percent in the year 1984 to 3.77 percent and 2.37 percent in the years 1994 and 2004, respectively (table 3 and figure 8).

Table 1. Projected number of people with HIV,Adult HIV prevalence,New AIDS cases,Annual HIV+ births,Annual AIDS deaths,and Cumulative AIDS deaths of 1984-2004, Addis Ababa.

| Year | HIV population (Thousands) | | | Adult Prevalence | New AIDS Cases (Thousands) | | | Annual HIV+ Births (Thousands) | | Annual AIDS Deaths (Thousands) | | | Cumulative AIDS Deaths (Thosands) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | M | F | % | Total | M | F | Total | Percent | Total | M | F | Total | M | F |
| 1984 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1985 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1986 | 1.09 | .72 | .37 | 0.11 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1987 | 3.97 | 2.56 | 1.41 | 0.37 | 0.00 | 0.00 | 0.00 | 0.03 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1988 | 9.37 | 6.12 | 3.61 | 0.84 | 0.04 | 0.03 | 0.02 | 0.07 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1989 | 18.92 | 11.62 | 7.31 | 1.52 | 0.13 | 0.08 | 0.05 | 0.13 | 0.35 | 0.04 | 0.03 | 0.02 | 0.04 | 0.03 | 0.02 |
| 1990 | 31.98 | 19.16 | 12.82 | 2.40 | 0.35 | 0.21 | 0.14 | 0.22 | 0.58 | 0.13 | 0.08 | 0.05 | 0.18 | 0.11 | 0.07 |
| 1991 | 48.6 | 28.43 | 20.17 | 3.42 | 0.74 | 0.44 | 0.30 | 0.33 | 0.86 | 0.35 | 0.21 | 0.14 | 0.53 | 0.32 | 0.21 |
| 1992 | 68.37 | 39.02 | 29.35 | 4.53 | 1.39 | 0.82 | 0.57 | 0.46 | 1.20 | 0.74 | 0.44 | 0.30 | 1.27 | 0.76 | 0.50 |
| 1993 | 90.54 | 50.40 | 40.14 | 5.67 | 2.34 | 1.37 | 0.97 | 0.60 | 1.57 | 1.39 | 0.82 | 0.57 | 2.66 | 1.59 | 1.07 |
| 1994 | 114.53 | 62.14 | 52.38 | 6.80 | 3.63 | 2.09 | 1.54 | 0.75 | 1.97 | 2.34 | 1.37 | 0.97 | 5.00 | 2.96 | 2.04 |
| 1995 | 137.88 | 73.48 | 64.39 | 7.79 | 5.27 | 2.99 | 2.28 | 0.87 | 2.24 | 3.63 | 2.09 | 1.54 | 8.63 | 5.05 | 3.58 |
| 1996 | 161.11 | 84.69 | 76.43 | 8.69 | 7.23 | 4.03 | 3.21 | 1.02 | 2.57 | 5.27 | 2.99 | 2.28 | 13.9 | 8.04 | 5.86 |
| 1997 | 182.55 | 94.93 | 87.62 | 9.43 | 9.41 | 5.16 | 4.25 | 1.15 | 2.86 | 7.23 | 4.03 | 3.21 | 21.13 | 12.07 | 9.07 |
| 1998 | 201.86 | 104.06 | 97.80 | 10.44 | 11.78 | 6.35 | 5.43 | 1.26 | 3.10 | 9.41 | 5.16 | 4.25 | 30.54 | 17.22 | 13.32 |
| 1999 | 218.10 | 111.66 | 106.45 | 10.44 | 14.14 | 7.50 | 6.63 | 1.34 | 3.29 | 11.78 | 6.35 | 5.43 | 42.32 | 23.57 | 18.75 |
| 2000 | 231.56 | 117.88 | 113.68 | 10.69 | 16.45 | 8.61 | 7.84 | 1.40 | 3.43 | 14.14 | 7.50 | 6.63 | 56.46 | 31.07 | 25.38 |
| 2001 | 241.74 | 122.50 | 119.23 | 10.78 | 18.55 | 9.61 | 8.94 | 1.42 | 3.52 | 16.45 | 8.61 | 7.84 | 72.91 | 39.69 | 33.22 |
| 2002 | 248.98 | 125.72 | 123.26 | 10.74 | 20.44 | 10.48 | 9.96 | 1.42 | 3.57 | 18.55 | 9.61 | 8.94 | 91.46 | 49.29 | 42.17 |
| 2003 | 253.00 | 127.39 | 125.61 | 10.57 | 21.99 | 11.20 | 10.80 | 1.40 | 3.57 | 20.44 | 10.48 | 9.96 | 111.90 | 59.78 | 52.12 |
| 2004 | 253.77 | 127.51 | 126.27 | 10.28 | 23.22 | 11.76 | 11.46 | 1.35 | 3.54 | 21.99 | 11.20 | 10.80 | 133.89 | 70.97 | 62.92 |

M - Male
F - Female

**Fig 1. Projected Adult HIV Prevalence**
1984-2004, Addis Ababa

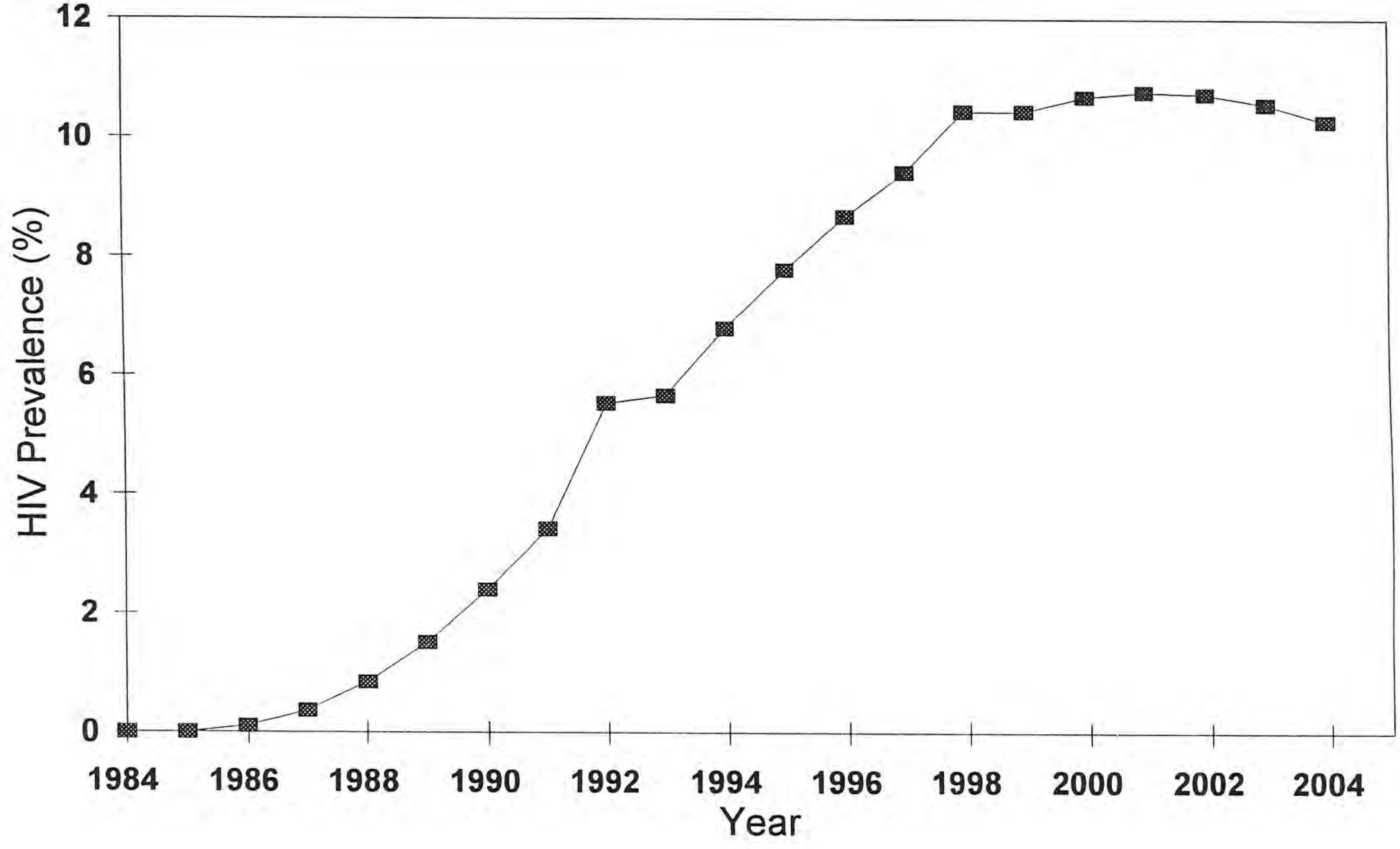


**Fig 2. Projected New AIDS cases and annual deaths 1984-2004, Addis Ababa**

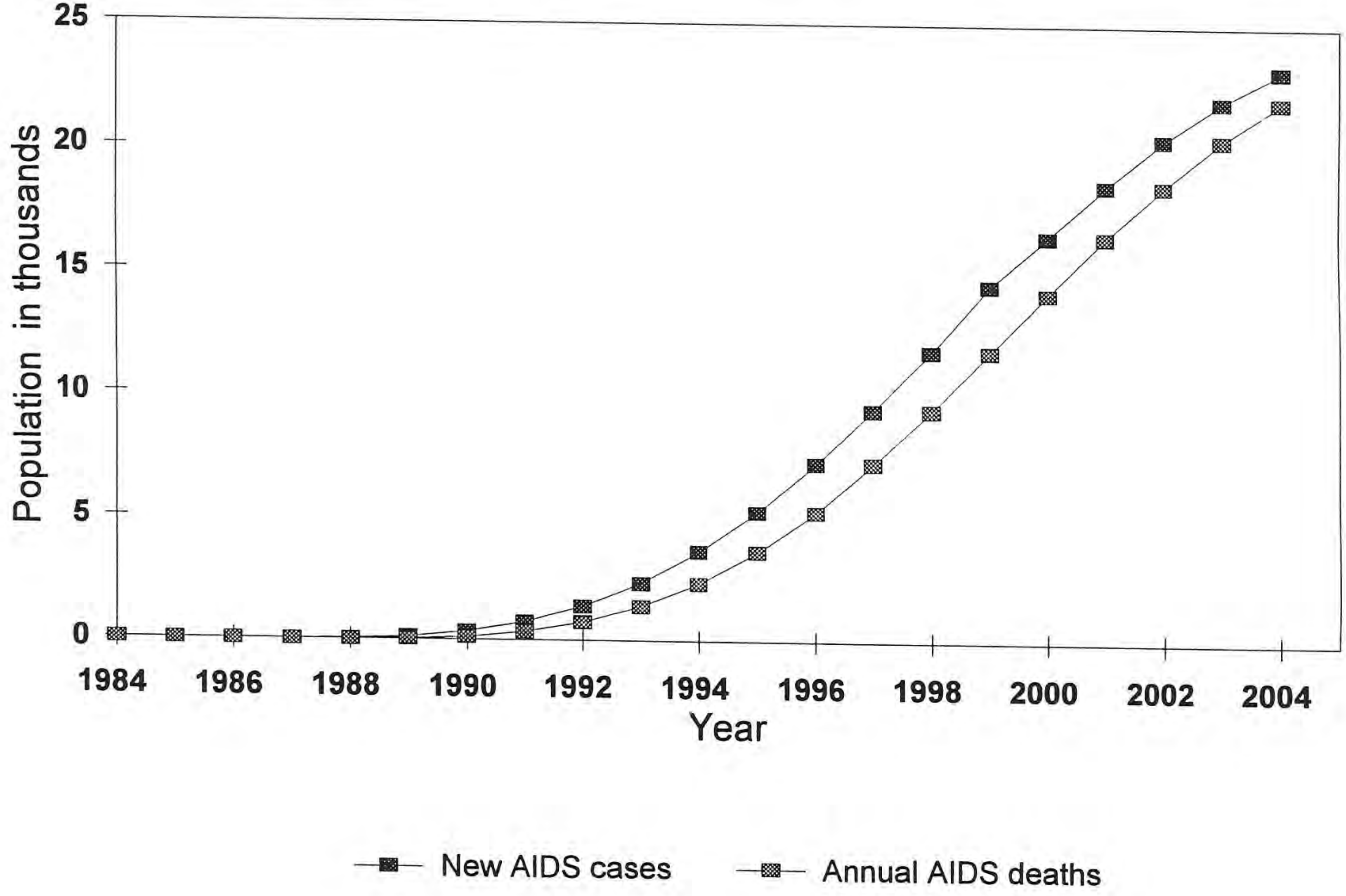


Table 2. Mortality Indicators in the absence of AIDS and presence of AIDS 1984-2004 in Addis Ababa.

| | IMR (Per 1000) | | LE(YEARS) | | U5MR (Per 1000) | | CDR (Per 1000) | |
|---|---|---|---|---|---|---|---|---|
| Year | NA | WA | NA | WA | NA | WA | NA | WA |
| 1984 | 80.4 | 80.4 | 62.0 | 62.0 | 144.8 | 144.8 | 7.3 | 7.3 |
| 1985 | 79.7 | 79.7 | 62.2 | 62.2 | 143.2 | 143.2 | 7.1 | 7.1 |
| 1986 | 78.9 | 78.9 | 62.4 | 62.4 | 141.7 | 141.7 | 7.0 | 7.0 |
| 1987 | 78.1 | 78.3 | 62.6 | 62.6 | 140.2 | 140.2 | 6.8 | 6.8 |
| 1988 | 77.3 | 77.7 | 62.8 | 62.7 | 138.6 | 138.9 | 6.6 | 6.6 |
| 1989 | 76.6 | 77.2 | 63.0 | 62.8 | 137.2 | 137.8 | 6.5 | 6.5 |
| 1990 | 75.8 | 76.9 | 63.2 | 62.7 | 135.7 | 137.1 | 6.4 | 6.5 |
| 1991 | 75.0 | 76.7 | 63.4 | 62.4 | 134.2 | 136.7 | 6.3 | 6.5 |
| 1992 | 74.2 | 76.6 | 63.6 | 61.8 | 132.7 | 136.8 | 6.2 | 6.6 |
| 1993 | 73.4 | 76.5 | 63.8 | 61.0 | 131.3 | 137.4 | 6.1 | 6.8 |
| 1994 | 72.7 | 76.5 | 64.0 | 59.9 | 129.8 | 138.3 | 6.1 | 7.0 |
| 1995 | 71.5 | 75.8 | 64.3 | 58.8 | 127.6 | 138.4 | 6.0 | 7.4 |
| 1996 | 70.3 | 75.3 | 64.6 | 57.5 | 125.4 | 138.4 | 5.9 | 8.0 |
| 1997 | 69.2 | 74.7 | 64.9 | 56.3 | 123.2 | 138.4 | 5.8 | 8.6 |
| 1998 | 68.0 | 74.0 | 65.2 | 55.0 | 120.9 | 138.4 | 5.7 | 9.3 |
| 1999 | 66.8 | 73.2 | 65.5 | 54.0 | 118.7 | 138.4 | 5.7 | 9.9 |
| 2000 | 65.7 | 72.3 | 65.8 | 53.1 | 116.7 | 138.3 | 5.6 | 10.6 |
| 2001 | 64.5 | 71.4 | 66.1 | 52.4 | 114.6 | 137.9 | 5.5 | 11.2 |
| 2002 | 63.4 | 70.3 | 66.4 | 51.9 | 112.6 | 137.1 | 5.4 | 11.6 |
| 2003 | 62.3 | 69.2 | 66.7 | 51.6 | 110.6 | 136.1 | 5.4 | 12.1 |
| 2004 | 61.1 | 68.0 | 67.0 | 51.5 | 108.6 | 134.8 | 5.3 | 12.3 |

NA - No AIDS
WA - With AIDS

**Fig. 3 Crude Death Rate per 1000**
Population 1984-20004

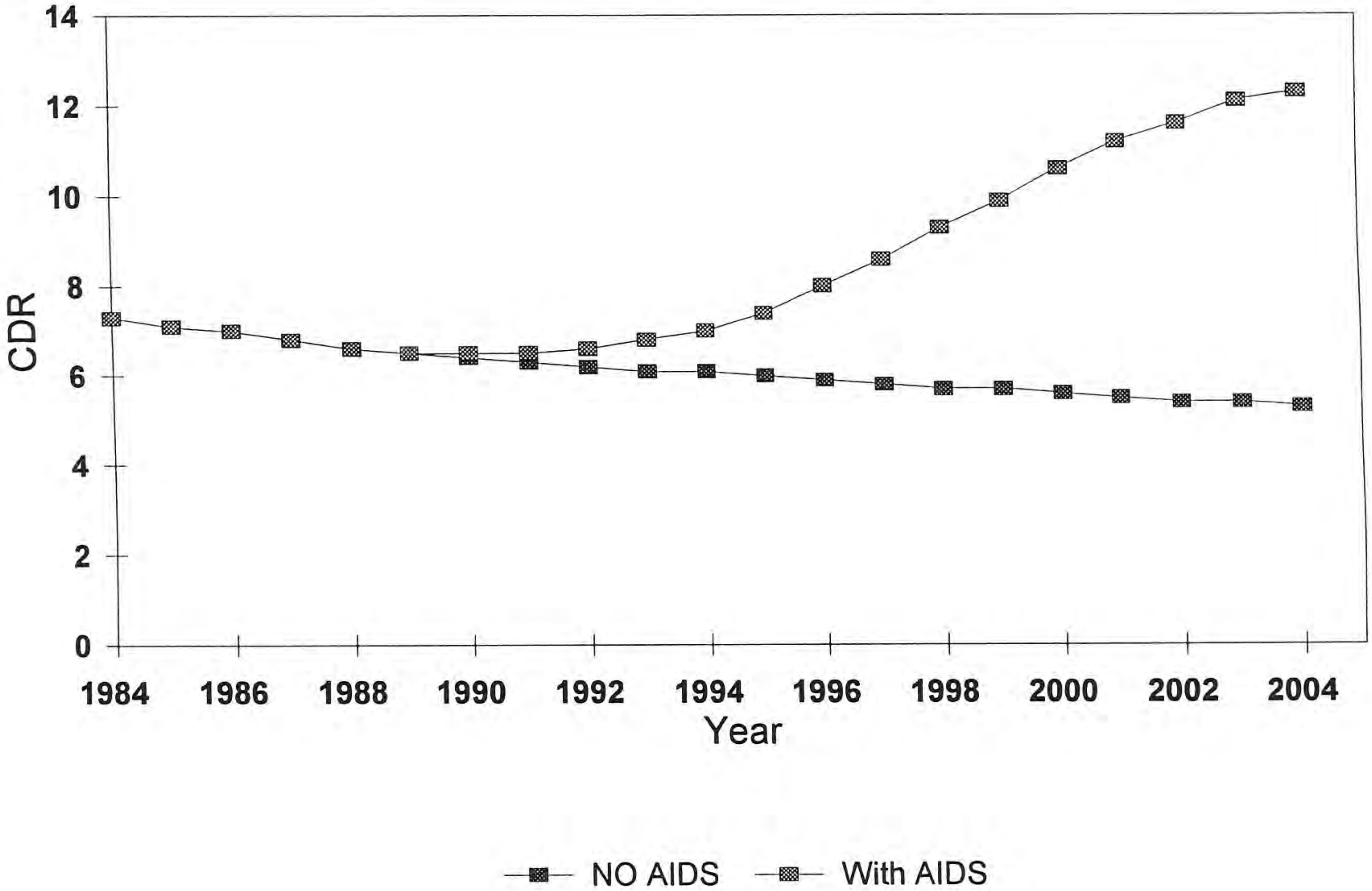


**Fig 4. Infant Mortality Rate per 1000**
Live Births,1984-2004, Addis Ababa

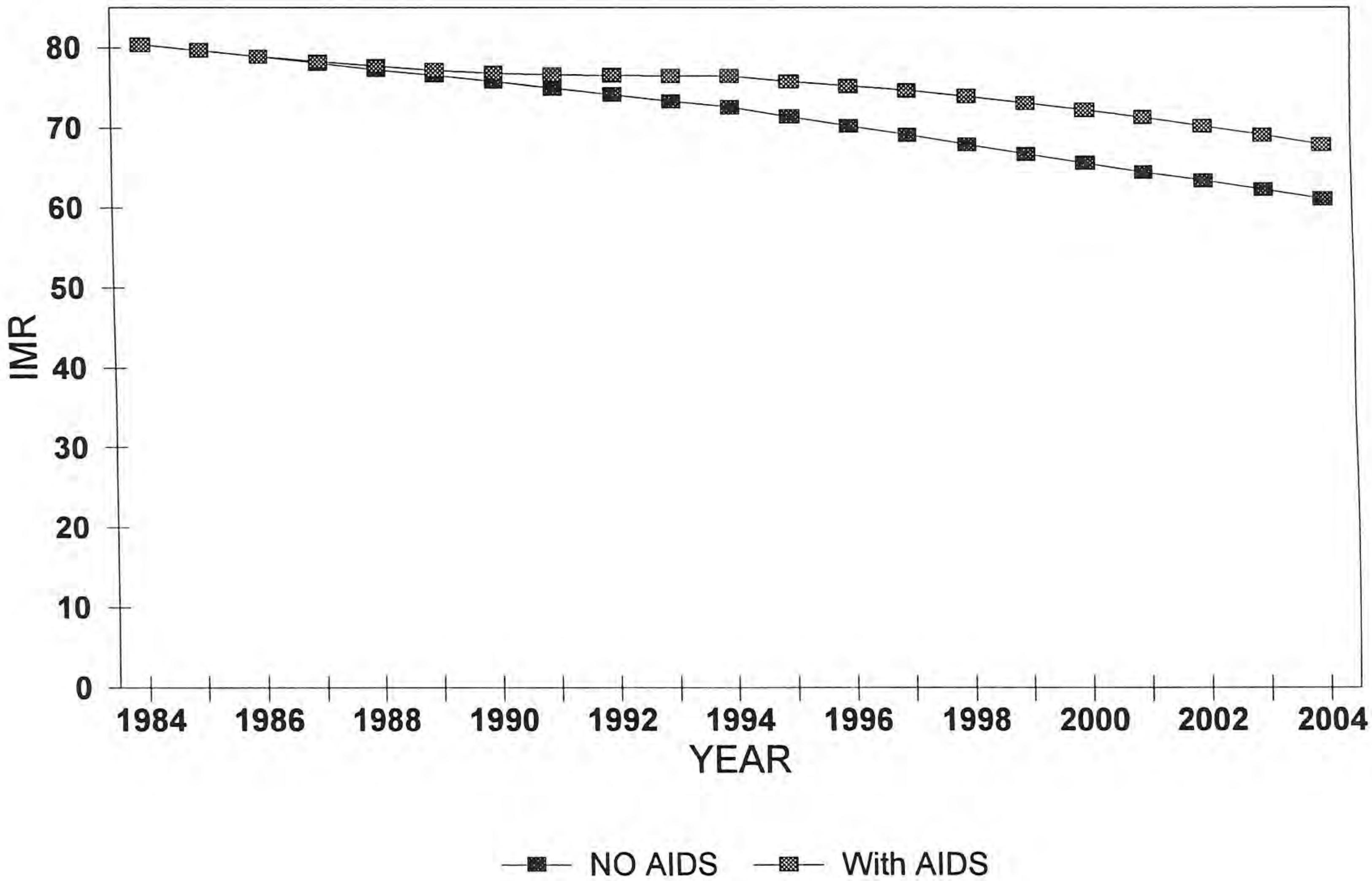


**Fig. 5 Under Five Mortality Rate per**
1000 Live Birth 1984-2004, Addis Ababa

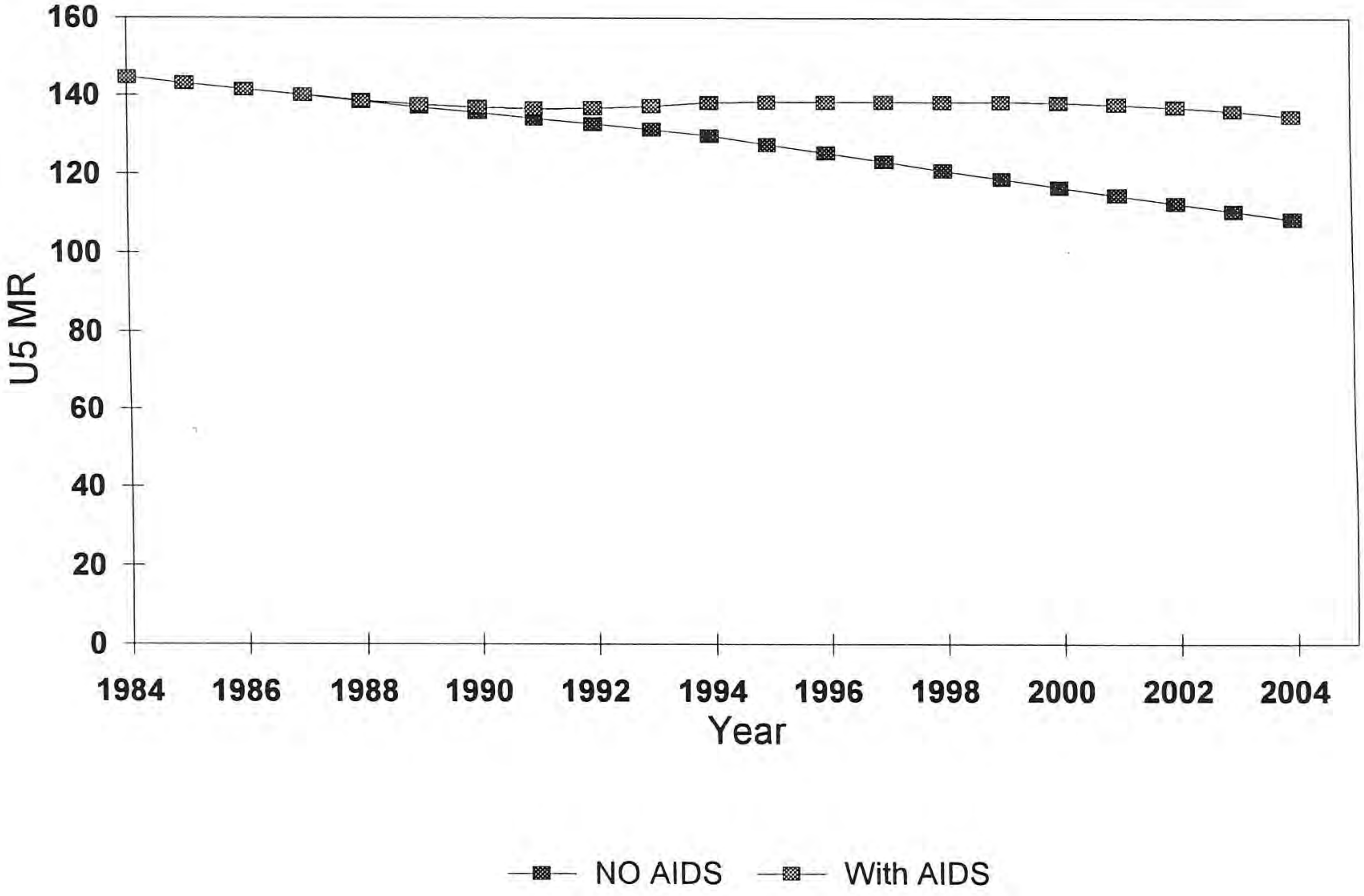


**Fig. 6 Life Expectancy at Birth**
1984-2004, Addis Ababa

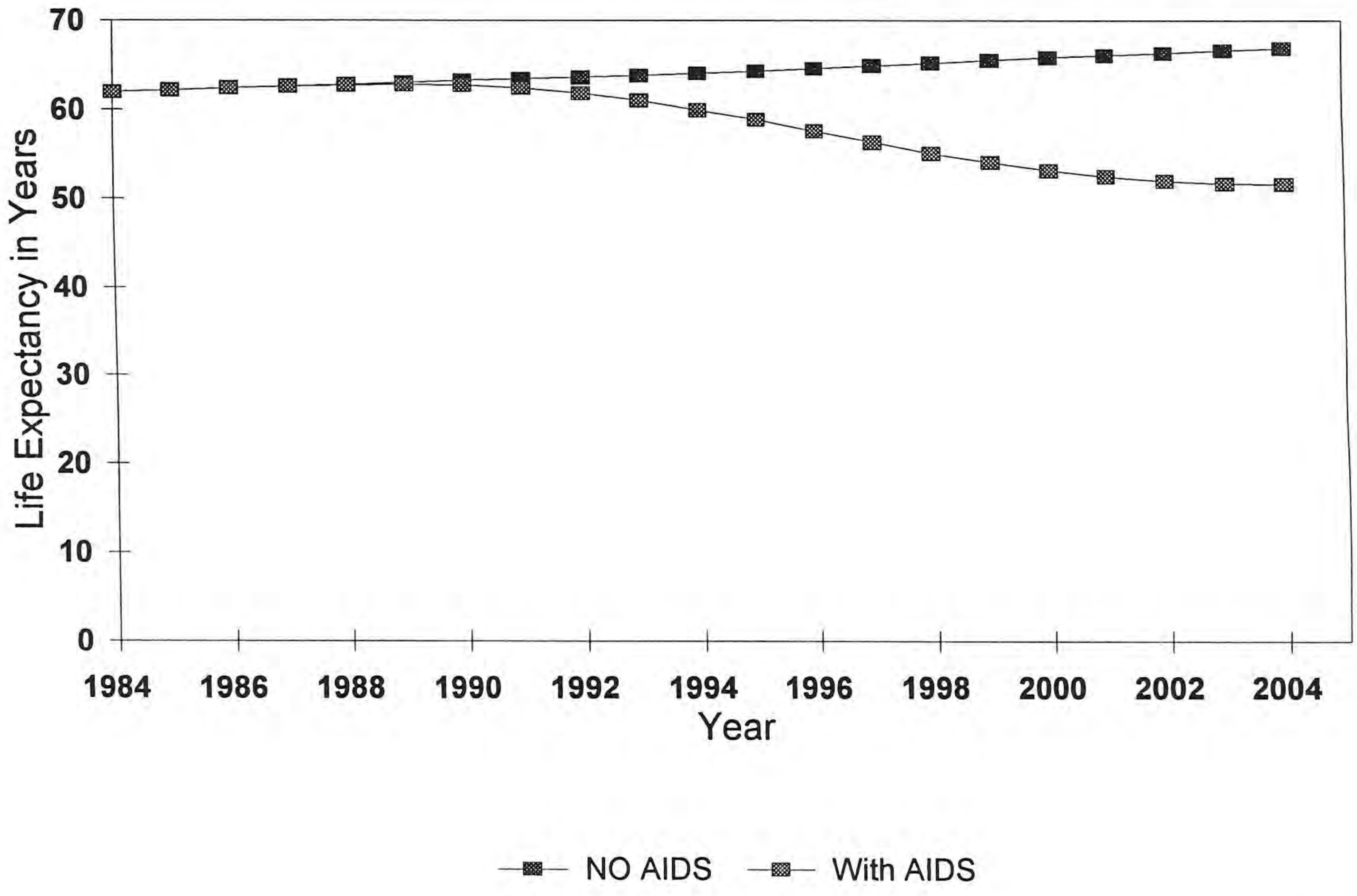


Table 3. Total Population, Annual growth rate, doubling time and rate of natural increase - in the presence and absence of AIDS epidemic 1984-2004 in Addis Ababa.

| Year | Total population (in millions) NA | WA | AGR (percent/year) NA | WA | RNI (percent/year) NA | WA | Doubling Time (year) NA | WA |
|---|---|---|---|---|---|---|---|---|
| 1984 | 1.43 | 1.43 | 5.43 | 5.43 | 1.57 | 1.57 | 13.1 | 13.1 |
| 1985 | 1.51 | 1.51 | 5.24 | 5.24 | 1.53 | 1.53 | 13.6 | 13.6 |
| 1986 | 1.60 | 1.60 | 5.07 | 5.07 | 1.50 | 1.50 | 14.0 | 14.0 |
| 1987 | 1.68 | 1.68 | 4.91 | 4.91 | 1.46 | 1.46 | 14.5 | 14.5 |
| 1988 | 1.77 | 1.77 | 4.76 | 4.76 | 1.42 | 1.42 | 14.9 | 14.9 |
| 1989 | 1.86 | 1.86 | 4.61 | 4.60 | 1.38 | 1.37 | 15.4 | 15.4 |
| 1990 | 1.95 | 1.95 | 4.46 | 4.45 | 1.33 | 1.31 | 15.9 | 15.9 |
| 1991 | 2.04 | 2.04 | 4.32 | 4.29 | 1.28 | 1.25 | 16.4 | 16.5 |
| 1992 | 2.13 | 2.13 | 4.17 | 4.12 | 1.22 | 1.16 | 17.0 | 17.2 |
| 1993 | 2.22 | 2.22 | 4.03 | 3.95 | 1.15 | 1.06 | 17.5 | 17.9 |
| 1994 | 2.31 | 2.31 | 3.89 | 3.77 | 1.08 | 0.95 | 18.2 | 18.8 |
| 1995 | 2.41 | 2.40 | 3.81 | 3.64 | 1.07 | 0.88 | 18.6 | 19.4 |
| 1996 | 2.51 | 2.49 | 3.73 | 3.50 | 1.05 | 0.80 | 18.9 | 20.1 |
| 1997 | 2.60 | 2.58 | 3.66 | 3.36 | 1.03 | 0.71 | 19.3 | 21.0 |
| 1998 | 2.70 | 2.67 | 3.57 | 3.20 | 1.00 | 0.60 | 19.8 | 22.0 |
| 1999 | 2.80 | 2.75 | 3.47 | 3.03 | 0.97 | 0.49 | 20.3 | 23.2 |
| 2000 | 2.91 | 2.84 | 3.38 | 2.87 | 0.94 | 0.38 | 20.9 | 24.5 |
| 2001 | 3.01 | 2.92 | 3.28 | 2.73 | 0.89 | 0.27 | 21.5 | 25.8 |
| 2002 | 3.11 | 3.00 | 3.19 | 2.59 | 0.85 | 0.16 | 22.1 | 27.1 |
| 2003 | 3.21 | 3.08 | 3.09 | 2.47 | 0.79 | 0.07 | 22.8 | 28.5 |
| 2004 | 3.32 | 3.16 | 3.01 | 2.37 | 0.73 | -0.02 | 23.4 | 29.6 |

* NA - AIDS WA - WITH AIDS

**Fig. 7 Projected Total Population in** millions, 1984-2004, Addis Ababa

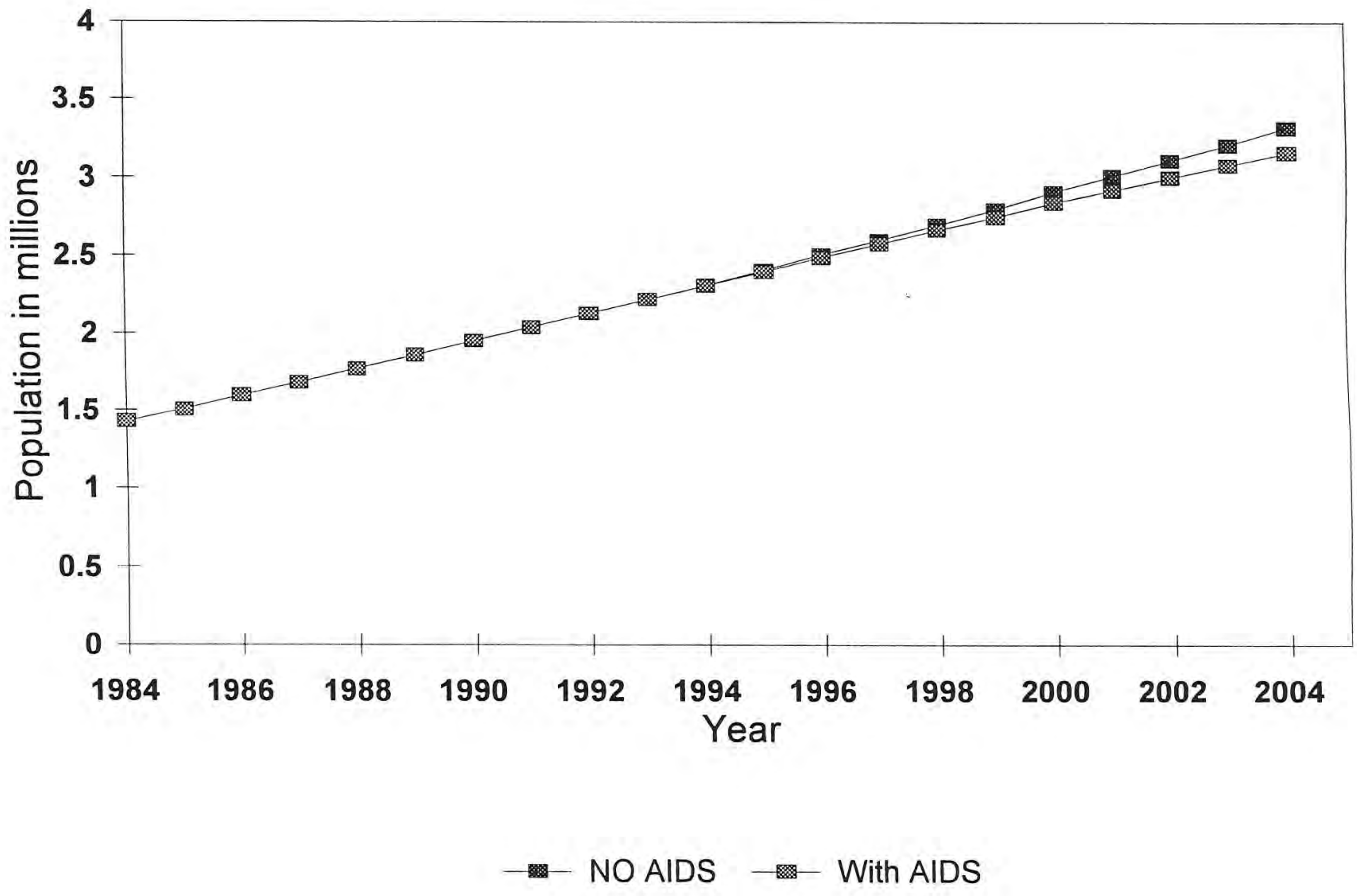


**Fig. 8 Annual Growth Rate projection**
1984-2004, Addis Ababa

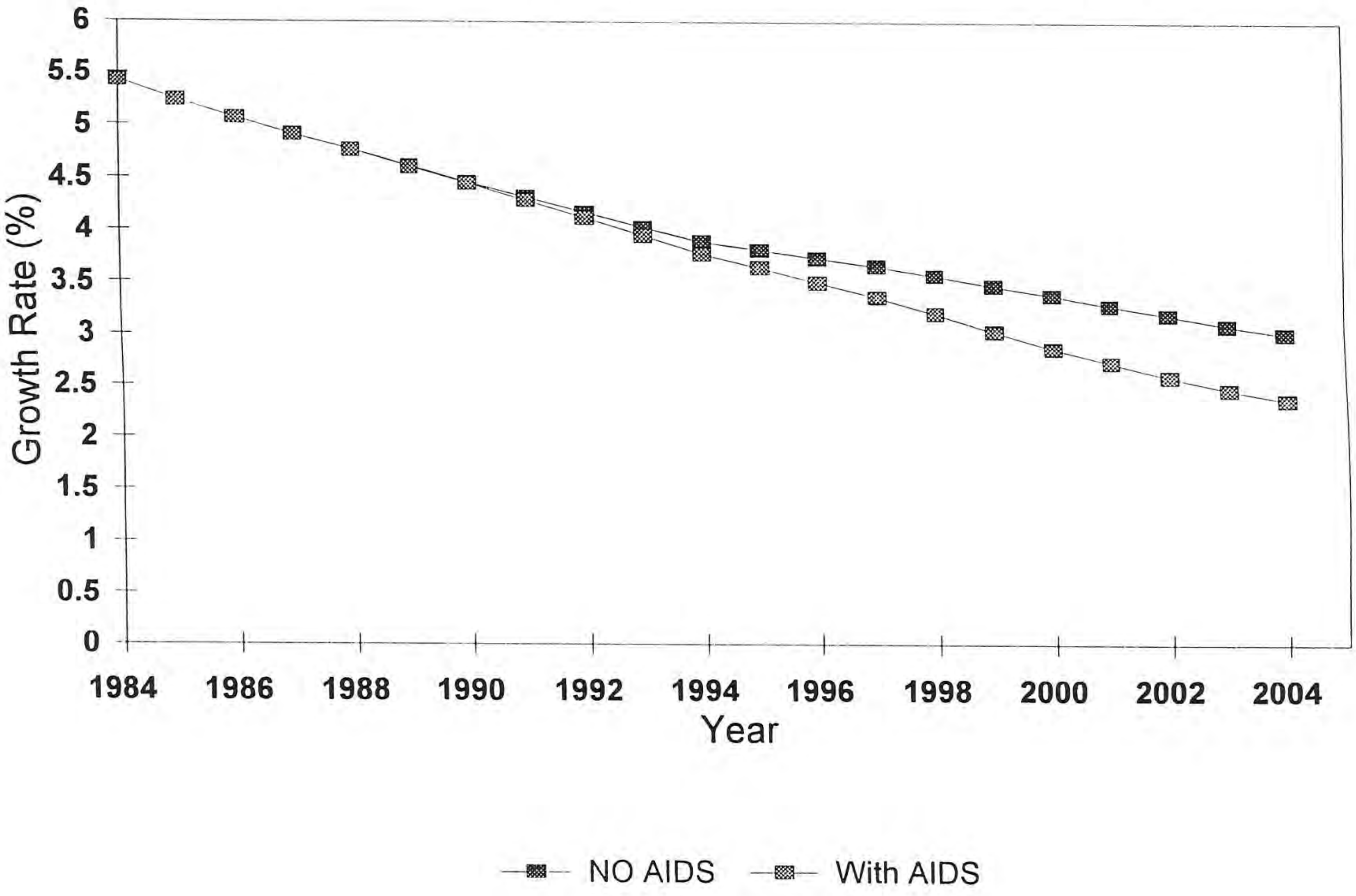


Table 4. Total Fertility Rate, General reproduction rate, NRR and child women ratio - in the presence and absence of AIDS epidemic 1984-2004 in Addis Ababa

| Year | TFR | | GRR | | NRR | | CWR | |
|---|---|---|---|---|---|---|---|---|
| | NA | WA | NA | WA | NA | WA | NA | WA |
| 1984 | 3.20 | 3.20 | 1.67 | 1.67 | 1.42 | 1.42 | 0.49 | 0.49 |
| 1985 | 3.06 | 3.06 | 1.59 | 1.59 | 1.36 | 1.36 | 0.44 | 0.44 |
| 1986 | 2.92 | 2.92 | 1.52 | 1.52 | 1.30 | 1.30 | 0.41 | 0.41 |
| 1987 | 2.78 | 2.78 | 1.45 | 1.45 | 1.24 | 1.24 | 0.38 | 0.38 |
| 1988 | 2.64 | 2.63 | 1.38 | 1.38 | 1.18 | 1.18 | 0.36 | 0.36 |
| 1989 | 2.50 | 2.49 | 1.30 | 1.30 | 1.12 | 1.12 | 0.35 | 0.35 |
| 1990 | 2.36 | 2.35 | 1.23 | 1.23 | 1.06 | 1.06 | 0.33 | 0.33 |
| 1991 | 2.22 | 2.20 | 1.16 | 1.16 | 1.00 | 1.00 | 0.32 | 0.32 |
| 1992 | 2.08 | 2.05 | 1.08 | 1.08 | 0.94 | 0.94 | 0.31 | 0.30 |
| 1993 | 1.94 | 1.91 | 1.01 | 1.01 | 0.88 | 0.88 | 0.29 | 0.29 |
| 1994 | 1.80 | 1.76 | 0.94 | 0.94 | 0.82 | 0.82 | 0.28 | 0.28 |
| 1995 | 1.74 | 1.70 | 0.91 | 0.91 | 0.79 | 0.79 | 0.27 | 0.27 |
| 1996 | 1.68 | 1.63 | 0.88 | 0.88 | 0.77 | 0.77 | 0.26 | 0.26 |
| 1997 | 1.62 | 1.57 | 0.84 | 0.84 | 0.74 | 0.74 | 0.25 | 0.25 |
| 1998 | 1.56 | 1.51 | 0.81 | 0.81 | 0.72 | 0.72 | 0.25 | 0.24 |
| 1999 | 1.50 | 1.45 | 0.78 | 0.78 | 0.69 | 0.69 | 0.25 | 0.24 |
| 2000 | 1.44 | 1.39 | 0.75 | 0.75 | 0.66 | 0.66 | 0.24 | 0.23 |
| 2001 | 1.38 | 1.33 | 0.72 | 0.72 | 0.64 | 0.64 | 0.24 | 0.23 |
| 2002 | 1.32 | 1.27 | 0.69 | 0.69 | 0.61 | 0.61 | 0.23 | 0.22 |
| 2003 | 1.26 | 1.21 | 0.66 | 0.66 | 0.59 | 0.59 | 0.22 | 0.22 |
| 2004 | 1.20 | 1.16 | 0.63 | 0.63 | 0.56 | 0.56 | 0.21 | 0.21 |

* NA - NO AIDS      * WA With AIDS

## Fig. 9 Total Fertility Rate
1984-2004, Addis Ababa

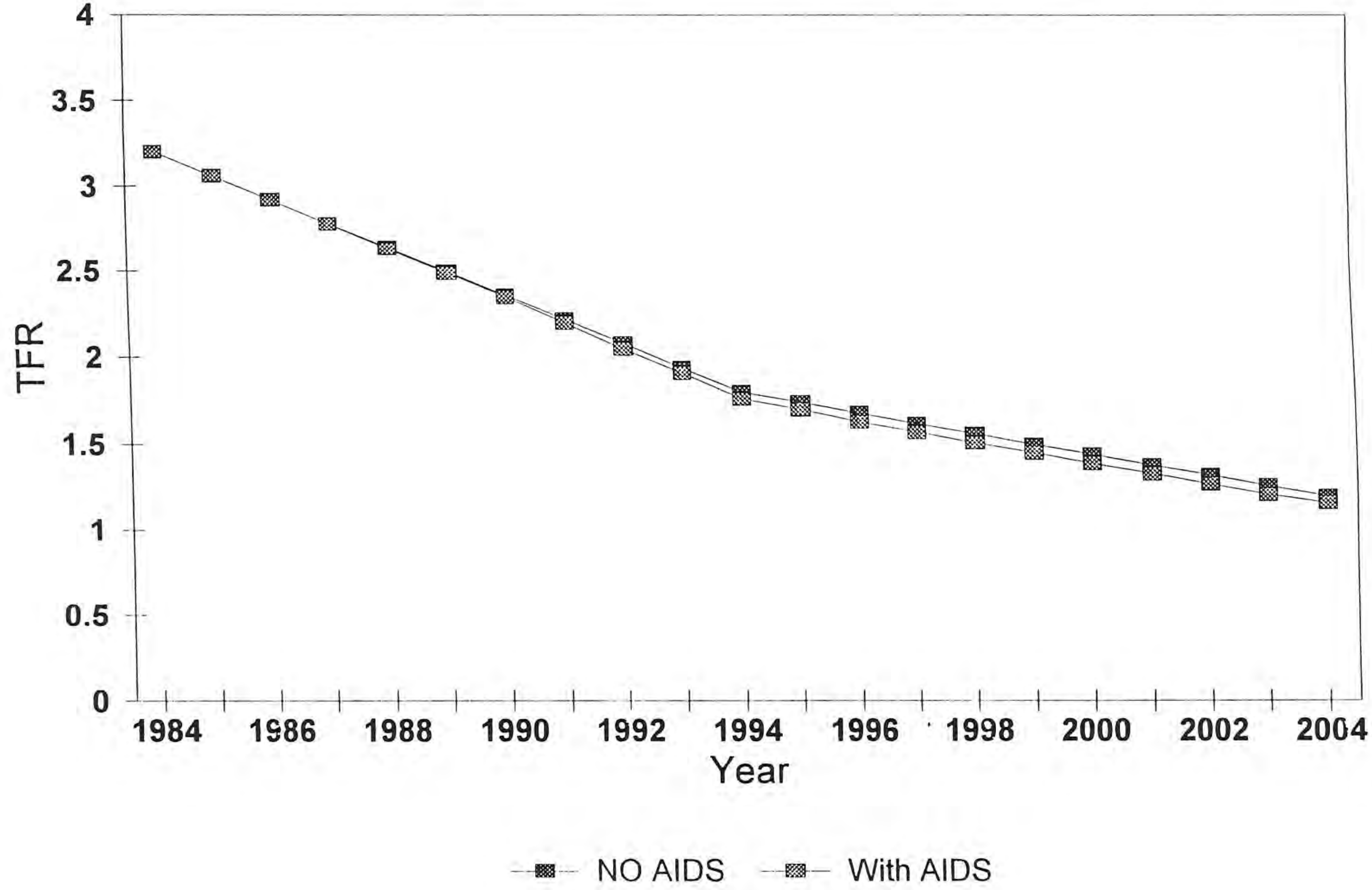
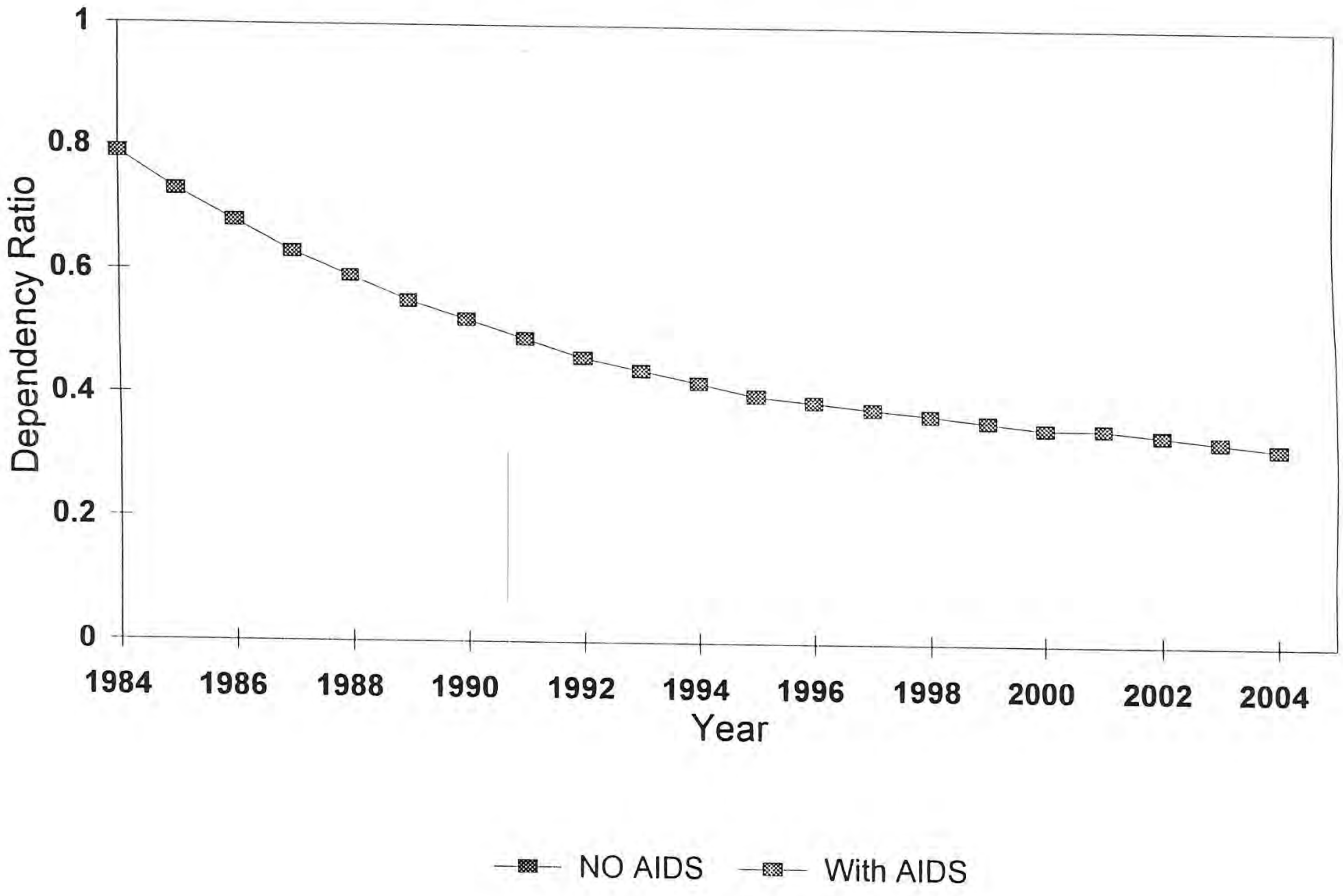


Table 5. Dependency and sex ratios in the absence and presence of AIDS epidemic 1984-2004 in Addis Ababa

| year | Dependency Ratio NA | Dependency Ratio WA | Sex Ratio NA | Sex Ratio WA |
|---|---|---|---|---|
| 1984 | 0.79 | 0.79 | 92.85 | 92.85 |
| 1985 | 0.73 | 0.73 | 92.97 | 92.97 |
| 1986 | 0.68 | 0.68 | 93.09 | 93.09 |
| 1987 | 0.63 | 0.63 | 93.21 | 93.21 |
| 1988 | 0.59 | 0.59 | 93.30 | 93.30 |
| 1989 | 0.55 | 0.55 | 93.39 | 93.39 |
| 1990 | 0.52 | 0.52 | 93.47 | 93.47 |
| 1991 | 0.49 | 0.49 | 93.55 | 93.53 |
| 1992 | 0.46 | 0.46 | 93.61 | 93.58 |
| 1993 | 0.44 | 0.44 | 93.67 | 93.62 |
| 1994 | 0.42 | 0.42 | 93.71 | 93.62 |
| 1995 | 0.40 | 0.40 | 93.75 | 93.62 |
| 1996 | 0.39 | 0.39 | 93.78 | 93.59 |
| 1997 | 0.38 | 0.38 | 93.80 | 93.54 |
| 1998 | 0.37 | 0.37 | 93.81 | 93.47 |
| 1999 | 0.36 | 0.36 | 93.81 | 93.40 |
| 2000 | 0.35 | 0.35 | 93.84 | 93.36 |
| 2001 | 0.35 | 0.35 | 93.85 | 93.31 |
| 2002 | 0.34 | 0.34 | 93.85 | 93.26 |
| 2003 | 0.33 | 0.33 | 93.86 | 93.22 |
| 2004 | 0.32 | 0.32 | 93.87 | 93.19 |

* NA - No AIDS * WA - With AIDS

**Fig. 10 Age Dependency Ratio project-ion 1984-2004, Addis Ababa**



**DISCUSSION**

(a) HIV/AIDS prevalence

This study showed that the adult HIV prevalence raised from 0% in 1984 to a plateau level of 10.78% in the year 2001,and then declined to 10.28% in the year 2004. This could be explained by the reduction in the incidence rate after stabilizing at 1.58% in 1996. Similar trend has been seen from a Tanzanian study(40), which also revealed seroprevalence levels reaching a plateau in some urban areas such as Dar es Salaam and Mwanza.

(b) Impact of HIV/AIDS on Mortality

In the absence of AIDS, the four indicators of mortality, i.e., crude death rate, infant mortality rate, under five mortality rate and life expectancy at birth, show a projected steady decline in mortality. The presence of AIDS slows this decline, and infact reverses it in some cases. It is shown that in the absence of AIDS crude death rate that would have been declined from 7.3 per 1000 in 1984 to 5.3 per 1000 in 2004, would raise to 12.3 per 1000 by the year 2004 in the presence of AIDS, which is larger by 7 per 1000 population as compared to the "with No AIDS" scenario. Similar trend has also been shown by a Tanzanian study (41).

The Zambian study conducted among employees of 33 factories and other businesses (20), which showed an increase in the crude death rate from 2.5 per 1000 in 1987 to 183 per 1000 in 1993 an increase virtually wholly attributable to HIV related disease. Although not as rapid as the Zambian study, our study

has shown similar trend.

The infant mortality rate which is expected to decline in "No AIDS" scenario from 80.4 per 1000 in 1984 to 61.1 per 1000 live births in 2004, would decline to 68.0 per 1000 in the presence of AIDS, which exceeds the "No AIDS" scenario by 6.9 per 1000 live births.

In the "No AIDS" scenario under five mortality rate is expected to decline from 144.8 per 1000 in 1984 to 108.6 per 1000 in the year 2004, but would be expected to decline to 134.8 per 1000 in the "with AIDS" scenarios. This finding indicates that AIDS is increasing the number of child deaths, which would undoubtedly threatens to reverse many of the recent gains of child survival programs, such as diarrhoea control and expanded programme on immunization. Similar trend was found from a study onducted on the impact of AIDS on child mortality in ten central and eastern African countries (7,19,41).

Life expectancy at birth is expected to rise in the absence of AIDS from 62 years in 1984 to 66.9 years in the year 2004, but in the presence of AIDS, it would be expected to decline from 62 years in 1984, to 51.5 years in 2004, which is lower by 15.5 years as compared to the "with no AIDS" scenario.

Similar trends was found from a study conducted on 21

Sub-saharan African countries by two major organizations: UN population division and US census Beuro (30-34). Studies in Ethiopia and Tanzanian have also reported the same findings (7,41).

(c) Impact on population size and growth rate

Our study shows that in the " No AIDS" scenario the total population would increase from about 1.43 million in 1984 to 3.32 million in 2004. But in the "with AIDS" scenario it would be expected to increase from 1.43 million in 1984 to 3.16 million in 2004, which results in 160,000 fewer people when compared to the "No AIDS" scenario. Similar reduction in the population size, as an effect of AIDS on the population size has been reported by studies conducted on the demographic impact of AIDS in Sub-saharan African countries (7,21,30-34).

In the presence of AIDS the population growth rate is expected to decline from 5.43 percent in 1984 to 2.37 percent in the year 2004. But it would have declined to 3.01 percent in the year 2004, in the "with no AIDS" scenario.

In contrary to Anderson's study which revealed that AIDS would turn the population growth negative (9), our study showed that AIDS would slow the growth rate of the population of Addis Ababa, but would not lead to negative population growth. This finding is in strong agreement with that of the MOH study in Ethiopia, Bongaart's study, the UN population division and the US census Beuro (7,10,21,30-34). The difference in the impact of HIV/AIDS on population growth rate seen among the various studies could be explained by the difference in assumptions made on the future level of HIV prevalence (11).

(d) Impact of HIV/AIDS on Fertility

In this study it has been shown that in the "with AIDS" scenario, total fertility rate would decline from 3.2 in 1984 to 1.16 in the year 2004. But in the "with no AIDS" scenario it would have been expected to decline from the same level in 1984 to 1.2 in the year 2004. This shows that the reduction in the total fertility rate would be higher by 3.5 percent in the "with AIDS" scenario than that in the absence of AIDS.

The pattern seen in this study is broadly similar to that observed in two African studies; Masaka district and Rakai district in Uganda (25-26).

(e) Impact on dependency ratio

This study shows that the dependency ratio declines from 0.79 in 1984 to 0.32 in 2004, in both the "with no AIDS" and the "with AIDS" scenarios. But, though the difference is very minor, the dependency ratio would be higher by 0.7 percent in the "with AIDS" scenario. This result is comparable with that of the UN population division and US census Bureau projection (30-34) which showed a slight increment in the dependency ratio as a result of AIDS.

It might seem that the dependency ratio should become worse (increase) due to AIDS because of the increased number of deaths to young adults. However, in the African context, AIDS also leads to an increase in the number of child deaths. These two factors tend to roughly balance each other, with the result that the dependency ratio does not change dramatically in the presence of an AIDS epidemic. This does not mean that the dependency situation is not serious.An AIDS epidemic does create many orphans, for example. However, the traditional dependency ratio is not a good measure of the dependency burden created by AIDS.

**Limitations**

It is to be noted that there are certain limitations of the study.

To begin with, many of the epidemiological, biological and behaviourial aspects of HIV infections are not fully understood or information about them is not available.

For instance, the exact incubation and survival time of AIDS are not known, nor is Ethiopia specific information on them is available.Most of the estimates of the epidemiologic input parameters used in this study, such as perinatal transmission rate, child and adult incubation period, progression rate from AIDS to death, etc, were adopted from studies conducted else where.

Secondly, the future adult HIV prevalence was projected for a period of 10 years, using WHO model

(Epimodel), which is designed primarily for short term (3-5 years) projection of AIDS cases and deaths. This itself would make the projection more inaccurate.

Thirdly, uncertainties exist regarding demographic factors such as the current size and structure of the population and future trends in fertility, mortality and migration.

Fourthly, the first year of the demographic projection and the year HIV first became widespread is same. Because the first census in Ethiopia was conducted in that year (1984).The first year of the demographic projection should have been a year before the year HIV first became wide spread,which is the year 1983 , so that the year HIV first became wide spread is included in the demographic projection and a more accurate result obtained.

Because there is no reliable data available for the year 1983, we were forced to use the 1984 census result as a base year data. This itself would contribute to the inaccuracy of the findings.

Though this study has got all the above mentioned limitations the fact that it was based on the adult HIV prevalence value obtained from a community based study would give it strength.

All in all, therefore, we feel that our projections are qualitatively likely but that quantitative generalizations should be made carefully. But, with all its limitations, this study would give an insight of the

HIV/AIDS epidemic in Addis Ababa to policy makers and planners.

**Conclusion**

In conclusion, the results show that:-

(a)The HIV prevalence will reach a plateau level and then declines.

(b) AIDS will slow the decline in mortality, and infact reverses it in some cases (increase mortality).

(c) AIDS will reduce the population size significantly and slows the population growth rate, but will not stop the growth or make it negative.

(d) AIDS will reduce fertility

(e) AIDS will not worsen the traditional dependency ratio (i.e., the population under age 15 and over age 64, as a proportion of the population age 15-64)

## Recommendations

1. Effective preventive strategies such as STD control,condom promotion,IEC and blood screening should soon be strengthened or designed and implemented, based on the AIDS policy, to prevent this catastrophe from becoming a reality.
2. Preventive strategies and actions should be implemented multisectorally, because the HIV/AIDS epidemic is no more a health problem only.
3. The impact of HIV/AIDS epidemic should be incorporated in the demographic projection, both at national and regional levels.
4 Studies should be conducted to determine:-
   a) The magnitude of HIV/AIDS in Addis Ababa as well as in Ethiopia.
   b) The incubation period of HIV infection.
   c) Progression rate from AIDS to death.
   d) Perinatal transmission rate.
   e) Reduction in fertility due to HIV infection.
   f) Behaviourial factors associated with HIV infection.
5. Deterministic Models Which incorporate behaviourial factors too should be applied to asses the demographic impact of HIV/AIDS more accuratly.
6. Data base on HIV/AIDS epidemic should be established, and updated frequently and regularly based on results of studies conducted locally.

REFERENCES


1. World Health Organization.**The World Health Report-1998.** Geneva ,1998.
2. De Cock KM,Adjorlolo G,Ekpini E,Sibailly T,Kouadio J,Maran M, et al. **Epidemiology and transmission of HIV-2. Why there is no HIV-2 Pandemic.** JAMA 1993, 270:2083-2086.
3. Tsega E, Mengesha B, Nordenfelt E, Hansson BG, Lindberg J: **Serological survey of human immunodeficiency virus (HIV) in Ethiopia.** Ethiop. Med J. 1988, 26:179-184
4. Lester FT, Ayehunies, Zewdie D: **Acquired immunodeficiency Syndrome: Seven cases in Addis Ababa Hospital.** Ethiopia Med. J. 1988, 26:139-145.
5. Ministry of Health.**AIDS in Ethiopia**, First Edition. Addis Ababa,1996.
6. Arnauld L. Fontanet,Messele T. ,Dejene A.,Enquselassie F.,Abebe A.,Cutts F.T. et al., **Age and sex specific HIV-1 prevalence in the urban community setting of Addis Ababa,Ethiopia.** AIDS 1998, 12: 315-322.
7. Ministry of Health.**AIDS in Ethiopia**,Second Edition.Addis Ababa,1998.
8. Chin J: **A Guide for using Epimodel:A computer program for estimation and projection of Cases of AIDS**;1997.
9. Anderson RM, May RM, Boily MC, Garhett GP, Rowley JT: **The spread of HIV-1 in Africa Sexual contact patterns and the predicted demographic impact of AIDS.** Nature 1991, 352:581-589.

10. Bongaarts J: **A model of the spread of HIV infection and the demographic impact of AIDS**. Stat Med. 1990, 8: 103-120

11. Stover J: **The impact of HIV/AIDS on population growth in Africa.** Washington, DC: African population Advisory committee Secretariat; 1993.

12. Kuiken CL, korber BTM. **Epidemiological significance of intra-and inter-person variation of HIV-1.** AIDS 1994, 8(suppl 1) S73-S83.

13. Chin J and Mann JM. **Global patterns and prevalence of AIDS and HIV infection.** AIDS 1988, 2 (suppl.): 5247-5252

14. Jonathan Mann et al., The Demographic, Economic, and social impact of AIDS. AIDS in the world, vol.2,1992.

15. The World Bank. **World Development Report-1993: Investing in health.** London: Oxford University press, 1993.

16. Mulder DW, Nunn AJ, kamali A, NakiyingiJ, Wagner HU, Kengeya Kayoudo JF.**Two year HIV-1 associated mortality in a ugandan rural population.** Lancet 1994; 343: 1021-23

17. Sewen kambo NK, Wawer MJ, Gray RH, et al., **Demographic impact of HIV infection in rural Rakai district, Uganda.** Results of a population based Cohort study. AIDS 1994,8:1707-13.

18. Chin HJ. **Current and future dimensions of the HIV/AIDS pandemic in Women and Children.** Lancet 1990, 336:221-24.

19. Selik RM, Chusy, Buehler JW. **HIV- infection as leading cause of death among young adults in US cities and states.** Journal of the American Medical Association, 1993,269: 2991-2994.

20. Baggaley R.,Godfrey-Faussett P.,Msiska R.,Chilangwa D.,Chitu E.,Porter J., et al. **Impact of HIV infection on Zambian businesses.** British Medical Journal, 1994, 309: 1549-1550.

21. Addis Ababa Regional Health Beuro.**HIV/AIDS in Addis Ababa** :October 1998,draft.

22. Armstrong, J.**The demographic, economic, and social impact of AIDS.** In AIDS in the world, eds J. Mann, D.M, Tarentola and T.W. Netter, PP 195-226. Harvard University press, Cambridge, MA,1992.

23. Gregson, S., T. Zhuwau, R.M. Anderson and S.K. Chandiwana. **"HIV-1 and Fertility change in Rural Zimbabwe"** presented at the socio-Demographic impact of AIDS in Africa. Conference, sponsored by the International union for the scientific study of population and the university of Natal- Durban, February 1997.

24. Ainsworth M.,D. Filmer and I.Semali.**The impact of AIDS Mortality on individual Fertility:** Evidence from Tanzania" "Results of a workshop on the link between infants and child mortality and Fertility. Washington DC, Nov. 1995.

25. Gray, R.H., D. Serwaddo, M.J. Wawer, et al. **"Reduced Fertility in women with HIV infection: A population Based study in Uganda."** Presented on the socio-Demographic impact of AIDS in Africa. Conference, sponsored by the international union for the scientific study of population and the university of Natal-Durban, February 1997.

26. Carpenter, L.M, J.S. Nakiyingi, A.Ruberantwari, S. Malamba, A.Kamali, and J.A.G. Whitworth," **Estimates of the impact of HIV-1 infection on Fertility in a Rural Ugandan Cohort"** Presented at the Socio-Demographic Impact of AIDS in Africa. conference, sponsored by the international union for the scientific study of population and the university of Natal-Durban, Feb, 1997.

27. Becker C.M. **The demographic and economic impact of the AIDS pandemic in sub-saharan Africa.** World Development.1990, 18: 1599-1619.

28. Nunn AJ, Mulder D.W, Kamali A., Ruberantwari A, Kengeya-Kayondo JF, whitworth J: **Mortality Associated with HIV-1 infection over five years in a rural Ugandan population cohort study.** BMJ 1997, 315: 767-771.

29. Suwanee Surasiengsunk,Suchada Kiranandana,Kua Wongboonsin,Geoffrey P.Garnett,Roy M.Anderson and Godfried(Frits) J.P. van Griensven. **Demographic impact of the HIV epidemic in Thailand.** AIDS 1998, 12: 775-784.

30. United Nations: **World population Prospects:** The 1992 Revision. Sales No. E.93. XIII. 7 New york: United Nations: 1993.

31. United Nations: **World population prospects:** The 1994 Revision. Sales No. E.95.XIII.16. New york: United Nations: 1995

32. United Nations: **World population prospects:** The 1996 Revision: Annexes I and II, Draft report, 24 October 1996, New york: United Nations; 1996.

33. US Bureau of the census: **World population profile:** 1994 Washington, DC.

34. Jamison E, Hobbs F: **World population profile:** 1994. Washington, DC: US Bureau of the Census; 1994.

35. Stover J: **The future demographic Impact of AIDS: What do we know? AIDS in development: The Role of Government.** Chateau de Limelette, June 1996 (Abstract).

36. Transitional Government of Ethiopia.Office of the Population and Housing Census Commission.Central Statistical Authority. **The 1994 population and Housing Census of Ethiopia.** Results for Addis Ababa,Statistical Report.Addis Ababa,Augus,1995.

37. Office of the Population and Housing Census Commision. The 1984 population and housing census of Ethiopia. **Analytical report on results for Addis Ababa.** Volume 1, Number 1, January 1987.

38. Stover J. **A computer Program for Making HIV/AIDS Projections and Examining the Social and Economic Impacts of AIDS.**The Futures Group International under the POLICY Project,November 1997.

39. Federal Democratic Republic of Ethiopia. Central Statistical Authority. Population Analysis and Studies Center. **Fertility Survey Of Urban Addis Ababa-1995**. Addis Ababa,1997.

40. Chin James and F.Sonnenberg.**The Epidemiology and Projected Mortality of AIDS in the United Republic of Tanzania.**Back ground paper prepared for the Tanzania AIDS Assessment and planning study. Washington,D.C. World Bank,January,1991.

41. Bulatao,Rodolfo A. **The demographic impact of AIDS in Tanzania.**Back ground paper prepared for the Tanzania AIDS Assessment and planning study. Washington,D.C World Bank.June,1990.

**Annex I**

**Methodology**

DemProj calculations are based on the standard cohort component projection modified to produce a single year projection.

A. Calculating the Base Population by Single Ages

The first step is to separate the population by five-year age groups into single age group. This is achieved through the use of the Beers formulas [Beers 1945]. The 0-4 age group is split using the following formulas:

$a^0$ : = 0.3333*p1-0.1636*p2-0.0210*p3+0.0796*p4-0.0283*p5

$a^1$ : = 0.2595*p1-0.0780*p2+0.0130*p3+0.0100*p4-0.0045*p5

$a^2$ : = 0.1924*p1+0.0064*p2+0.0184*p3-0.0256*p4+0.0084*p5

$a^3$ : = 0.1329*p1+0.0844*p2+0.0054*p3-0.0356*p4+0.0129*p5

$a^4$ : = 0.0819*p1+0.1508*p2-0.0158*p3-0.0284p4+0.0115*p5

Where p1, p2, p3, p4 and p5 are the population aged 0-4, 5-9, 10-14, 15-19 and 20-24 respectively and $a^0$, a1, a2, a3 and a4 are the populations at single ages 0, 1,2,3 and 4 respectively.

Similarly the 5-9 age group is split using the following formulas:

a5 : = 0.0404*p1+0.2000*p2-0.0344*p3-0.0128*p4+0.0068*p5

a6 : = 0.0093*p1+0.2268*p2-0.0402*p3+0.0028*p4+0.0013*p5

a7 : = 0.0108*p1+0.2272*p2-0.0248*p3+0.0112*p4-0.0028*p5 a8 : = 0.0198*p1+01992*p2+0.0172*p3+0.0072*p4-0.0038*p5

a9 : = 0.0191* p1+0.1468*p2+0.0822*p3-0.0084*p4-0.0015*p5

The age groups from 10-14 to 70-74 are split using the following formulas:

a1 : = $0.0117*p_{a-2} +0.0804*p_{a-1} + 0.1570*p_{a-}0.0284*p_{a+1} +0.0027*p_{a+2}$

a2 : = $0.0020*p_{a-2} + 0.0160*p_{a-1} + 0.2200pa-0.0400*p_{a+1} + 0.0060*p_{a+2}$

a3 : = $0.0050*p_{a-2} - 0.0280*p_{a-1} + 0.2460*p_a- 0.0280p_{a+1}+0.0050*p_{a+2}$

a4 : =0.0060*pa-2-0.0400*pa-1+0.2200*pa+0.0160*pa+1-0.0020*pa-2

a5 : = 0.0027*pa-2-0.0284*pa-1+0.1570*pa+0.0804*pa+1-0.0117*pa+2

Where a1,a2,a3, a4, and a5 are the first, second, third, fourth and fifth ages in the particular age group and pa-2 is the population of the age group two groups younger than the reference group, Pa-1 is the populate of the age group one group younger than the reference group, and so on.

The 75-79 age group is split with the formulas:

a75:=0.0015* P60-64-0.0084*P65-69+0.0+0.0822*P65-69+0.1468*P65-69-0.0191*P80+

a76:=-0.0038*P60-64+0.0072*P65-69+0.0172*P65-69+0.1992*P65-69-0.0198*P80+

a77:=0.0028*P60-64+0.0112*P65-69-0.0248*P65-69+0.2272*P65-

69-0.0108*P80+

a78:=0.0013*P60-64+0.0028*P65-69-0.0402*P65-69+0.2268*P65-69+0.0093*P80+

a79:=0.0068*P60-64-0.0128*P65-69-0.0344*P65-69+0.2000*P65-69+0.0404*P80+

**B. Survival Rates**

Survival rates are the proportion of the population of a particular age that survive to the next age in the next year. The life tables used in DemProj provide single-year survival rates for birth to age one, age one to two, two to three, three to four, and four to five. Beyond age five that tables provide five-year survival rates. That is, the proportion of a five-year age group that survives to the next five-year age group five years later. These five-year survival rates are converted to single-year survival rates by taking the fifth root of the five-year survival rate. The result is used as the survival rate for all five ages in the corresponding age group.

**C. Migration**

The net number of migrants for each age and sex group is determined as the total number of migrants for that sex in the previous year, multiplied by the proportion that are in the corresponding five-year age group, divided by five.

D. Deaths

Deaths for a particular age and sex are calculated as follows:

$deaths_{a,s,t-1,t} = (Pop_{a-1,t-1,5} = migr_{a-1,s,t-1}/2) * (1-sr_{a,s,t})$

Where:

$Deaths_{a,s,t}$ = (deaths occurring as people age from age a-1 at time t-1 at time t $pop_{a,s,t}$ = the population of age group a and sex s at time

$migr_{a-1,st-1}$ = the net number of migrants of age a-1 at time t-1

$sr_{a,s,t}$ = Proportion of the population of age a-1 and sex s at time t-1 that survives to age a at time t

**E. Population Size**

The population of most age groups is calculated as the number of people one year younger one year ago plus the next migration during the year minus the number of deaths.

$pop_{a,s,t} = pop_{a-1,s,t-1} + migr_{a-1,s,t-1} - deaths_{a,s,t-1,\ t}$

For the last age group the population also includes those who were in the last age group one year ago and survive to the present year.

$pop_{80+,s,t} = pop_{79,s,t-1} + migr_{79,s,t-1} - deaths_{79,s,t-1,t} + pop_{80+,s,t-1} + migr_{80+,s,t-1} - deaths_{80+,s,t-1,t}$

The population under one year of age is calculated as the number of births during the year that survive to the end of the year plus the net migrants.

$pop_{0,s,t} = births_{s,t} + ,migr_{0,s,t-1} - deaths_{0,s,t-1,t}$

**F. Births**

The number of births in a year is calculated from the number of women of reproductive age, the TFR and the age distribution of fertility.

$births_{a,t} = TFR_t * ASFR_{a,t} * PoP_{a,females,t}$

Where:

$births_{,t}$ is the number of births to women at age a

$TFR_t$ is the total fertility rate at time t

$ASFP_{a,t}$ is the proportion of lifetime fertility that takes place at age a

Total births are found by summing births to women in all the reproductive ages.

$births_t = \Sigma_a\ births_{,t}$

Births by sex are calculated from total births and the sex ration at birth.

$births_{,t} = births_t * SexRatioAtBirth_s$

Annex II

Epimodel projects the past the past and future course of an AIDS epidemic based on the key assumptions: (i) the year in which the HIV infection first became widespread, (ii) the number of people alive with HIV infection in the current year, and (iii) the shape of the infection Curve. The model allows the user to select a curve type to describe cumulative HIV infections over time. A gamma curve is fitted to two points zero infections the year before HIV infection became well established in a care group, and the current estimate of infections. The user decides where on the gamma curve the current year lies. If the user decides that the epidemic is still in its early stages, then the point representing the current year would be placed in the early part of the s-curve, leaving the most rapid increase in infections to occur in the future. If the user decides that HIV incidence is currently at its peak, then the current year estimate would be placed right in the middle of the s-curve. Similarly, if it is assumed that the epidemic has reached the endemic stage, then the current year estimate would be placed near the top of the s-curve. Thus, the assumption about the current stage of the epidemic largely determines the future projection.

Epimodel also requires an assumption about adult and child incubation periods.

Once these assumptions are made, the Epimodel projection process follows these steps:

1. Read the number of adults alive with HIV infection from the gamma curve for a particular year.
2. Calculate the number of new adult HIV infections required to reach the total number alive with HIV infection in that year (by subtracting the number of infections in the previous year from the number of infections in the current year and adding the number of AIDS deaths during the past year).
3. Use the assumption about the incubation period to determine when people with a new HIV infection will develop AIDS and die.
4. Calculate the number of child deaths from AIDS based on assumptions about the crude birth rate, the perinatal transmission rate of HIV, and the incubation period for child infections.

Epimodel is used to determine the number of AIDS- related deaths by year. These deaths are then distributed by age and sex according to a typical pattern of AIDS deaths.

## ANNEX III

### METHODOLOGY

### EPIDEMIOLOGY

The AIDS projections in AIM are based on an approach suggested by James chin and Jonathan Mann of the Global Programme on AIDS, WHO [Chin 1989] and John Stover of The Futures Group International. The approach is based on the fact that a certain proportion of those infected with HIV in year't' are assumed to develop AIDS by year 't+n'. Thus, if we know the number of people infected by year and we know the proportion progressing to AIDS by time since infection, we can determine the number of new AIDS cases each year. This methodology has been adapted for AIM by developing an age-specific version and incorporating a more exact calculation of AIDS deaths and non-AIDS deaths. The complete methodology is described below.

Adult Population

The number of adults is the sum of the population aged 15 and over.

$adults_t = \Sigma_{a,s}\ PoP_{a,st}$, were = a = 15 to 80 + and s = male to female

HIV - infected Adults

The number of adults infected with HIV is the sum of the infected population for each age from 15 to 80 and over.

$HIV\text{-}adults_t = \Sigma_{a,s}\ HIV\text{-}PoP_{a,s,t}$, where a= 15to80+and s = males, female

Target HIV Prevalence

The number of HIV-infected adults required in year t to match the assumed prevalence level is the number of adults multiplied by the assumed prevalence.

$$Target\text{-}HIV_t = adults_t \times prevalence_t$$

New Adult HIV Infections

The number of new adult HIV infections in any year is calculated as the target number minus the number of adults already infected.

$$New\text{-}adult\text{-}HIV_t = Target\text{-}HIV_t - HIV\text{-}adults_t$$

If some new infections (that are not acquired perinatally) are assumed to occur to children under the age of 15, then given the assumed level of adult prevalence, the number of new infections required to achieve the assumed level of adult prevalence needs to be increased by the proportion of new infections that will occur to children.

$$New\text{-}adult\text{-}HIV_t = (Target\text{-}HIV_t - HIV_t\text{-}adults_t) / Percent\text{-}New\text{-}HIV\text{-}Under\ 15$$

New HIV Infections by Age and Sex

The new HIV infections are distributed by age and sex according to the distribution entered as an input assumption.

$$New\text{-}HIV_{a,st} = New\text{-}adult\text{-}HIV_t \times Percent\text{-}new\text{-}infections_{a,s,t}$$

Surviving HIV Infections

The number of new infections in year t will survive into future years will be subject to death due to AIDS and death due to non-AIDS causes. The number surviving is first adjusted by non-AIDS deaths.

$$HIV\text{-}infection_{a,s,t,y} = HIV\text{-}infection_{a-1,s,t-1,t} \times (1\text{-}mortality\text{-}rate_{a,s,t}),$$

Where $HIV\text{-}infection_{a,s,t,y}$ represents the number of persons surviving HIV infections in age group a, of sex s, in year t, that were initially infected in year y.

Surviving HIV infections are further reduced by the number of people who die due to AIDS.

$$HIV\text{-}infection_{a,s,t,y} = HIV\text{-}infection_{a,s,t,y} - AIDS\text{-}deaths_{a,s,t,y}$$

The total number surviving with HIV in any year is the sum of those surviving to that year from cohorts of infection from all previous years.

$$HIV\text{-}infection_{a,s,t} = \Sigma_y \, HIV\text{-}infection_{a,s,t,y}$$

New AIDS Cases

The number of new AIDS cases in year t is calculated as the sum of the number of people progressing to AIDS in year t who were infected in the twenty years before year t.

$\text{New-AIDS}_{a,s,t} = \Sigma_y \text{ New-HIV}_{a,s,y} \times \text{Prop-progessing-to-AIDS}_{t-y,}$ where y varies from t-20 to t.

AIDS Deaths

AIDS deaths are simply the number of new AIDS cases lagged by the life expectancy after AIDS.

$\text{AIDS-deaths}_{a,s,t} = \text{New-AIDS}_{a,s,t}\text{-ALE}$

If the life expectancy is not entered as an integer number of years then the deaths are distributed between the two years proportionally. For example, if the life expectancy after AIDS is assumed to be 1.5 years, then half of the new AIDS cases would be assumed to die one year later and half two years later.

Perinatal Infections

The number of infected children is determined by the number of infected babies born. The number of infected babies is a function of the perinatal transmission rate, fertility and the percentage of mothers who are infected.

$\text{HIV-births}_t = \text{PTR} \times \text{TFR}_t \times \Sigma_a \text{ ASFP}_{a,t} \times \text{HIV - infection}_{a,f,t}$

Where:

$\text{HIV-births}_t$ = the number of infected births in year 't'

PTR = perinatal transmission rate

$TFR_t$ = total fertility rate at time 't'

$ASFP_{a,t}$ = the proportion of lifetime births that occur during age 'a'and at time t

$HIV\text{-}infection_{a,f,t}$ = the number of infected females at age 'a' and time 't'

Children progress from HIV to AIDS to death in a similar manner to adults; however,, the time to progress from HIV to AIDS is much shorter for children.