

**The AIDS Transition: impact of HIV/AIDS on the  
demographic transition of black/African South  
Africans by 2021**

**Sandra D. Matanyaire**



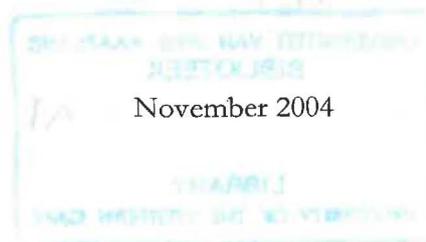
**UNIVERSITY of the  
WESTERN CAPE**

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## Keywords

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## Abstract

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The first two official AIDS cases were diagnosed in South Africa in 1982. During the same period of the 1980s, the black/African population was experiencing an accelerated fertility decline, following a period of accelerated mortality decline. Demographers invoked the demographic transition theory to explain the observed mortality and fertility decline. According to the demographic transition theory, mortality and fertility rates would continue declining to low, post transitional levels with increasing modernization.

The relatively higher prevalence of HIV/AIDS estimated among black/African South Africans is expected to alter their demographic transition. This research investigates the impact of HIV/AIDS on the demographic transition of black/Africans by 2021.

Projections of mortality and fertility rates were obtained from runs of the ASSA2002 model, an AIDS demographic model of the Actuarial Society of South Africa (ASSA). Projections of the UNDPs Human Development Index (HDI) were taken as a measure of modernization. HIV/AIDS is projected to alter the demographic transition of the black/African population therefore a more appropriate term was introduced: the AIDS transition.

The AIDS transition is characterized by increased mortality levels similar to levels observed in the black/African population in the 1950s, with an accelerated fertility decline. A reversal of more than a decade in levels of human development is also expected. The AIDS transition is paradoxical, as one of the identifiers of modernization is attained in the form of fertility decline whilst an indicator of a reversal in modernization will be attained in the form of mortality incline.

November 2004

## Declaration

I declare that *The AIDS Transition: impact of HIV/AIDS on the demographic transition of black/African South Africans by 2021* is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Sandra Dzidzai Matanyaire



November 2004

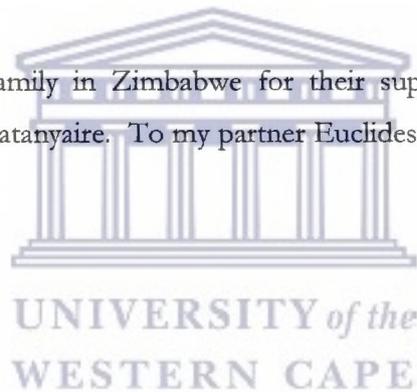
Signed:

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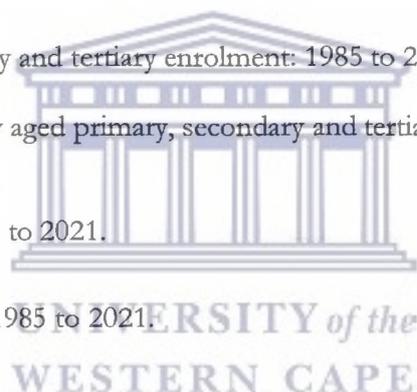
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## Chapter one

### Introduction

#### 1.1 HIV/AIDS and the demographic transition in South Africa

The first two official AIDS cases were diagnosed in South Africa in 1982 (Whiteside and Sunter 2000: 47). AIDS is an acronym for Acquired Immune Deficiency Syndrome, the final disease manifestation from infection by the Human Immunodeficiency Virus (HIV). HIV belongs to a family of retroviruses within the subgroup of lentivirus. Retroviruses (*Retroviridae*) contain a unique enzyme: reverse transcriptase, which facilitates the formation of a copy of the host cell DNA when the retrovirus enters a cell. The copy of the DNA then physically integrates with the host cell DNA and directs the manufacture of required proteins. Lentiviruses are retroviruses that are slow in manifesting disease ('lenti' means slow in Greek), resulting in a lag from infection, to morbidity, to death (Schoub 1994: 55-56).

Two types of HIV are known to cause AIDS: HIV-1 and HIV-2. HIV-1 has three groups: the main group M, the outlier group O and group N (Barin *et al* 2002: 161). Group M viruses cause the majority of HIV infections in the world and this group is further divided into 10 subtypes from subtype A to subtype J (Renjifo and Essex 2002: 268). In South Africa, subtype C of the HIV-1 group M is the most prevalent, with over 95% of the HIV infections in South Africa thought to be subtype C infections (Morris *et al* 2000: 339).

Once HIV infection occurs, the virus attacks two main types of white blood cells: CD4 cells referred to also as T-helper lymphocytes and monocytes and macrophages. T-helper cells play a central role in controlling the immune system by functioning as regulators for the immune system. Monocytes and macrophages get rid of foreign proteins in the body by ingesting them and presenting them to the immune system to mount a response against the foreign proteins (Schoub 1994: 24). HIV infection therefore results in the gradual and progressive impairment of the human immune system resulting in the emergence and recurrence of a variety of infections commonly referred to as opportunistic infections (Palloni 1996: 4).

HIV can be transmitted through transfusion of HIV infected blood or administering HIV infected blood products; vaginal, oral or anal sexual intercourse with an infected partner; mother-to-child transmission either intrauterine, perinatally or through breastfeeding and through intravenous injection with HIV contaminated needles, syringes or sharp objects (Schoub 1994: 91-120, Palloni 1996: 4).

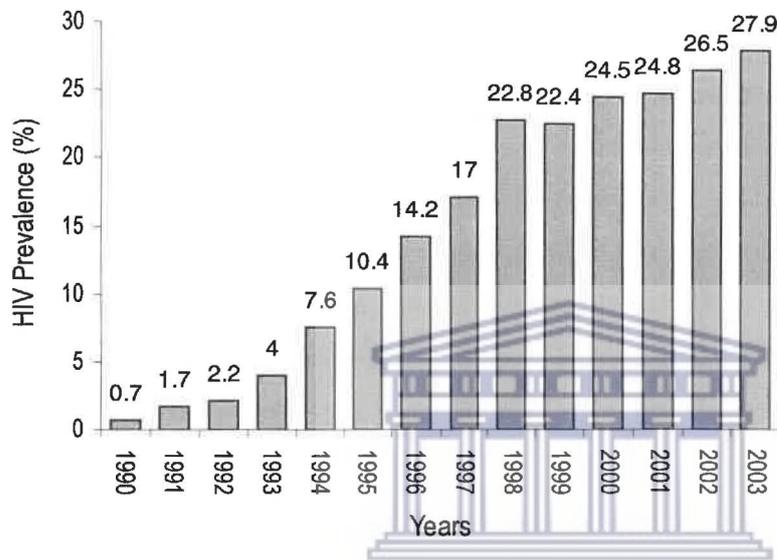
When HIV/AIDS emerged in South Africa (officially), mortality and fertility rates were declining within the South African population. Demographers had already invoked the demographic transition theory to explain the fertility and mortality decline. According to the demographic transition theory populations move from levels of high mortality and high fertility with increasing modernity, to post transitional levels characterized by low mortality and low fertility. Modernity is associated with processes like urbanization, industrialization, economic development and socio-economic development. Variations however existed in the pace of mortality and fertility decline across the four population groups in South Africa: black/African, Indian/Asian, Whites and Coloureds (Mostert *et al* 1998: 15-16). Although these population group classifications were used in the apartheid era, this research does not purport to continue with the segregatory and discriminatory purpose for which the population groups were used in the past. Reference to the population groups is purely for academic purposes. The black/African population began their demographic transition at a later stage compared to other population groups in South Africa.

Consequently at the start of the HIV/AIDS pandemic the black/African population had entered a period of accelerated fertility decline although fertility decline had began in the 1960s (Moultrie and Timæus 2002: 27). Levels of mortality had been declining since 1945 from levels of 23.4 per 1000 to 9.1 per 1000 of the population in 1980 (Mostert *et al* 1998: 76). Mortality and fertility rates were expected to continue declining to post transitional levels, as the black/African population progressed through their demographic transition.

Twenty years after its inception, AIDS has become the single leading cause of death in South Africa, accounting for 30% of all deaths (Bradshaw *et al* 2003: 31). The Department of Health has been conducting national sentinel surveys since 1990 of pregnant women

attending public antenatal clinics (ANC) for the first time to determine the prevalence of HIV (Figure 1.1). HIV prevalence among antenatal attendees increased almost exponentially from 0.7% in 1990 to 27.9% in 2003.

**Figure 1.1:** HIV prevalence among antenatal clinic attendees in South Africa: 1990-2003



Source: Department of Health (2004: 6)

The antenatal clinic survey results should however, be considered in the light of the following limitations (Boerma, Ghys and Walker 2003: 1929):

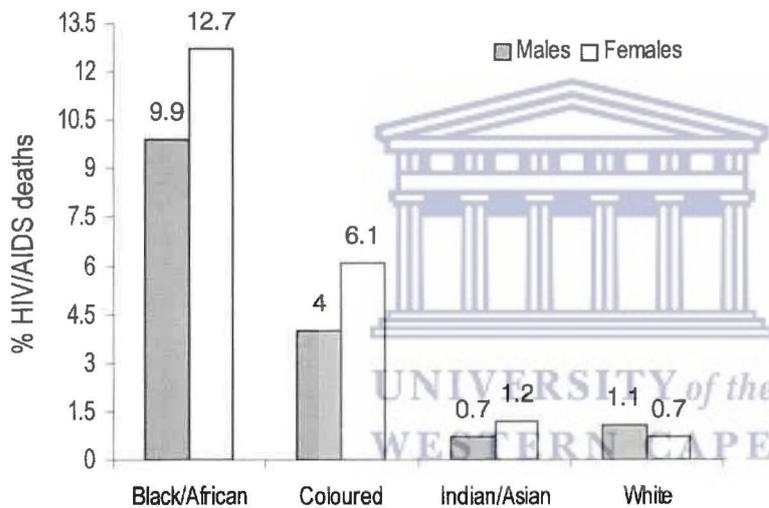
- i. The representativeness of pregnant women who attend public antenatal clinic of all pregnant women as the survey only captures data on public clinics
- ii. The bias introduced from reduced fertility due to biological effects in HIV-1 infected women
- iii. Under representation of smaller rural sites.

The Nelson Mandela/Human Sciences Research Council (HSRC) study of HIV/AIDS conducted in 2002 showed a prevalence rate of 12.9% (11.2-14.5) for the black/African population compared with 6.2% (3.1-9.2) for the Whites, 6.1% (4.5-7.8) for the Coloureds and 1.6% (0-3.4) for the Indian/Asians. The study however excluded children under the age

of 2 years and was prone to limitations of a socio-behavioural study including moderate participation rates and recall biases by respondents (HSRC 2002: 31-32).

A study on the causes of death in South Africa for the period 1997 to 2001 revealed that the black/African population experienced the largest relative percentage of HIV/AIDS deaths across the four population groups with males experiencing 9.9% and females 12.7%. The lowest male and female percentage of AIDS deaths was 0.7% occurring among the Indian/Asian and White populations (Figure 1.2).

**Figure 1.2:** Percentage of HIV/AIDS deaths for each population group and sex: 1997- 2001



*Source: Statistics South Africa (2002: 17, 19)*

The Nelson Mandela/HSRC study and the causes of death study both indicate that the black/African population is the hardest hit by the HIV/AIDS pandemic in South Africa. Some of the reasons attributed to the high prevalence among the black/African population include the migrant labour system, and the forced removals and relocations as a result of past apartheid policies (HSRC 2002: 59).

Contrary to expectations of the demographic transition theory, HIV/AIDS is increasing mortality rates. Furthermore, HIV/AIDS is expected to accelerate the declining fertility rates

through (a) deaths of women in reproductive years (b) reduced coital frequency due to AIDS related illnesses (c) reduced spermatozoa production (d) co-infection of HIV/AIDS with other sexually transmitted infections (STIs) that reduce fecundity (e) foetal loss among HIV positive women (f) weight loss resulting in amenorrhoea (Du Plessis 2003: 83). A Department of Health (1999) publication of maternal deaths in South Africa in 1998 showed that over 87% of the women who died of AIDS had less than three deliveries and 74% of those women were below 30 years of age. Paradoxically the impact of HIV/AIDS is expected to decline fertility, an 'accomplishment' of the demographic transition theory.

At the formulation of the demographic transition theory, the possibility of a gigantic, incurable pandemic like HIV/AIDS had not been anticipated. Hence no demographic transition model incorporates the effects of HIV/AIDS. Omran (1998: 100) however in stating epidemiological transition dynamics notes that the "Flow of the [epidemiological] Transition can be disrupted or reversed under crises or the Transition may accelerate under strikingly favourable conditions". Omran refers to HIV/AIDS as one of the health burdens in 'non-western' populations. The epidemiological transition is encompassed in the demographic transition. Furthermore, Shell (1998) argues:

The effects of such epidemics as HIV/AIDS which will only bite deeply into the cohorts in the next century...might retard the demographic transition since the demographic transition has historically been preceded by a drop in mortality. Since AIDS is a comparatively recent pandemic for human populations, little work has been directed to its overall effect on the long-term process of the demographic transition (1998:7).

A gap therefore exists between the theoretical demographic transition and the observed or expected demographic transition especially in high HIV prevalence populations like the black/African South Africans.

## **1.2 Research problem**

To project the impact of HIV/AIDS on the demographic transition of the black/African population in South Africa and if the effects are large enough, to determine whether reference can be made to a new type of transition: the AIDS transition.

theory links demographic, social and economic factors, an interrelated impact analysis can be conducted.

## **1.6 Assumptions**

The main assumptions of the study are that:

- i. The demographic transition model is applicable to the black/African population in South Africa.
- ii. Population projections of the ASSA2002 and those produced by the author provide a reasonable view of the black/African population.
- iii. No HIV/AIDS cure is supposed for the length of study until the year 2021.

## **1.7 Limitations of study**

- i. Limitations of population projections in making assumptions on human behaviour and forecasting demographic rates.
- ii. Aggregating the study across South African provinces that exhibit varying HIV prevalences.
- iii. Combining rural and urban black/Africans in varying stages of the demographic transition.

## **1.8 Research method**

The ASSA2002 model of the Actuarial Society of South Africa (ASSA) was selected to project the impact of HIV/AIDS on the demographic transition of the black/African South Africans. The ASSA2002 model is an AIDS demographic model of the Actuarial Society of South Africa (ASSA). The AIDS Committee of the Actuarial Society of South Africa (ASSA) released earlier models, namely: ASSA500 in 1996, ASSA600 in 1999, ASSA2000 in 2001 with the latest release being the ASSA2002 released in 2004. The ASSA2002 model produces population projections as at 1 July of each respective year starting from 1985.

The impact of HIV/AIDS on mortality and fertility rates by 2021 will be obtained from forward projections run from the ASSA2002 model. Population projections of the ASSA2002 model will also be used as a basis (where appropriate) in determining the impact of HIV/AIDS on modernization. The projections of mortality, fertility and modernization will determine the overall impact of HIV/AIDS on the demographic transition.

The ASSA2002 model was selected for this research based on the following:

- i. The model allows for the four general population groups in South Africa to be modelled separately
- ii. The ASSA2002 model is an AIDS demographic model, hence it models HIV/AIDS into population rates simultaneously
- iii. The model allows modelling assumptions to be changed by the user and hence the effects of varying assumptions made by the ASSA AIDS Committee can be studied.
- iv. Projections of the ASSA2002 model are widely used and quoted in South Africa

## 1.9 Thesis outline

This section has introduced HIV/AIDS in South Africa, concluding that HIV is more prevalent in the black/African population. Mortality and fertility rates of the black/African population were declining at the inception of the pandemic with rates expected to continue declining as the population progressed through their demographic transition. However, HIV/AIDS is expected to affect their transitional progress, thus motivating this study on the impact of HIV/AIDS on the demographic transition of the black/African.

The demographic transition theory will be reviewed in chapter two. The conception and evolution of the demographic transition theory is discussed chronologically in the first section. The various critics of the theory will be highlighted, mainly causality factors of the fertility decline. A statement of the demographic transition theory will follow leading to a discussion of the applicability of the demographic transition theory to the South African population, particularly the black/African population.

In chapter three assumptions of the impact of HIV/AIDS on elements of the demographic transition theory: mortality rates, fertility rates and modernization, will be discussed. Some key assumptions of HIV modelling of the ASSA2002 model are discussed, as projections of mortality and fertility rates will be obtained from the model. The UNDP's Human Development Index (HDI) will be used as a measure of modernization. The projected impact of HIV/AIDS on the human development index will be discussed and assumptions stated.

Results of projections of HIV/AIDS, mortality rates, fertility rates and the human development index are provided in chapter four. Population projections will show the impact of HIV/AIDS estimated on the black/African population by 2021. Mortality rates will be increased, fertility decline will be accelerated and modernization levels as measured by the human development index will be reduced and retarded from the impact of HIV/AIDS. It will be shown and suggested in chapter four that perhaps reference to an AIDS transition is more appropriate and relevant due the higher prevalence of HIV/AIDS among the transitional black/African population.

Chapter five discusses the demographic implications of the AIDS transition. Age and sex population structure of the black/African population in 2021 and the implications of either a second demographic transition or a continuation of the disrupted transition after the AIDS transition will be discussed.

Chapter six concludes this research with a summary of the main points raised in the five preceding chapters and aspects for further study will be provided.

## Chapter two

### The demographic transition theory

#### 2.1 Introduction

In traditional societies, fertility and mortality are high. In modern societies, fertility and mortality are low. In between there is demographic transition (Demeny 1972: 153).

Following a discussion of HIV/AIDS and its emergence during a period of demographic transition, literature on the demographic transition will be reviewed in this section. The literature review will not cover economic theory perspectives of the transition theory (Coale and Hoover 1958, Easterlin 1978). A historical account of the theory will be provided, leading to a statement of the early demographic transition theory and criticisms which followed. The present day demographic transition theory will be provided with the concluding section discussing the demographic transition in South Africa, particularly the black/African population.

#### 2.2 Literature review

The origin of the demographic transition theory can be traced to articles published by Landry (1909, 1934), Thompson (1929) and Notestein (1945). Notestein is considered to have formulated the demographic transition theory in its present day form, although his was not the first statement of the theory (Kirk 1996: 361).

Writing before world war one, Adolphe Landry's earlier work refers to three regimes of population development: primitive, intermediate and modern. Landry published a study in 1909 and a later edition in 1934 entitled *Les trois théories principales de la population*. In 1934, Landry also published an article entitled *La révolution démographique* (Landry 1987: 731).

Landry (1987: 736) describes the primitive regime as "...characteristic of all living beings other than man, although it has been characteristic of man in the past and can still be

found". Birth rates are not limited by any economic factors but by factors like the procreative ability of individuals and the age at marriage. Populations in the primitive regime are in equilibrium as a result of mortality rates equalling or fluctuating around fertility levels.

In the intermediate regime, economic factors reduce fertility levels through aspirations of individuals for a certain standard of living for themselves and their families. Celibacy and delayed age at first marriage are employed to prevent the lowering of lifestyle (Landry 1987: 737). If medical advances coupled with technological progress take place, productivity will be increased resulting in population growth. Landry cites the populations of France and England, which grew in the intermediate stage.

The modern regime is characterized mainly by a higher standard of living and a widespread use of birth control. Fertility decline is the main determinant of population change and Landry explains this fertility decline with 'selfish feelings' that were becoming dominant: (a) children being seen as an expense and an inconvenience (b) children getting in the way of their mother's career and of their parent's pleasures and travel (1987: 739). Landry refers to the prospect of depopulation in the modern regime, "Where, then, will we stop on the downward slope of fertility...the prospect of depopulation looms..." (1987: 739). The modern regime is evident at present in developed countries experiencing fertility levels below the replacement level.

Landry wrote of a demographic revolution being experienced in Europe that would become widespread throughout the world. The demographic revolution was a result of improvements in material conditions due to progress achieved in technology, medicine and hygiene.

On the eve of the great depression in 1929, Warren Thompson published an article entitled *Population*. Thompson also believed that changes in population growth would influence the future history of mankind (1929: 959). However Thompson did not refer to Landry. In his article, Thompson classified countries into three main groups according to their birth rates and death rates:

Group A: Western Europe, Australia, United States of America and Canada

Group B: Italy, Spain and the Slavic Countries of Central Europe

Group C: Russia, Japan, India and countries from Africa, Asia, and South America.

Group A was characterised by countries with rapidly declining birth and death rates. Birth rates were declining at a faster pace than death rates. According to Thompson, group A populations had progressed from high growth to low growth and would become stationary and start declining in numbers. France was noted as an exception to group A countries because of its more rapidly declining death rates compared to birth rates (1929: 967).

Group B countries had declining death and birth rates, with death rates declining the same or more rapidly than fertility rates. Thompson (1929: 969), states that the condition of countries in group B was identical to group A countries thirty to fifty years earlier although birth rates in group B were likely to decline faster than in group A. Thompson attributed the rapidity of birth rate decline to the speed of industrialization (1929: 970)

Countries in group C had high birth rates and high death rates. With the exception of Japan and India, Thompson had no data for the other countries and thus made estimations on these populations: "But when these C countries are compared with A and B countries, we are fully justified in assuming that in the former neither births or deaths have come under voluntary control to anything like the same extent that they have in the latter" (1929: 971).

Neither Thompson nor Landry refer to the term demographic transition. Nevertheless, Thompson implies a progression of populations from group C to group A, a characteristic similar to the progression through the demographic transition model.

Near the end of world war two, Frank Notestein published a seminal article entitled *Population: The long view*. Notestein (1945) did not make reference to earlier articles by Landry (1909, 1934) or Thompson (1929). In his article, Notestein distinguishes three types of population change or demographic types: incipient decline, transitional growth and high potential growth. His formulation of the three demographic types was based on the observations that (a) during the last three centuries world population had been growing at a rapid and accelerating pace (b) the rapid growth had been particularly evident in Europe and

the Middle East, all of Asia except for the former Soviet Union and Japan, the Pacific and Caribbean islands, and much of Central and South America.

Notestein's demographic 'prototypes' are the basis for the early formulation of the demographic transition theory. The early demographic transition theory was a three-staged model with a pre-transitional stable population characterised by high mortality and high fertility in the first stage. Mortality rates decline initially which, coupled with high rates of fertility, result in rapid population growth. Fertility subsequently declines during the transitional stage, to fluctuate around relatively low stable levels of mortality in stage three of the transition. Economic development, industrialisation, and modernization are processes Landry, Thompson and Notestein respectively associated with the demographic transition. However HIV/AIDS is expected to disrupt the envisaged flow of transition in high prevalence populations like the black/African South Africans.

The demographic transition theory has been criticised in applicability to non-western populations as its formulation stemmed from historical accounts of 'western' demographic trends. Perhaps one of the notable dismissive quotes regarding the demographic transition is the following quote from Goldscheider:

Suffice it to say that despite the general temptation of viewing demographic history through the lens of demographic transition theory, the theoretical, methodological and empirical inadequacies associated with these hypothesized relationships render the theory virtually useless analytically (1971: 14).

In an introduction to *The Study of Population*, Hauser and Duncan also question the demographic transition theory:

However the influences on population growth that it postulates are closely bound up with the particular historical circumstances of population growth in Western countries. Hence there is a big question as to whether it can provide more than vague, general suggestions about the factors likely to govern growth in the future. Because the theory is an attempt to generalize from a particular body of historical facts, it raises in perhaps the clearest form the issue of "historicism", i.e., that of whether such generalizations can successfully be applied to new situations (1959: 14).

Most probably the main criticism of the demographic transition theory is its failure to incorporate the role of international migration in determining population growth (Goldscheider 1971: 14, Teitelbaum 1987: 32; Ziehl 2002: 30). Substantial international migration can either moderate the effects of population growth or accelerate growth. The emigration of millions of Europeans to the 'new world' in the nineteenth century alleviated problems of population growth in Europe (Teitelbaum 1987: 32). In particular Ireland quoted as "the only country that can truthfully be said to have resolved a problem of acute overpopulation by mass emigration" (Notestein *et al* 1944: 60). In the present day however, defined country borders and international migration laws control international migration thus largely diminishing the role of international migration in affecting population growth significantly. The overall effects of international migration are also reduced by simultaneous emigration and immigration.

Modernization is attributed as the cause of mortality and fertility decline. The term modernization is however too vague as it encompasses several processes. In early formulations of the transition theory economic factors were largely associated with the demographic transition Kirk (1996: 369). According to Beaver (1975: 4) the demographic transition is associated with the process variously known as modernization, development, socio-economic development, industrialization, bureaucratisation or urbanisation. Teitelbaum (1987: 29) notes that the stages of the demographic transition are derived from the "...fundamental economic and social changes of 'development' of 'modernization'". The United Nations (2002: 2) describe modernization as a result of industrialization, urbanization, education, empowerment of women, and substantial socio-economic development. Srinivasan states that:

In simple terms 'modernisation', connotes the process by which a traditional-bound agrarian society of very low levels of per capita income, health, education, status of women and welfare, gets transformed into an industrial society with a large proportion of the population living in the urban areas, with a high level of income, expectation of life, literacy and education and other concomitant social changes specially relevant to the improvement of the status of women in the society (1986: 171).

However Goldscheider cautions that the use of modernization as a general term avoids specifying the particular and significant features of modernization effecting population change:

Modernization is not synonymous with all social change; it does, however, cover the most visible, large-scale structural and cultural social changes that have engulfed significant segments of the world...However, because modernization includes an enormous range of changes-social, economic, political, cultural, and personal-we must be wary of not to end up connecting every change to demographic processes (1971: 79-80).

Modernization will be considered as a general term associated with processes like industrialization, urbanization, education, social development and economic development in the general discussion of the demographic transition theory. The result of these processes includes increased life expectancy, improved standards of living, increased literacy and empowerment of women. However the specific processes of modernization associated with the demographic transition of the black/Africans will be specified in a later section.

Modernization has been sufficiently accepted in explaining mortality decline. Debates on the mortality decline have been limited mainly to identifying the most significant factors. Causality of fertility decline in contrast has been a widely debated issue. Kirk (1996: 373) attributes the debates of fertility decline on the emphasis given to socio-economic or modernization factors by American authors, although they made reference to other factors as well.

Caldwell (1976), questions the validity of 'modernization' in explaining the fertility decline of 'Third World' countries. Using the Ibadan society of Nigeria as an example of a transitional society, Caldwell attributes 'Westernization' as the cause for the fertility transition. Westernization brought about from importing 'western' values and manners. The agents of westernization are noted as "mass schooling" and "mass media" which bring about "mass infusion of European manners" (Caldwell 1976: 353). Caldwell implies an interchange in the causality and instead of modernization effecting fertility change rather fertility decline effects modernization.

Caldwell's restatement of a demographic transition achieved through communication tools (mass media and mass schooling) corresponds with diffusion-based theories of fertility decline. Theories of diffusion attribute the spread and dissemination of information and new ideas as the cause for the decline in fertility (Carlsson 1966, Rogers 1995). New ideas and skills spread from the pioneers who adopt them first, and are then spread or diffused into the rest of the population (Coale 1973: 67). Palloni (2001) on diffusion models states:

In diffusion models, the behaviour "spreads" and is adopted by individuals irrespective of their socio-economic positions, even among those whose social or economic positions are hypothetically associated with cost-benefit calculations that do not necessarily require the new behaviour (2001: 68).

Furthermore Casterline notes that:

...What sets diffusion explanations apart...is the assertion that fertility decline is not simply an adaptive response to changes in demographic, economic, and social structures; rather, it reflects the spread of certain key attitudes (e.g., about the costs and benefits of children) and behaviours (e.g., birth control technologies) (2001: 3).

Therefore diffusion theories explain observed fertility transitions in populations without significant modernization, for instance in Bangladesh, fertility declined from a total fertility rate of seven children per woman to nearly 3.5 children per woman in thirty years without meeting economic development or large scale industrialization goals (Palloni 2003: 238). Moreover the pace of fertility decline in demographic transitions in some non-European countries has prompted Kirk (1996: 377) to state that if the diffusion assumption is omitted it would, "...be difficult-if not impossible-to explain the rapidity and pervasiveness of fertility declines". Diffusion processes can however, work in the reverse way with individuals resisting new ideas or rejecting them (Palloni 2001: 68).

Cultural factors have been also attributed to contribute to the process of fertility decline. Lesthaeghe (1983: 431) argues that one of the dimensions of modernization is the shift from 'group orientation' to 'individual orientation'. The changing of traditionally kinship based family systems to 'individualistic' based family systems and the secularism of individuals. Landry in his 1934 publication attributes 'selfish feelings' (synonymous with individuality) as the reason for widespread fertility decline (1987: 739).

The role of government has been identified as an important factor in influencing the both fertility and mortality decline. Kirk (1996: 376) uses the case of Colombia and Mexico with total fertility of 2.7 and 3.2 respectively in 1992, to illustrate the impact of government intervention. The Colombian government supported family planning since the 1960s compared to the Mexican government, which initially opposed family planning but reversed its stand 1972. Although socio-economic conditions were higher in Mexico in 1992, total fertility was lower in Colombia due to the extent of government involvement. Kirk (1996: 376) also shows how government intervention was unsuccessful in Pakistan. Kirk attributes the success of government intervention with the readiness of people to accept contraception, stated otherwise: the success of diffusion. As mentioned earlier Palloni (2001: 68) notes that new ideas can be accepted or rejected. In South Africa, the case of government intervention is very apparent with the launching of the National Family Planning Programme in 1974 although the South African government had strongly supported family planning since the 1960s (Swartz 2003: 11). The National Family Planning Programme was politically motivated to reduce the growth rate of black/Africans. The programme resulted in an accelerated fertility decline among black/Africans.



The key to the causality of fertility decline lies in the diversity of social, economic, cultural, traditional, linguistic and political circumstances of populations. No single factor can wholly explain the mortality and fertility decline and neither can factors hold the same significance for triggering the demographic transition in different populations.

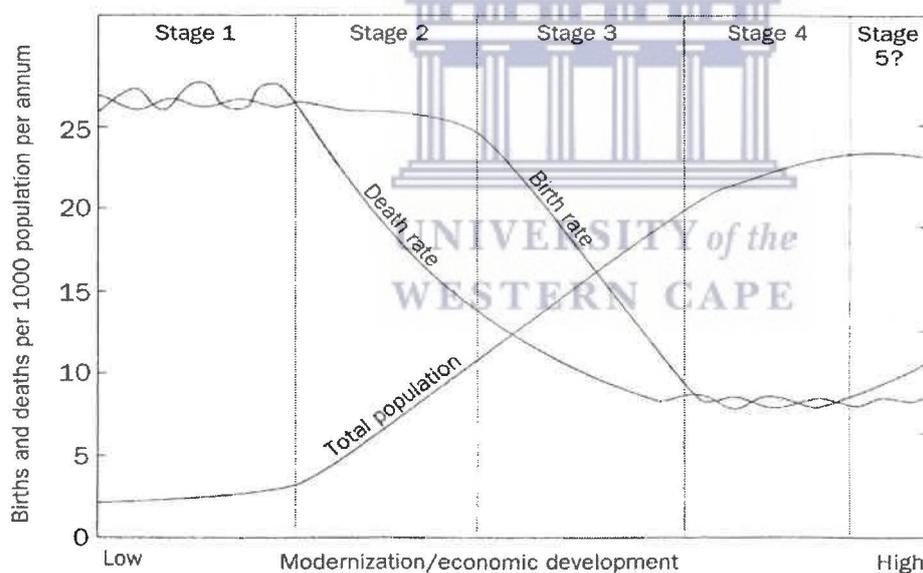
However, despite the wide range of factors responsible for the decline in fertility, modernization is generally accepted as a principal cause of fertility decline through reduced infant and reduced child mortality rates (Beaver 1975: 8, Teitelbaum 1987: 35, Kirk 1996: 379). It is questionable whether fertility rates would decline to replacement levels in the absence of modernization.

### 2.3 Statement of the demographic transition theory

The earlier formulated three-staged demographic transition model has been extended to a four-stage model. The transitional stage was divided into a mortality transition stage and a fertility transition stage. Furthermore, increasing mortality being observed in post-transitional populations as a result of population ageing is raising the possibility of a fifth stage (Figure 2.1).

Stage 1 is characterised by high and fluctuating mortality and fertility rates resulting in low population growth. High fertility is driven by high rates of infant mortality and child mortality resulting in low population growth.

**Figure 2.1:** The contemporary demographic transition model



Source: Unknown

Stage 1 of the demographic transition theory is characteristic for most of human history, estimated between 2 to 5 million years (Ziehl 2002: 24, Hassan 1980: 305). Disease and famine plagued the hunter-gatherer and farming populations of this stage.

In Stage 2 mortality levels decline rapidly whilst fertility levels remain high. Fertility decline

The following key factors can be attributed for the mortality transition (Beaver 1975: 5, Kirk 1996: 368, Mostert *et al* 1998: 13, Ziehl 2002: 26-27):

- i. The Industrial Revolution which started in the middle of the eighteenth provided resources and initiated processes that prompted mortality decline:
  - Improvements in the agricultural sector resulted in increased food supplies. Nutrition was improved and resistance to infectious diseases increased. For example the introduction of the potato to Europeans by Spanish colonists from South America.
  - Improvements in sanitation levels like better sewerage systems reduced chances of catching infectious water-borne diseases like typhoid, cholera, diarrhoea and dysentery.
- ii. The medical revolution extending from the last third of the nineteenth century to the present reduced mortality rates due to:
  - Improved and effective disease treatment methods for example the discovery and use of antibiotics from Fleming's discovery of penicillin and its synthesis in 1943 and discoveries by Pasteur, Koch and others.
  - Introduction of vaccinations for disease treatment and for immunization purposes particularly for infants and children.
- iii. The spread of results and processes of the industrial revolution and the medical revolution to developing countries.

The following key factors can be attributed for the decline in fertility (Beaver 1975: 9, Lesthaeghe 1983: 431, Kirk 1996: 375-369, Ziehl 2002: 27-29):

- i. The decline in mortality levels; particularly the drop in infant and child mortality rates ensured the survival of more children consequently there was no need to conceive many children to ensure that some reach maturity. Exceptions have been noted in France and Hungary where birth rates started declining before the onset of mortality decline.
- ii. Industrial development replaced agriculture as the only source of income. The shift from an agrarian based to an industrial based way of life reduced the need for large

families.

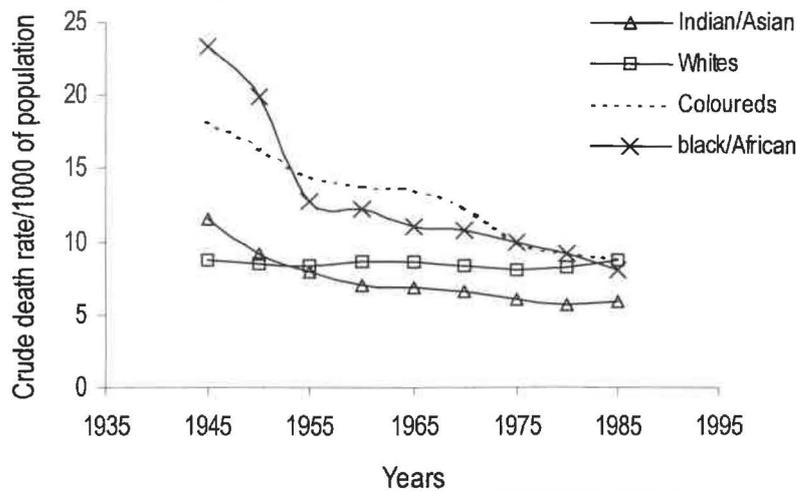
- iii. Changing of cultural values, linguistic ideals and traditional norms. Attitudes of people changed to become more secular, materialistic and individualistic.
- iv. Government intervention in the following areas:
  - Compulsory education for children and the prohibition of child labour increased the costs of raising children.
  - Promotion of family planning and modern contraception methods.
  - Advocating for women empowerment through increased education and job opportunities for women. With economic empowerment women gain reproductive independence and there is a move from motherhood being the central role for women.
- v. The diffusion or spread of contraception ideas and family planning information.

#### **2.4 The demographic transition in South African**

Mortality and fertility rates have been declining in South Africa with rates documented from 1945 (Mostert *et al* 1998: 76,124). However the pace of decline had been varied across the four general population groups (Figures 2.3 and 2.4). Levels of mortality for the black/Africans in 1945 were still relatively high with rates of 23.4 per 1000 of the population compared with rates of 18.3 for the Coloureds, 11.6 for the Indian/Asians and 8.8 for the White population. The rapid decline in mortality of the black/African population from 1945 to 1955 illustrates their mortality transition.

The less rapid mortality decline of the Indian/Asians and Coloureds from 1945 coupled with the lower crude death rates compared to the black/Africans illustrates that these populations were in later stages of their demographic transition. The White population had already completed its mortality transition, as indicated by the low and almost steady death rates. The slight increment in crude death rates of the White population and the Indian/Asians from 1980 to 1985 can be attributed to population ageing.

**Figure 2.3:** Crude death rates across population groups in South Africa: 1945 to 1985

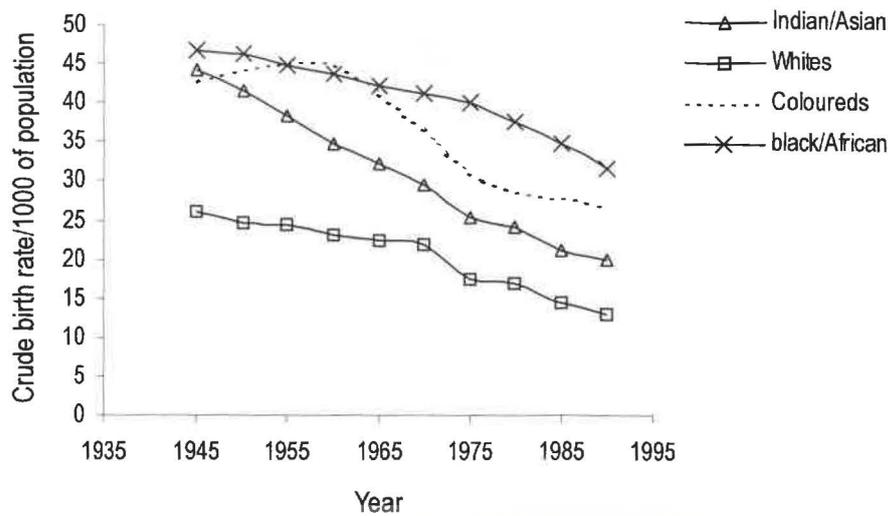


Source: Mostert et al (1998: 76)

Fertility decline across the population groups in South Africa is evident from Figure 2.4. Although relatively high crude fertility rates of 46.8, 44.2 and 42.9 live births per 1000 of the population were present in the black/African, Indian/Asian and Coloured populations in 1945 respectively, by 1985 fertility rates of the Indian/Asians were 21.2, the Coloureds 27.9, whilst the black/Africans had a rate of 34.9 live births per 1000 of the population. The relatively lower crude birth rates of the white population declined from 26.1 in 1945 to 14.4 per 1000 of the population in 1985.

Therefore the demographic transition has been taking place within the South African population proving its validity. The demographic transition of the black/African population will be discussed in detail in the following section.

**Figure 2.4:** Crude birth rates across population groups in South Africa: 1945 to 1990



Source: Mostert *et al* (1998:124)

## 2.5 The demographic transition of black/Africans

To understand the demographic transition of the black/Africans and the context in which it occurred, a brief discussion of South African history will be provided. The discussion will be limited to events considered to have significantly affected the demographic history of black/Africans.

- i. Colonialism: The first European settlers and their slaves arrived in South Africa, in the Cape in 1652 (Mostert *et al* 1998: 25). These European settlers would later interfere with the way of life of the black/Africans.
- ii. Zulu wars: *Mfecane* is a Nguni word that is used to refer to the wars and disturbances that took place in the rise of the Zulu kingdom during the 1820s. The rise of the Zulu kingdom under Shaka resulted in warfare with many chiefdoms. The resultant deaths, famine and disease reduced the black/African population in South Africa (Mostert *et al* 1998: 26).
- iii. Boer Trek: 15,000 Whites (Afrikaner Boers) emigrated from the Cape to the northern parts of the country from 1835 (Mostert *et al* 1998: 26). This great trek started the displacement of the black/Africans from their land and resulted in warfare with the Xhosa and the Zulu nations who were defeated because of the

before the harvest which had controlled the country's population in pre-colonial times...". Furthermore, Ross (1999: 144) makes reference to the "...Rinderpest epizootic of the 1890s."

Pre-transitional fertility levels were high probably due to the following:

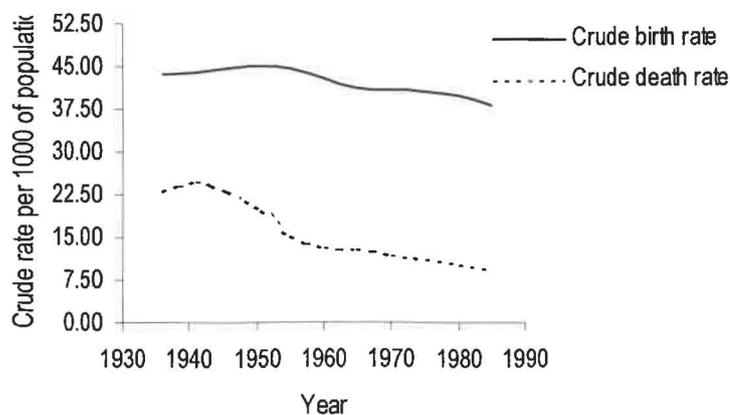
- i. The high death rates in particular the high infant mortality during the pre-transitional period led to more babies being born to ensure that some survive to adult.
- ii. The mainly agricultural based way of life of the black/Africans in which children were seen as manpower.

Mackenzie (2000: 114) challenges the notion of uncontrolled fertility in pre-transitional societies and asserts that South African women (and the rest of Africa) used traditional methods of family control like; sex between the thighs, breastfeeding, terminal abstinence and returning home after having a child.

### Transitional mortality and fertility rates

Historic rates of the black/Africans estimated from 1936 to 1985 and from 1945 to 1985 respectively are provided in Figures 2.5 and 2.6 below.

**Figure 2.5:** Mortality and fertility rates of the black/African population: 1936 to 1985



Source: Sadie (1988: 50)

## Chapter three

### Methodological assumptions

#### 3.1 Introduction

This section discusses assumptions made in determining the impact of HIV/AIDS on the demographic transition of the black/African population. The ASSA2002 model of the Actuarial Society of South Africa (ASSA) was selected to project the impact of HIV/AIDS on mortality and fertility rates. The model was also used as a basis for projections of the impact of HIV/AIDS on modernization. The structure of the ASSA2002 model is discussed first along with some key HIV assumptions of the model. Assumptions on the impact of HIV/AIDS on modernization are discussed in the second section.

#### 3.2 The ASSA 2002 model

##### 3.2.1 The structure of the ASSA2002 model

The ASSA2002 model (full version) divides the South African population into the four general population groups: black/African, Indian/Asian, Coloured and White. Each population is split by sex and by age into a young population aged 0 to 13 years, an adult population aged 14 to 59 years of age and an old population 60 years and older.

The adult population (aged 14-59) is divided into four risk groups according to their risk of contracting HIV through heterosexual activity. Dorrington, Johnson and Budlender (2004: 6) define each risk group as follows:

PRO: "Individuals whose level of sexual activity is such that it is similar to that of commercial sex workers and the level of condom usage and infection with STDs is similar to that of the STD group."

The ASSA2002 estimated antenatal prevalence can be observed to be a good fit of the observed antenatal clinic prevalence levels from the close fit of the survey points along the estimated curve. Limitations of the ANC data were highlighted in chapter one.

### **3.3 Impact of HIV/AIDS on modernization**

#### **3.3.1 Modernization as human development**

Modernization has been discussed as one of the principal causes of the demographic transition in chapter two. Although other forces have also triggered the fertility decline, however modernisation is considered as the main determinant of the fertility decline by reducing infant mortality rates (Beaver 1975: 8, Teitelbaum 1987: 35, Kirk 1996: 379). Therefore to investigate the impact of HIV/AIDS on the demographic transition, mortality rates, fertility rates and modernization will be included in the analysis. Modernization was selected as one of the key factors behind the demographic transition, either to initiate the decline or to maintain and sustain the decline to post transitional levels. HIV/AIDS is expected to affect all elements of the transition hence the impact of the pandemic needs to be explored simultaneously on mortality rates, fertility rates and causality (taken as modernization). Therefore in this research, the impact of HIV/AIDS on modernization will be explored alongside the impact of the pandemic on mortality and fertility rates.

Modernization was discussed as being synonymous with processes of industrialization, urbanization, education, social development, and economic development, all of which result in increased life expectancy, improved standards of living, increased literacy, and empowerment of women. Thus, to investigate the impact of HIV/AIDS on modernization, a suitable measure of modernization with the ability to combine several aspects linked with modernization into a single quantifiable measure was essential. The concept of human development was identified as a close measure of modernization.

Human development is defined as, "...a process of enlarging people's choices. The most critical ones are to lead a long and healthy life, to be educated and to enjoy a decent standard of living" (UNDP 1990:2). The definition of human development encompasses three end-

results of modernization namely: life expectancy, standard of living and education. The concept of human development is used to assess human progress, one of the results of the demographic transition as populations become more modern. Human development is measured by the human development Index (HDI).

### 3.3.2 Human development index

The human development index (HDI) of the United Nations Development Programme (UNDP) reflects the "...ability of individuals within a country or across various countries to live long, informed and comfortable lives" (Statistics South Africa 2001: 1). The HDI is computed from three measures: longevity, educational attainment and income:

- i. Longevity: measured by life expectancy at birth
- ii. Educational attainment: measured by adult literacy and combined gross primary, secondary and tertiary enrolment ratio. The educational attainment index is then computed by weighting the two variables, two-thirds to adult literacy and one-third to the combined gross primary, secondary and tertiary enrolment ratio
- iii. Income: measured by gross domestic product (GDP) per capita; converted to purchasing power parity in dollars (PPP\$), to allow international comparability (Statistics South Africa 2001: 1):

The HDI is measured on a scale of 0 to 1 with an HDI of 0 reflecting the lowest human development and a value of 1 indicating the highest human development. High human development corresponds to an HDI value between 0.8 and 1; medium human development is between 0.5 and 0.799 and human development indices below 0.5 reflect low human development.

The HDI however, is a generalised population index not reflecting individuality, and how individuals deviate from the general norm (Statistics South Africa 2001: 8). Criticisms have also been raised regarding the quality of data used in computing the HDI and concerning the changing of methodology, which makes year-to-year and country comparisons difficult (Morse 2003: 285, Neumayer 2001: 103). Furthermore, the HDI does not include political or religious factors directly in its formulation. Nevertheless despite not being an exhaustive

measure of human development, the HDI is widely used as it allows comparability across different populations and over time. Projections of the HDI in this study were conducted in light of the limitations of the index as Morse (2003: 296) cautions, “Simple and highly aggregated indices are supposed to help...but may also mislead and need to be handled with care.”

Therefore to determine the impact of HIV/AIDS on modernization, estimates of HDI components were projected to the year 2021. Population projections of the ASSA2002 model were used as a basis (where appropriate) in producing projections of the human development index to allow for a coherent and linked analysis of the demographic transition. Although computational methods of the HDI have been revised since its inception in 1990, the latest recommended formulas (Refer to Appendix II) have been used to compute historical and projected HDI values (Morse 2003: 286). The assumptions made in projecting the impact of HIV/AIDS on the human development index will be discussed in the following section.

#### **3.3.2.1 Impact of HIV/AIDS on longevity**

Longevity is measured using the life expectancy at birth indicator. Life expectancy at birth is the average number of years a newborn baby is expected to live at birth if the mortality patterns at the time of birth remain constant throughout the infant's life. HIV/AIDS is increasing mortality rates thus reducing expectations of life at birth. Life expectancies were obtained from runs of the ASSA2002 model.

#### **3.3.2.2 Impact of HIV/AIDS on education attainment**

Education attainment is computed from two educational variables; combined gross primary, secondary and tertiary enrollment and adult literacy. Components of the educational attainment index can be defined as follows:

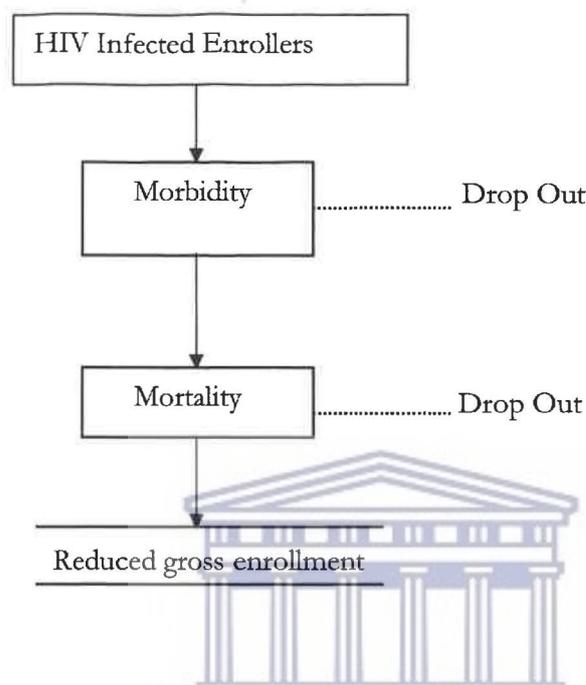
- i. Adult literacy: “The percentage of people aged 15 and above who can, with understanding, both read and write a short, simple statement on their everyday life (Statistics South Africa 2001: 24)”. The adult literacy rate is calculated as the number of persons with grade 7 and higher as a percentage of all persons 15 years and older.
- ii. Combined gross primary, secondary and tertiary enrollment: “The combined gross primary, secondary and tertiary enrollment ratio refers to the number of students at all these levels as a percentage of the population of official school age for these levels” (Statistics South Africa 2001: 24).

The educational attainment index is then obtained by assigning a weight of two-thirds to adult literacy and one-third to the combined gross primary, secondary and tertiary enrollment ratio.

The impact of HIV/AIDS on education is threefold: demographic, socio-economic and psychological. Demographic; by reducing the population of young people, socio-economic; through impacting household financial and social arrangements and psychological through its emotional damage on young people (Economic Commission for Africa 2000: xi). Education attainment is being threatened by HIV/AIDS as noted by the World Bank, “Achieving Education for All in a world of AIDS presents an unprecedented challenge to the world’s education community” (2002: ix).

Three groups of school children potentially at greatest risk from HIV/AIDS were identified by Bennell *et al* (2002: 48) as: HIV positive children, children in households with AIDS sick family members and children whose parents or guardians have died of AIDS. Incorporating the three groups of school children, the impact of the pandemic on primary, secondary and tertiary enrolment is therefore either directly through HIV infected enrollers or indirectly from HIV/AIDS affected enrollers (Figures 3.2 and 3.3).

**Figure 3.2:** A schematic flow of the impact of HIV infection of students in primary, secondary and tertiary institutions.



HIV infected enrollers result in reduced gross enrolment either from dropping out during stages of AIDS related illnesses or dropping out after death (Figure 3.2). HIV/AIDS affected enrollers are grouped into orphans and enrollers with AIDS-sick financially supportive parents or guardians, with allowance for moving into the orphan category upon death of AIDS sick parents.

An orphan is defined as a child under the age of 15 who has lost either a mother or both parents (ASSA2002). HIV/AIDS affected enrollers are expected to either increase gross enrolment through re-entry into school after drop out, grade repetition or late enrolment, or reduce gross enrolment by permanently dropping out (Figure 3.3). According to ASSA2002 highest proportion of orphaned children is projected in 2016 where 13.63% of black/African children under the age of 15 will be orphaned. Household financial and psychological strain are the main consequences of the impact of HIV/AIDS.

of HIV is set to erode and impede significant asset gain, as family assets are channelled towards medical costs and funeral expenses. AIDS morbidity and mortality of household 'breadwinners' paralyses income generation thus making it harder to defend against school disruption shocks. Collins and Rau note that:

Poor people are really impoverished people. They are impoverished by inequitable socio-economic structures-on the household level, on the village level, on the national level.... This becomes clear as we look at AIDS as one in a series of "shocks" experienced by the majorities of people in developing countries (2000: 8).

Furthermore, Bennell *et al* (2002) attribute the high enrolment ratios observed in high HIV prevalence countries as a result of the strong schooling culture that keeps most children in primary school. The question then is whether the black/African South Africans have a strong schooling culture enough to avert or lessen the negative impact of HIV/AIDS expected on the education sector?

South Africa achieved independence in 1994 from the apartheid government. During the apartheid era, the 'Bantu' education system introduced for the black/Africans limited their educational training and skills as the policy was designed to be limited and appropriate for the needs of the white run economy (Maharaj *et al* 2000: 9, Ross 1999: 121). Furthermore the inequitable education resource allocation in 'Bantu' schools limited the quality of training.

The enrolment history of black/Africans was affected by the political situation in South Africa. Maharaj *et al* (2000: 9) argues, "Education thereafter [after the introduction of 'Bantu' education] became a focal point of violence and disruption in the struggle to end apartheid. The 1976 Soweto uprising is one of the most infamous..." Nkomo 1990 cited in Maharaj *et al* (2000: 9) stated, "The slogan 'liberation now, education later' became common cries for students and youth participation in protests". Therefore based on the political unrest and inequalities in South Africa and the participation of enrollers in the struggle for freedom, it may be satisfactorily implied that the schooling culture of the black/Africans may not be strong enough to avert the impact of HIV/AIDS.

An analysis of historic gross enrolment rates across primary, secondary and tertiary levels can also be used to ascertain the existence or non-existence of a strong schooling culture among

black/Africans. Gross enrolment is measured by the gross enrolment rate (GER) defined as “The number of students enrolled in a level of education, regardless of age, as a percentage of the population of official school age for that level” (Statistics South Africa 2001: 24). A GER of more than 100% indicates more learners than the official school age, indicating the presence of under-aged and/or over-aged learners. Inversely a GER of less than 100% indicates fewer learners than the official school age, implying dropping out among official age learners. The official school age for primary enrolment is between the ages of 7 to 13, secondary enrolment official ages are in the range 14 to 18 years old and the official tertiary enrolment population is aged 19 to 24 years.

**Table 3.2:** Percentage primary, secondary and tertiary historic gross enrolment rates: 1985 to 2000.

YEAR	PRIMARY GROSS ENROLMENT RATES	SECONDARY GROSS ENROLMENT RATES	TERTIARY GROSS ENROLMENT RATES
1985	110.64	46.19	2.47
1986	110.55	48.39	3.00
1987	112.76	53.61	3.62
1988	113.31	58.54	4.26
1989	112.39	62.19	4.89
1990	112.68	66.53	5.46
1991	114.57	71.27	6.25
1992	116.17	76.10	6.45
1993	121.37	79.82	7.28
1994	124.90	82.69	7.82
1995	129.05	87.00	10.14
1996	120.00	90.00	11.46
1997	112.00	90.00	12.88
1998	108.00	90.00	14.30
1999	106.18	89.45	14.03
2000	100.00	87.00	15.73

*Source: Research institute for Education Planning (RIEP) cited in the 1995 South African Statistics for values from 1985 to 1994, the author estimated values from 1995 to 2000 from various sources.*

Gross enrolment rates (GERs) for primary enrolment were fluctuating in the period 1985 to 1990. Primary GERs increased from 112.68% in 1990 to a high of 129.05% in 1995, indicating repetition, re-entry and late entry into primary school following achievement of democracy. Primary GERs subsequently declined from 1996 onwards reaching 100% in 2000. The attainment of a GER of 100% was obtained as official ages were implemented and the inequalities of the past education system were addressed as rates of repetition, re-entry and late entry into primary school declined.

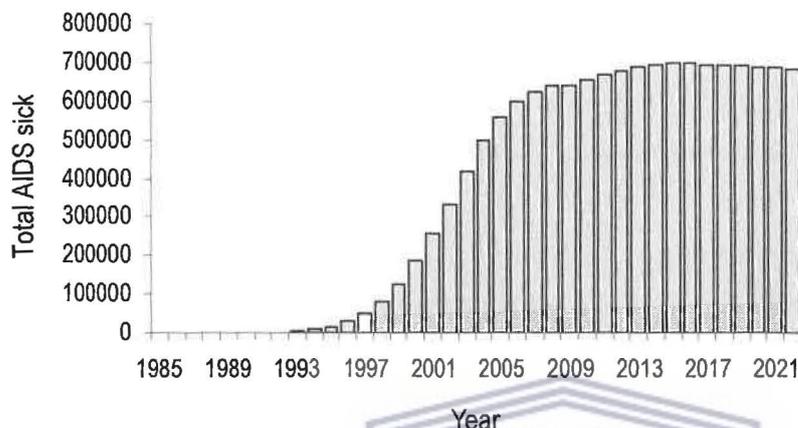
Individuals aged 65 years and older are projected to have the lowest HIV prevalence, peaking at a rate of 1.78% in 2019. This is attributed to the assumption in the ASSA2002 model of no HIV infections occurring after the age of 60. The age group 15 years and below is expected to have a higher prevalence than those aged 65 years and older as a result of mother-to-child transmission. HIV prevalence of individuals 15 years and younger is expected to increase for the entire study period; however increments of less than one percentage are projected from 2014 to 2021, with slight fluctuations between 2016 and 2017. HIV prevalence of those 15 and younger is estimated at 2.74% in 2021.

The functional group aged 15 to 64 years is projected to have a higher HIV prevalence than the total population (Figure 4.1). HIV prevalence among this age group (15 to 64) will peak in 2007 at a rate of 20.93%. Those aged 15 to 64 years can be defined as the economically active or potentially active group; therefore by affecting the economically active group HIV/AIDS is expected to disrupt financial arrangements in households. Females of reproductive age are however projected as the age group with the highest HIV prevalence among the black/Africans. HIV prevalence is projected to peak in 2007 (as those aged 15 to 64) but at a higher level of 25.36%. The Nelson Mandela/HSRC study of HIV/AIDS (2002: 58), state that, "The logistic regression analysis confirms that both age, in particular being between 25 and 49 years, and being female increases the likelihood of a person being HIV positive." Gender inequality is attributed as one of the reasons for the higher prevalence as women have little control over their sexual and reproductive health (Johnson and Budlender 2002: 9). HIV prevalence of those aged 15 to 64 years is projected to peak at a level 52.48% higher than the total population prevalence, whilst prevalence of women in reproductive ages will peak at a level 84.71% higher than the total population prevalence.

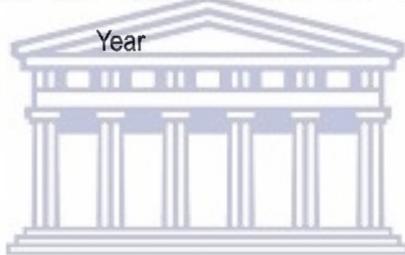
Based on functional age group definitions, those younger than 15 and older than 64 years are dependents, being dependent on the economically active or potentially active aged 15 to 64 years, the dependants are projected to be affected less by HIV/AIDS than the economically active group. The ratio of dependents to the economically active is projected to increase due to the impact of HIV/AIDS.

AIDS sick individuals in the total population will peak in 2016 with almost 700,000 (697,756) AIDS sick black/Africans (Figure 4.2).

**Figure 4.2:** Total AIDS sick black/Africans: 1985 to 2021



Source: ASSA 2002

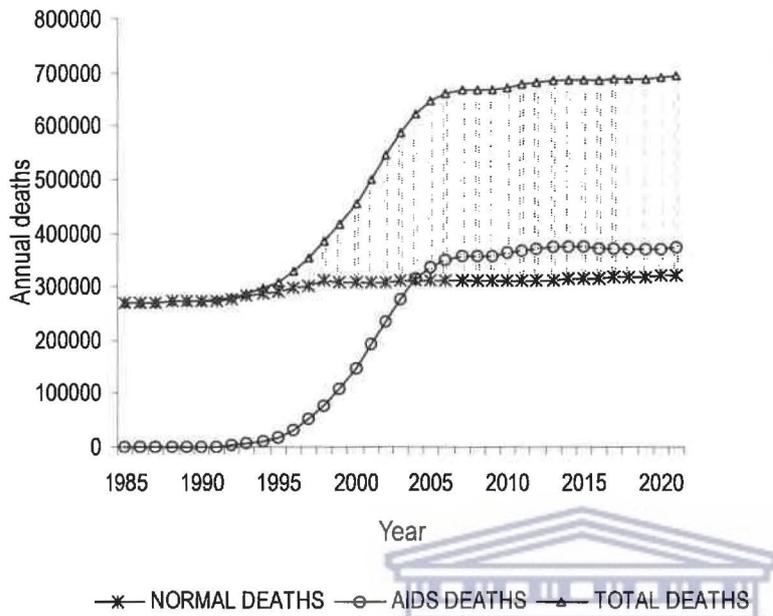


### 4.3 Projected impact of HIV/AIDS on mortality and fertility rates

#### 4.3.1 Mortality projections

Normal deaths (no-AIDS deaths) constituted the bulk of total deaths from 1985 to 1992. AIDS deaths accounted for less than one percent of total deaths in the same period. However, rising HIV prevalence within the black/African population is increasing total deaths, and AIDS deaths are estimated to surpass normal deaths in 2004 (Figure 4.3). The increment in total deaths due to AIDS deaths is highlighted between the total deaths trend line and the normal deaths trend. AIDS deaths are projected to constitute 54% of total deaths from 2013 to the end of the period in 2021. In a no-AIDS scenario total deaths would have been approximately constant during the entire period of study at around 300,000 deaths. However total deaths will be increased by 115.79% in 2021 due to the impact of HIV/AIDS of increasing mortality.

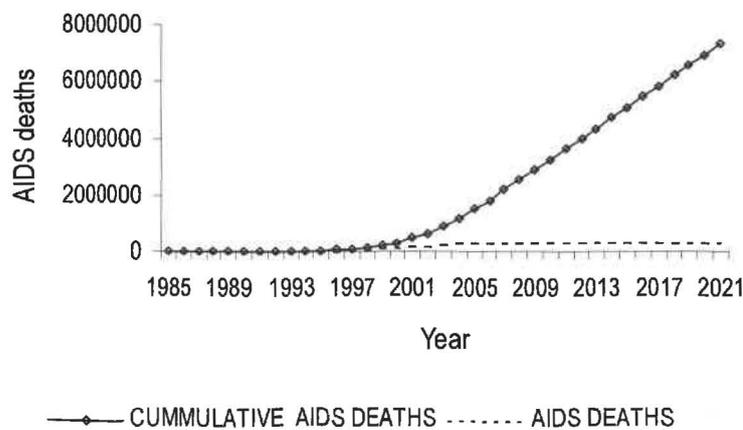
**Figure 4.3:** Normal deaths, AIDS deaths and total deaths of black/Africans: 1985 to 2021.



Source: ASSA2002

Cumulative AIDS deaths in 2021 will amount to just above seven million deaths, exactly 7,297,274 deaths (Figure 4.4). The total black/African South African population is currently estimated at 35,833,419 (ASSA2002). Therefore cumulative AIDS deaths will amount to a reduction of 20.36% of the current black/African population by 2021.

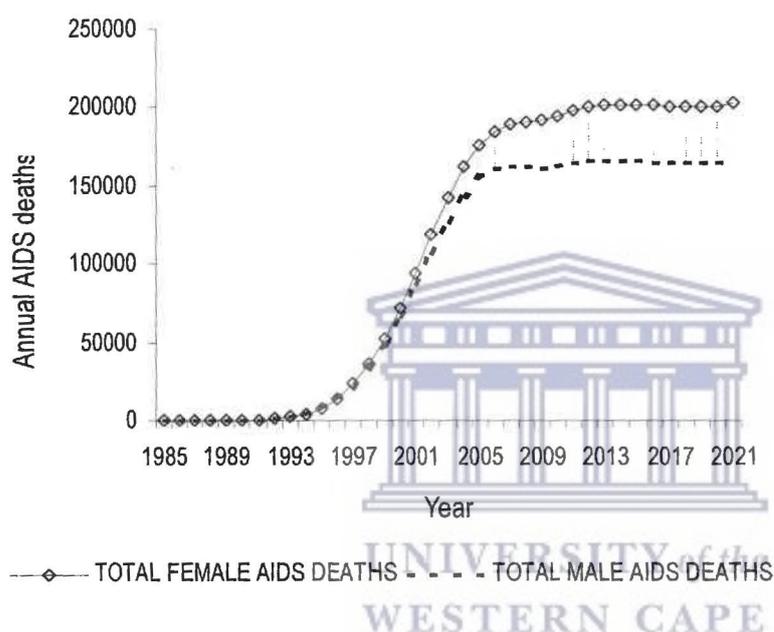
**Figure 4.4:** Annual and cumulative AIDS deaths of black/Africans: 1985 to 2021.



Source: ASSA2002

However females are projected to experience more annual AIDS deaths compared to males during the study period (Figure 4.5). Female AIDS deaths are estimated to be 22% more than male deaths in 2021 due to the higher HIV prevalence among women especially those of reproductive age. The extra AIDS mortality among females is shaded in figure 4.5.

**Figure 4.5:** Annual male and female AIDS deaths: 1985 to 2021.

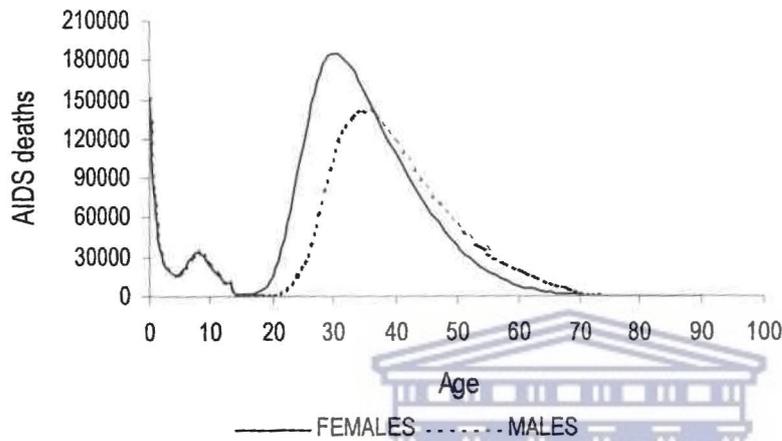


Source: ASSA2002

To determine the single age patterns of AIDS deaths across sex, AIDS deaths were summed across single ages from 1985 to 2021 (Figure 4.6). The trend in AIDS deaths across ages is similar for both males and females with differences exhibited in AIDS mortality peak ages and in the scale of AIDS deaths. Mother-to-child transmission is reflected in the relatively high AIDS deaths of male and female infants aged 0 and 1. The increased deaths of infants under one year will increase the infant mortality rate, taken as the number of deaths under one year divided by the number of live births in that year (Figure 4.7). The rate of infant mortality is used as an indicator of progress through the demographic transition model and its reduction indicates a reversal in the progress. Infant mortality rates are estimated to have increased to a high of 73.22 per 1000 live births in 2000 from the impact of HIV/AIDS, a rate estimated in the late 1970s, thus reversing progress made in the past stages of the

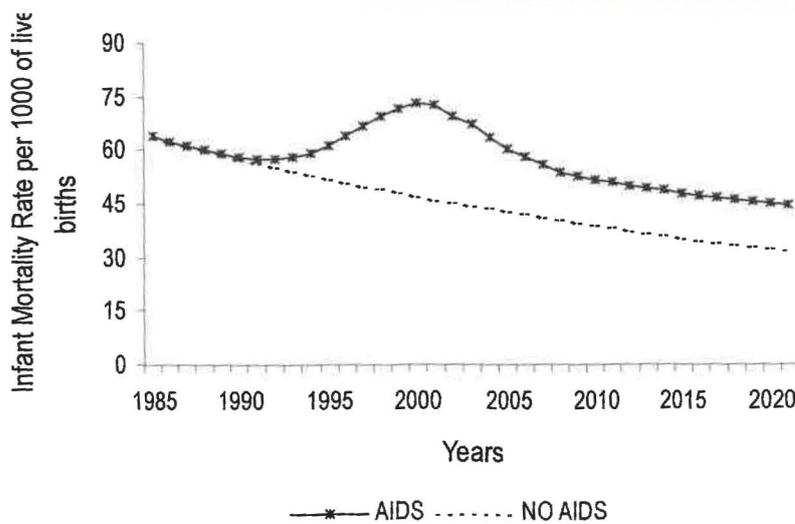
demographic transition (Figure 4.7). Returning to the AIDS deaths by age and sex, distinct differences in the pattern of AIDS deaths across sexes are observed from the age of 15 and older (Figure 4.6).

**Figure 4.6:** Male and female AIDS deaths by age: 1985 to 2021.



Source: ASSA2002

**Figure 4.7:** Infant mortality rates in an AIDS and no AIDS scenario: 1985 to 2021.



Source: ASSA2002

The highest female AIDS deaths are projected to occur at age 30; with cumulative AIDS deaths of 184,503 by 2021. Females aged 28 to 34 are projected to have the highest AIDS deaths in the range of 166,063 to 184,503. Male adult deaths in contrast are projected to peak in an older age range between the ages of 34 to 36 years with total deaths by 2021 ranging from 140,589 to 142,000. The highest number of male deaths is projected to occur at age 0 with AIDS deaths amounting to 150,199. Otherwise male adult AIDS deaths peak at age 35 with cumulative deaths of 142,000 by 2021.

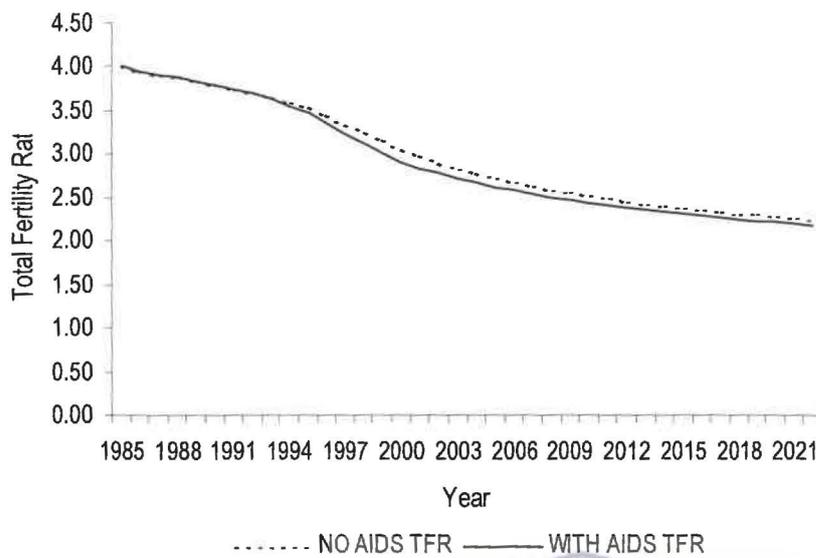
The higher HIV prevalence estimated for women aged 15 to 49 results in higher female deaths projected in the reproductive ages (Figure 4.6). Females of reproductive age are one of the main determinants of the fertility transition within the demographic transition, and are projected to account for 82% of total female AIDS deaths by 2021. The next section discusses the projected impact of the pandemic on fertility.

#### 4.3.2 Fertility projections

The impact of HIV/AIDS on fertility will cause a slight reduction in fertility levels (Figure 4.8). A plot of fertility in a no-AIDS scenario against an AIDS scenario shows a fertility differential due to HIV/AIDS projected at a maximum just above 5% (5.09%) in 2000. Total fertility rates (TFR) are projected at rates of 2.21 compared to a no-AIDS scenario of 2.27 children per average woman in 2021. These levels of total fertility rates are close to the replacement level of 2.1 although HIV/AIDS is projected to slightly accelerate the fertility decline with a TFR of 2.64% lower than a no-AIDS scenario.

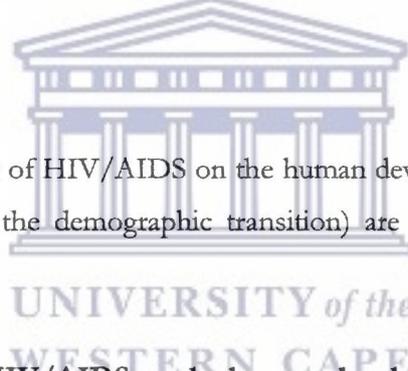
Fertility levels of black/Africans have been declining in line with the demographic transition theory and HIV/AIDS is projected to accelerate the fertility decline. However the fertility decline will be achieved through deaths of potential mothers and the fecundity reduction associated with the pandemic.

**Figure 4.8:** Total fertility rates in an AIDS and a no-AIDS scenario: 1985 to 2021



Source: ASSA2002

Results of the projected impact of HIV/AIDS on the human development index (taken as a measure of modernization of the demographic transition) are discussed in the following section.



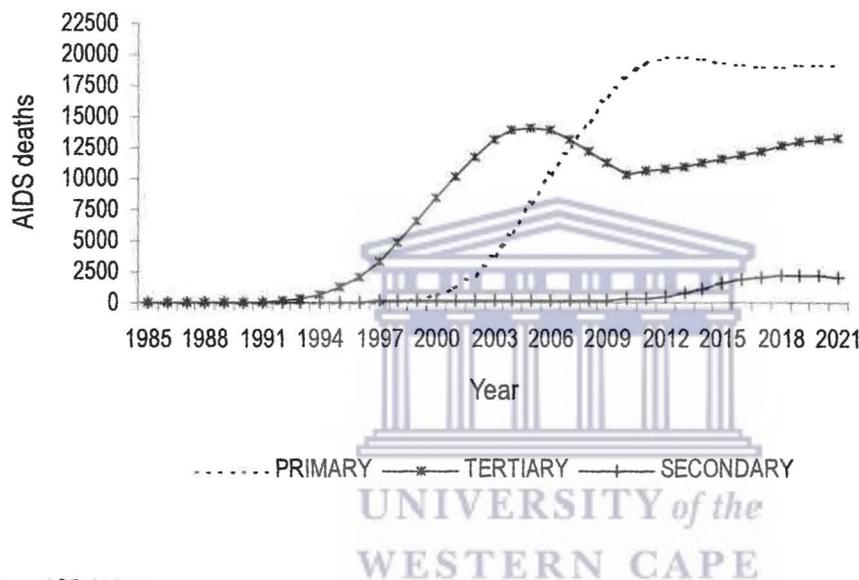
#### **4.4 Projected impact of HIV/AIDS on the human development index**

##### **4.4.1 Life expectancy**

Life expectancy for black/Africans is estimated to have increased by 1.68% from 1985 to a value of 59.53 in 1992. Values of life expectancy declined from 1993 as a result of HIV/AIDS, from a value of 59.53 with the decline projected until 2006 to a value of 46.20. The steepest decline in life expectancy is estimated to have occurred between 1998 and 2004 declining from 55.63 to 47.01 with decrements ranging between 2.1% and 3.2%. Increases of less than 0.5% are projected from 2007 onwards with a life expectancy of 48.03 years projected for 2021 (Figure 4.9).

enrolment until 2012. From 2012 to 2021 secondary gross enrolment is projected to decline by 12% as a result of increased projected AIDS deaths of secondary school enrollers (Figure 4.12). An upward trend in gross tertiary enrolment is projected for the period of study except from 2005 to 2010 when the ASSA2002 tertiary aged population declines, causing a reduced tertiary enrolment of 9%.

**Figure 4.12:** AIDS deaths of officially aged primary, secondary and tertiary enrollers: 1985 to 2021.



Source: ASSA2002

The highest number of AIDS deaths are projected for primary enrollers (aged 7 to 13) due to mother-to-child transmission. An estimated 19,883 AIDS deaths of officially aged primary enrollers are projected to peak in 2013. Officially aged secondary enrollers (aged 14 to 18) have the lowest projected AIDS deaths estimated to peak at 2,219 deaths in 2019 at only 11.16% of primary AIDS deaths. AIDS deaths of tertiary enrollers increase from 1985 to peak in 2005 at 14,135. Tertiary AIDS deaths decline from 2005 until 2011 with deaths projected at 10,568 in 2011, then increase to 13,234 in 2021.

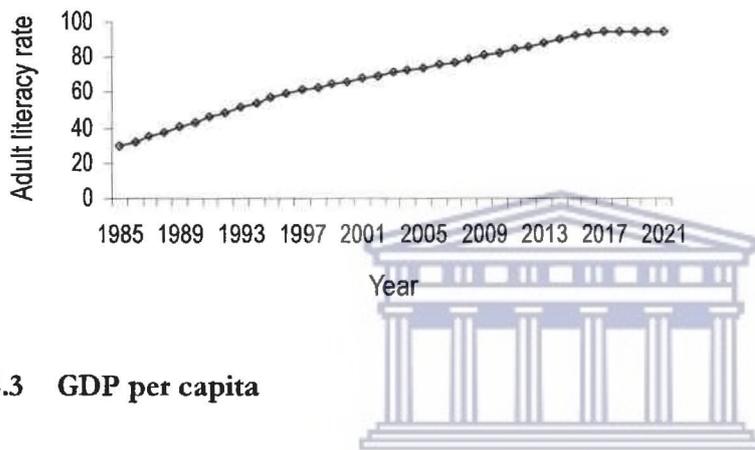
The projected pattern of primary AIDS deaths peaking in 2013, secondary AIDS deaths rising significantly after 2012 and AIDS deaths of officially aged tertiary enrollers peaking in 2005 then declining to rise again after 2012 (Figure 4.12) indicates the impact of prevention and treatment programmes modelled into the ASSA2002 model. The relatively low AIDS

deaths of secondary enrollers may be the result of the ASSA2002 assumption that HIV infection of those under the age of 13 years is either at birth or during breastfeeding.

#### 4.4.2.2 Adult literacy rates

Adult literacy is estimated to increase from 28.84% in 1985 and projected to 95% in 2021.

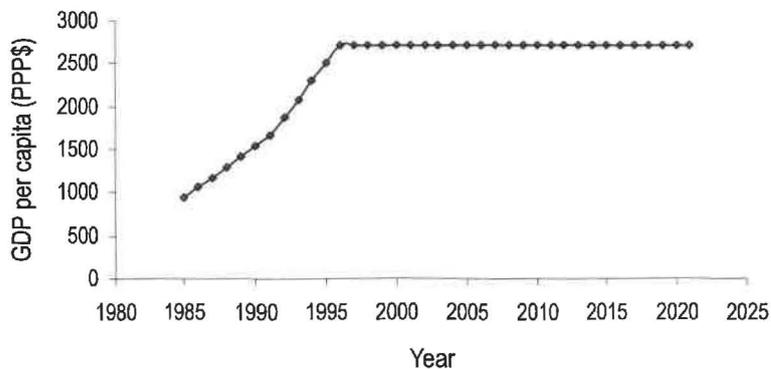
**Figure 4.13:** Adult literacy rates: 1985 to 2021.



#### 4.4.3 GDP per capita

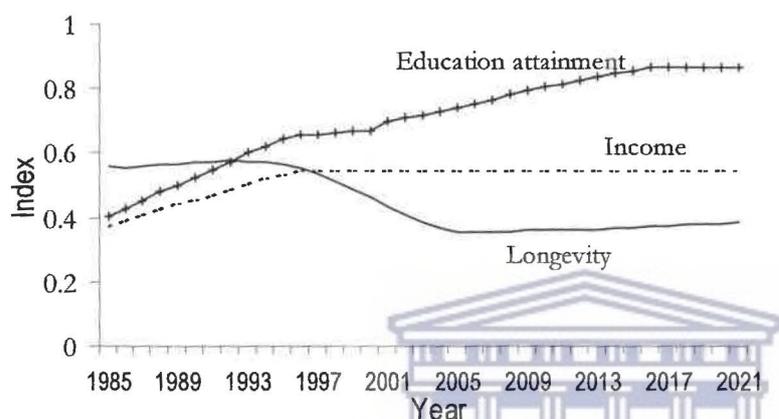
GDP per capita projections were assumed to be constant at a value of 2713 estimated as the 1996 GDP per capita value (Statistics South Africa 2001: 9).

**Figure 4.14:** GDP per capita values: 1985 to 2021.



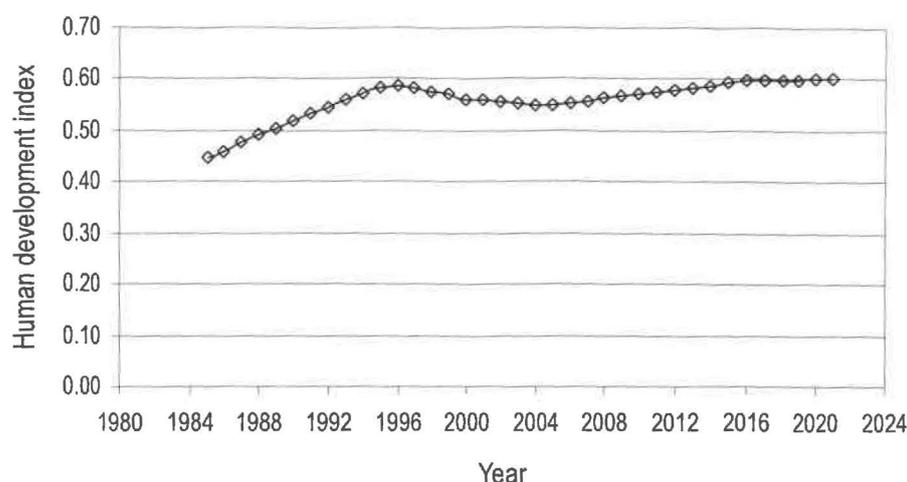
Indices of life expectancy, education attainment and GDP per capita were computed from 1985 to 2021 using the most recent recommended formulas by the UNDP (Formulas provided in Appendix II). Figure 4.15 provides a plot of the indices of the human development index.

**Figure 4.15:** Trends in the HDI components of the black/African population: 1985 to 2021



The education attainment index is projected to increase parallel to the decrease in life expectancy thus making up for the loss in human development as a result of the reduced life expectancy. The increased gross enrolment especially marked at primary school level is misleading since it increases the education attainment index thus moderating the reduction in the HDI. Net enrolment calculated as the number of enrollers of official school age divided by the total official school age population might be a better indicator to illustrate the impact of HIV/AIDS on enrolment. GDP per capita is assumed to not have a varying impact on the human development index from 1996 to 2021. Projections of the human development index for the black/Africans are provided in figure 4.16.

**Figure 4.16:** Projections of human development index for the black/African: 1985 to 2021.



The human development index of the black/African population is projected to decline by 5.51% from 0.581 to 0.549 between 1997 and 2004. The increase in HDI from 2004 to 2021 is projected at less than 1% compared to an average HDI increase of 2.54% per annum in the 1980s and early 1990s. Levels of human development estimated for 2004 are similar to levels observed in 1992; therefore under the assumptions of this study, HIV/AIDS will cause more than a decade reversal in levels of human development.

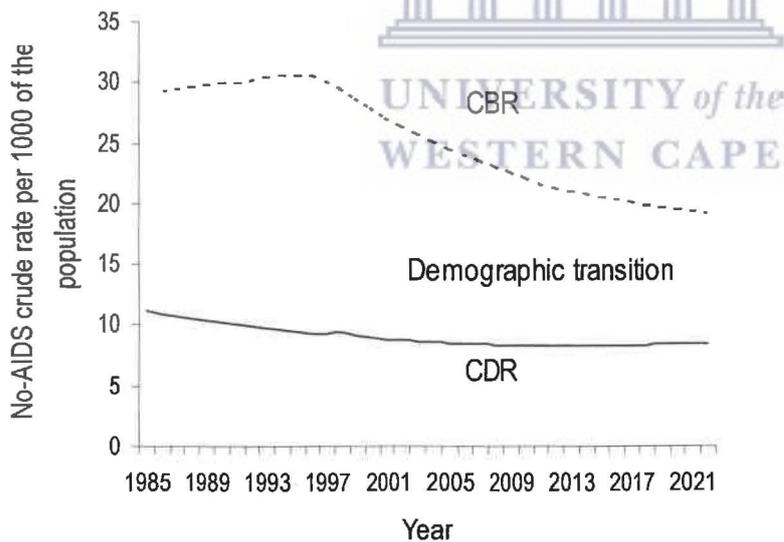
Levels of HIV prevalence projected by the ASSA2002 model determine the impact of HIV/AIDS on the human development index. The level at which HIV prevalence plateaus in the ASSA2002 model, is determined largely by the percentage of black/Africans in the NOT group, assumed to not be at risk of HIV infection. The ASSA AIDS Committee assumes that 48.8% of black/Africans constitute the NOT group. An analysis was conducted by varying the percentage of the NOT group to investigate the impact of the varied assumption on HIV prevalence and on projections of the human development index (Appendix I). However the assumption of 48.8% was accepted in this study as the most likely.

Projections of mortality, fertility and the human development index discussed above will be used to illustrate the impact of HIV/AIDS on the demographic transition of the black/Africans and determine the AIDS transition.

#### 4.5 The AIDS transition

In a no-AIDS era the demographic transition model of the black/African was projected as figure 4.17. Crude rates of mortality and fertility were projected to decline as the black/African population progressed through their demographic transition. Fertility and mortality rates were estimated to be at current levels (2004) 25.27 and 8.60 per 1000 of the population respectively and projected to decline to fertility and mortality rates of 19.48 and 8.50 per 1000 of the population respectively in 2021. The mortality rate was expected to increase slightly from 2012 to 2021 as a result of anticipated population ageing, as the black/African population progressed their demographic transition (Figure 4.17).

**Figure 4.17:** Projected no-AIDS scenario demographic transition over time: 1985-2021.



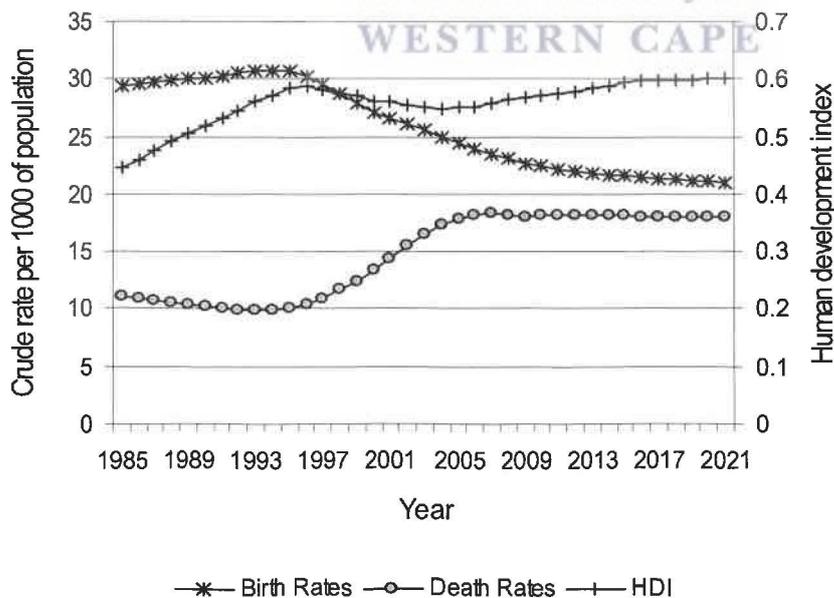
Source: ASSA2002

denominator (population estimate) will be lower thus translating to a higher crude birth rate compared to a no-AIDS scenario. However when the TFR is used, the number of children per average woman is slightly lower due to HIV/AIDS, estimated at 2.21 compared to a no-AIDS estimate of 2.27 children per average woman.

HIV/AIDS is projected to increase mortality levels; a contradiction of the classic demographic transition and at the same time slightly accelerate the fertility decline; a favourable condition of the demographic transition model. HIV/AIDS is projected to alter the demographic transition model of the black/Africans by 2021 (Figure 4.18). Therefore it may be more appropriate to introduce a more appropriate term to account for the disruption in transition as a result of HIV/AIDS: the AIDS transition.

The demographic transition theory supposes a progression in transition levels with increasing levels of modernization. HIV/AIDS is expected to affect mortality rates, fertility rates and processes of modernization. The AIDS transition will be plotted alongside human development index projections.

**Figure 4.19:** The AIDS transition plotted alongside human development index projections over time: 1985 to 2021.



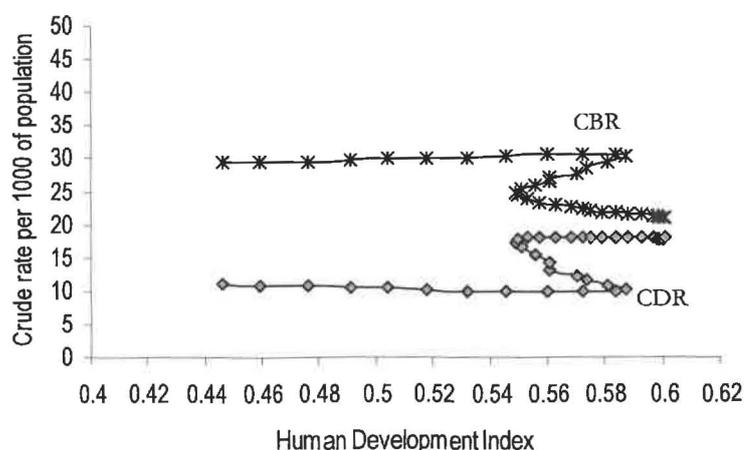
Source: ASSA2002 model for CBR and CDR

Levels of human development index were increasing with declining mortality and fertility rates, a condition of the demographic transition (Figure 4.19). However the dual impact of HIV/AIDS on components of the demographic transition is evident from 1996 to 2004 with the human development index decreasing whilst mortality rates increased and (although not evident from figure 4.19) fertility levels were slightly accelerated in their decline. Human development index levels reduced from 0.58 to 0.55 between 1996 and 2004, whilst mortality increased from 10.34 per 1000 of the population to 17.38 per 1000 in 2004 and fertility levels declined from 30.26 to 24.96 per 1000 of the population.

Assuming that the relationship between the human development index (a measure of modernization) with mortality and fertility rates is a direct causality, the HDI as the independent variable and crude rates of mortality and fertility as dependent variables, figure 4.20 was plotted. Figure 4.20 illustrates the simultaneous impact of HIV/AIDS on elements of the demographic transition assuming the HDI (modernization) as a single causality factor and as a predictor of mortality and fertility rates. However assuming modernization as the sole instigator of the demographic transition has been disputed (chapter two), nevertheless figure 4.20 will be used for illustration purposes.

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**Figure 4.20:** Mortality and fertility rates plotted vs. the human development index: 1985 to 2021



Source: ASSA2002 model

The estimated decline in HDI levels reversed the unidirectional trend in mortality and fertility rates from 1996 to 2004. As the pandemic recedes, HDI levels increase to 0.60 in 2021 and a positive trend in the transition components is regained. Mortality levels are projected at almost constant levels from 2005 fluctuating to a rate of 18.02 in 2021. Fertility levels declined to 21.01 live births per 1000 in 2021.

In this chapter, results of HIV/AIDS and its projected impact on mortality rates, fertility rates and the human development index culminated into the impact of HIV/AIDS on the demographic transition of black/Africans. The impact of the pandemic is projected to alter the demographic transition of the black/African population by 2021. Although not to disregard the classic demographic transition theory, the higher HIV prevalence within the black/African population necessitates an adjustment of the classic demographic transition theory to account for the impact of HIV/AIDS. Therefore it may be more appropriate to speak of an AIDS transition in this era of HIV/AIDS. Implications of the AIDS transition will be discussed in the following chapter.



## Chapter five

### Demographic implications of the AIDS transition

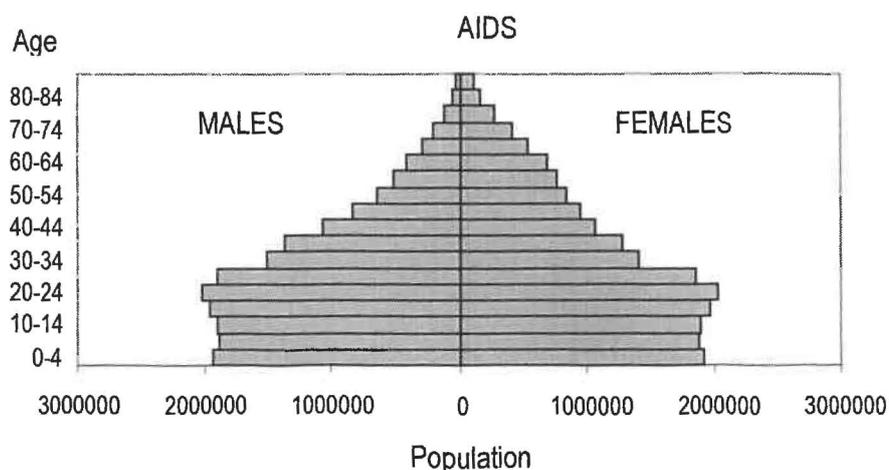
#### 5.1 Introduction

The AIDS transition has been introduced and recommended as an appropriate term to account for the impact of HIV/AIDS on the demographic transition of black/Africans in the preceding chapter. In this chapter the demographic implications of the AIDS transition will be discussed. The projected age and sex structure of the black/African population in 2021 is discussed in the first section. The last section will discuss possible implications of the AIDS transition on the future demographic transition of black/Africans.

#### 5.2 Population age and sex structure

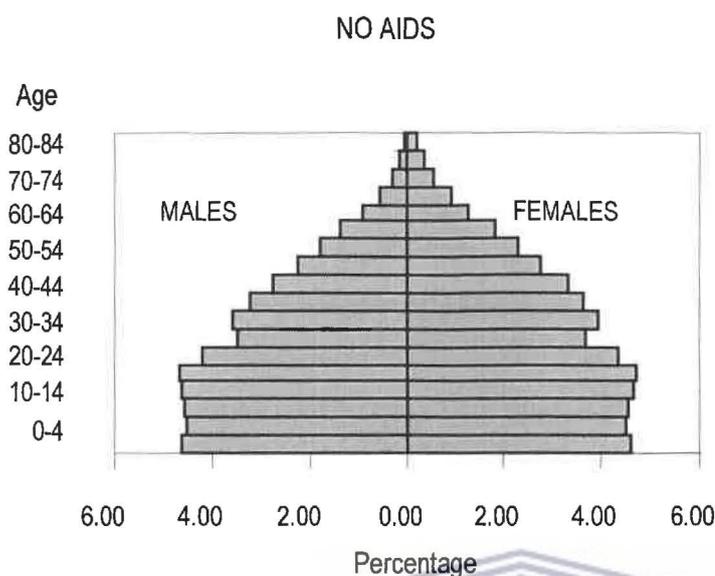
The total black/African population is projected to be 38,630,248 in 2021 compared to a population of 46,293,156 in the absence of HIV/AIDS, a 17% reduction due to HIV/AIDS impacts. The population pyramid of population totals projected for 2021 indicates a declining young population as reflected by the concave shape in the ages 5 to 19 years (Figure 5.1).

**Figure 5.1:** Projected population pyramid of population totals for black/Africans in 2021.



Source: ASSA2002 model

**Figure 5.3:** Projected population pyramid showing percentage distribution in 2021 in a no-AIDS scenario.

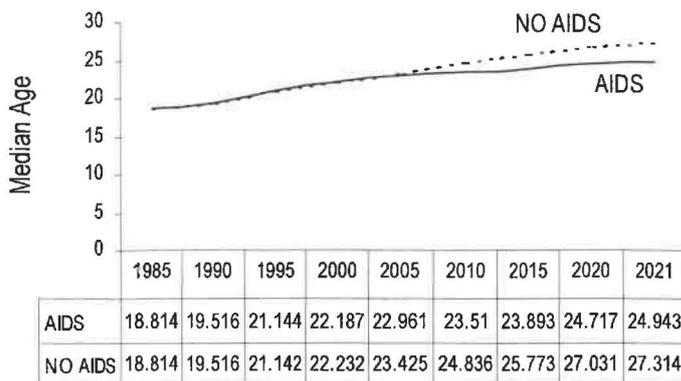


Source: ASSA2002 model

The relatively higher proportion of AIDS deaths of those aged five years and below and of adults aged 25 to 45 accounts for the differences in the shape of the projected age structures in an AIDS and a no-AIDS scenario. As a result of AIDS deaths, the age group 20-24 is projected to be the most populous in 2021 estimated at 10.49% across males and females and therefore protrudes noticeably in figure 5.2 compared to the no-AIDS scenario. Although the projected population pyramid reflects an accelerated fertility decline, the older ages are less populous and reflect increased deaths as a result of HIV/AIDS, a variation from the typical population pyramid resulting from the demographic transition.

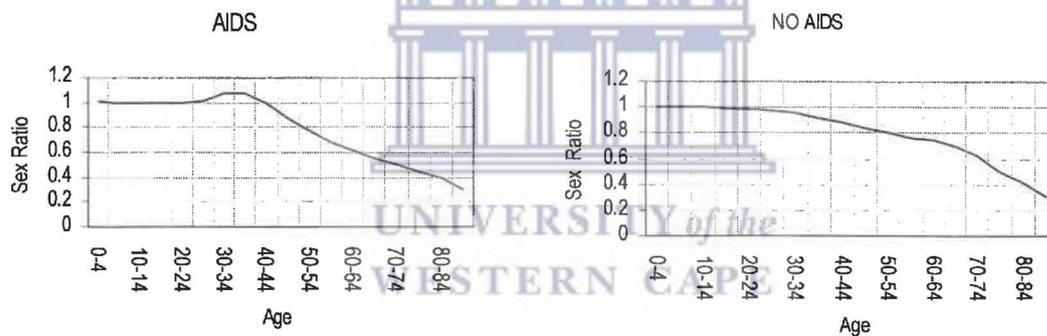
The proportion of the young (aged below 15) is projected to be 29.47% (11,385,920) in 2021, compared to a no-AIDS scenario of 27.38% (12,674,257). The potentially economically active group aged 15 to 64 years will comprise 64.88% (25,061,639) in 2021 relative to a proportion of 67.27% (31,140,518) in the absence of HIV/AIDS. The old age group 65 years and older is projected at a higher percentage of 5.65% (2,182,690) compared to a no-AIDS scenario of 5.35% (2,478,381). Therefore the impact of AIDS deaths among the potentially economically active can be noted in the reduced population of those 15 to 64

**Figure 5.5:** Median ages for an AIDS and a no-AIDS scenario: 1985 to 2021



Source: ASSA2002

**Figure 5.6:** Five-year age group sex ratios for black/Africans projected for 2021.



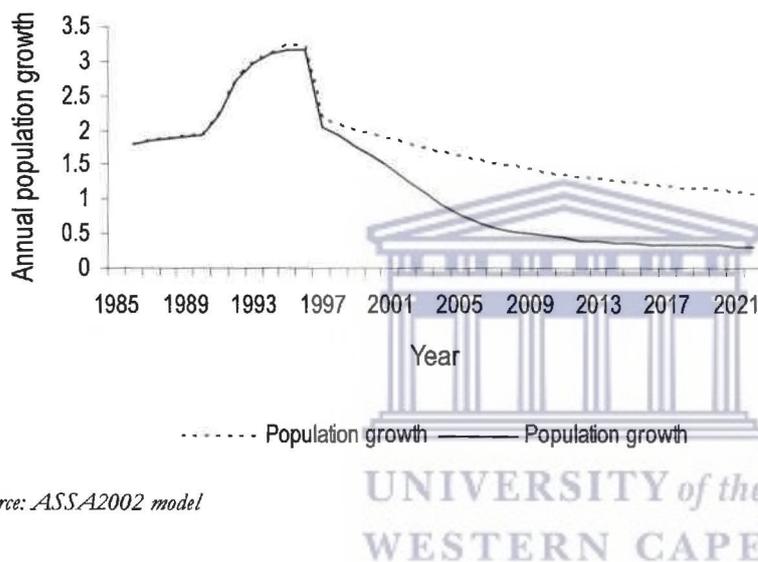
Source: ASSA2002

The sex ratio is interpreted as the number of males per females. An age specific sex ratio greater than one implies more males than females and inversely a sex ratio below one implies more females than males. The impact of AIDS mortality among females of reproductive age is evident from the higher numbers of males in the age group 20 to 44 years.

### 5.3 Population growth

The result of the increased mortality and slightly reduced fertility rates has implications for population growth. The demographic transition theory postulates that populations move from a period of stable population growth, through the transitional phase characterised by high population growth to post transitional phases of low and stable population growth.

**Figure 5.7:** Projected annual growth rates: 1985 to 2021



Source: ASSA2002 model

Figure 5.7 illustrates population growth projected for the period compared to a no-AIDS population growth. Population growth is projected to be lower than in the absence of AIDS as a result of increased mortality coupled with the slight fertility reduction. An annual growth rate of 0.3% is projected for 2021 compared to growth of 1.1% in a no-AIDS scenario. An almost 250% decline in population growth is projected as a result of the pandemic. Therefore the impact of HIV/AIDS will attain the transitional population growth, even at a faster rate than anticipated. However the lower population growth projected for the black/Africans will not be attained through increased modernization but rather through the unprogressive means of increased mortality.

#### 5.4 Implications for the demographic transition

Mortality rates are projected at 18.02 per 1000 of the black/African population in 2021, whilst fertility rates are projected at 21.01 live births per 1000 of the population. The approximating fertility and mortality rates at the end of the AIDS transition resembles the pre-transitional stage the demographic transition model, prompting the question of how fertility and mortality rates are expected to behave afterwards. What are the implications of the AIDS transition on the future pattern of the classic demographic transition of the black/Africans?

The AIDS transition is expected to influence demographic patterns of black/Africans in two possible ways:

- i. A continued demographic transition: A continuation of the interrupted demographic transition on completion of the AIDS transition. The receding pandemic will lower mortality levels, which combined with the fertility decline will complete the demographic transition of the black/Africans.
- ii. A second demographic transition: A post-AIDS baby boom may increase fertility levels which coupled with decreasing mortality rates (from the receding pandemic) could result in a second demographic transition where fertility levels will eventually decline to fluctuate around low levels of mortality. Fertility aspirations may be higher with the receding pandemic, which may trigger a rise in family formation, early age at marriage and an increased number of children per average woman as the risk of HIV infection will be declining.

This chapter discussed the age and sex structure of the population in 2021, population growth, and possible implications of the AIDS transition on the classic demographic transition model. The following chapter concludes this research on the impact of HIV/AIDS on the demographic transition of black/Africans.

## Chapter six

### Conclusion

The nature of HIV/AIDS was contextualised within the progression of the demographic transition of the black/African population in the introduction. Mortality rates and fertility rates were on the decline, estimated at 8.1 per 1000 of the population and 34.9 live births per 1000 of the population respectively in the early 1980s (Mostert *et al* 1998: 76, 124). The decline in death and birth rates was expected to continue with progression of their demographic transition. However, research indicated that HIV/AIDS was increasing mortality and expected to accelerate the fertility decline. The research aimed to alter the classic demographic transition of the black/Africans to include the impact of HIV/AIDS using population projections of the ASSA2002 model.

The demographic transition theory was reviewed in chapter two. In spite of criticisms on the whether the theory was applicable to 'developing' or 'non-western' countries the demographic transition was shown to be applicable to the black/African population. Causality of the demographic transition was attributed to the various factors that had been put forward by scholars to explain the transition. No one factor was attributed for the demographic transition however modernization was taken as a principal causality factor of the demographic transition.

In chapter three, methodological assumptions of the ASSA2002 model and of the human development index (taken as a measure of modernization) were discussed. The ASSA2002 model is calibrated using estimates of antenatal clinic HIV prevalence. The ANC data however, has several limitations. The UNDP's human development index was used as a measure of modernization. The HDI has several computational including the fact that it is not an exhaustive measure of modernization.

Population projections of the black/Africans projected to 2021 illustrated that the pandemic would alter their demographic transition in chapter four. Mortality rates are projected to increase whilst fertility decline will be slightly accelerated. Levels of human development

index are projected to be simultaneously reduced and retarded by HIV/AIDS. Therefore the AIDS transition was introduced to account for the impact of HIV/AIDS on the demographic transition of the black/Africans.

The demographic transition theory does not account for the possibility of a reversal or acceleration in the trend of mortality or fertility rates and even in the levels of processes associated with the transition (like modernization). The prevalence of HIV within the black/African population is projected to alter their demographic transition, by reversing the mortality transition and accelerating the fertility decline. The impact of HIV/AIDS is expected to override the various causality factors of the demographic transition and is expected to alter mortality and fertility patterns. The AIDS transition is an appropriate term to account for the impact of HIV/AIDS.

Demographic implications of the AIDS transition were discussed in chapter five. The projected population pyramid in 2021 illustrated the impact of AIDS deaths with younger cohorts 'bit deeply' compared to a no AIDS scenario. The age dependency is projected to be higher as a result of AIDS deaths of the potentially economically active persons. Sex ratios of those ages 25 to 44 years will be more than one indicating more males than females as a result of the highest number of AIDS deaths projected among women aged 15 to 49. The median age of black/Africans in 2021 is projected to be an intermediate age. Population growth will be reduced sharply as a result of HIV/AIDS.

Possible implications of the AIDS transition on the classic demographic transition were also discussed in chapter five. Either the disrupted demographic transition will be continued after the AIDS transition or a second demographic transition will be observed. Whilst mortality rates can be expected to decline following the AIDS transition, fertility trends may not be easily discernible as behavioral changes as a result of the AIDS transition are expected to influence fertility trends. Further research is required to determine the impact of the AIDS transition on fertility aspirations of the black/African population.

Therefore projected values of mortality will reflect a reversal in modernization by 2021, yet on the contrary projected values of fertility are expected to signify positive gains in

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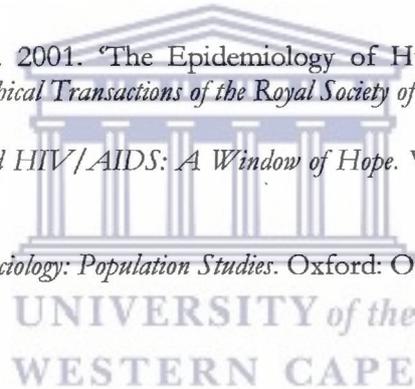
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## Appendix I: Varying assumptions of the NOT group

The prevalence level at which HIV prevalence is projected to plateau is determined to a large extent by the proportion of the NOT group. The NOT group is assumed to be the percentage of the black/African population at no risk of acquiring HIV. To determine the impact of varying the NOT group on projections of the HDI, an analysis was conducted with the NOT percentage at:

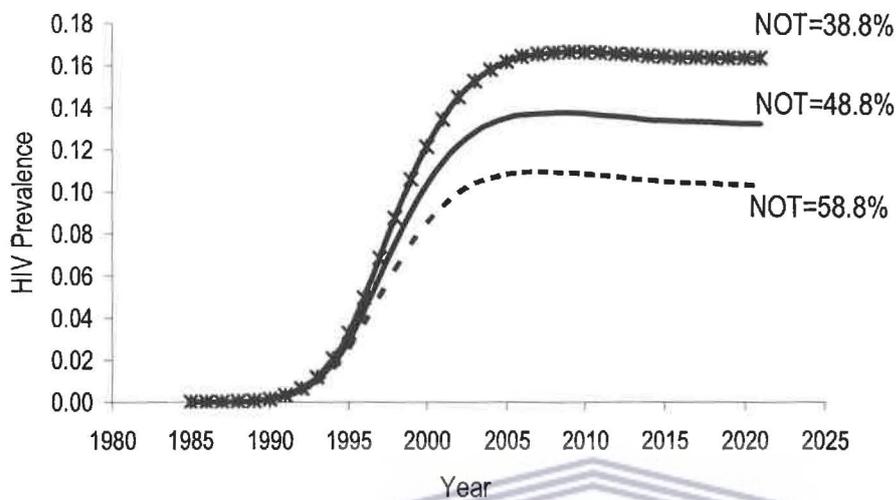
- i. 38.8%: taken as the high impact of HIV/AIDS
- ii. 48.8%: taken as the medium impact and the most likely impact as set by the ASSA AIDS Committee
- iii. 58.8%: considered as the low impact of HIV/AIDS

The effect of varying the NOT group was to determine a change in one of the key HIV/AIDS assumptions; however the calibration estimates used by the ASSA2002 model would be affected in the analysis. Nevertheless since population projections are based on assumptions made, it is important for an analysis which presents projections under varying possible assumptions.

The number of projected primary school dropouts was estimated from the orphan totals provided with the NOT group at 48.8% (the most likely). For the high impact of HIV/AIDS (NOT=38.8%), a 30% drop out rate of the total annual orphans was used. Whilst for the low impact of HIV/AIDS (NOT =58.8%), an orphan drop out of 20% of the total annual orphans was used.

The total population HIV prevalence plateaus at a higher prevalence of 16.63% in 2010 when the proportion of the NOT group is set at 38.8%. On the other hand when the NOT group is increased to 58.8%, HIV prevalence plateaus at 10.94% in 2007. With the NOT group set at 48.8% (as assumed by the ASSA AIDS Committee), HIV prevalence peaks at 13.73% in 2008.

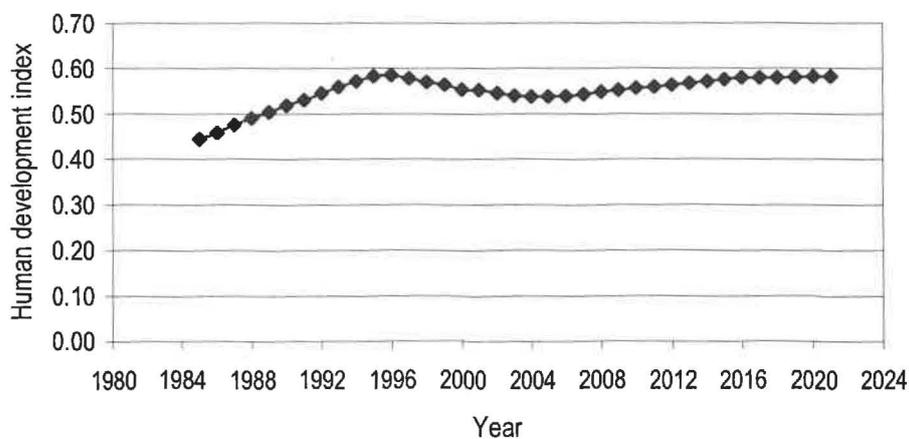
Total population prevalence from varying the percentage of the NOT group



Source: ASSA2002

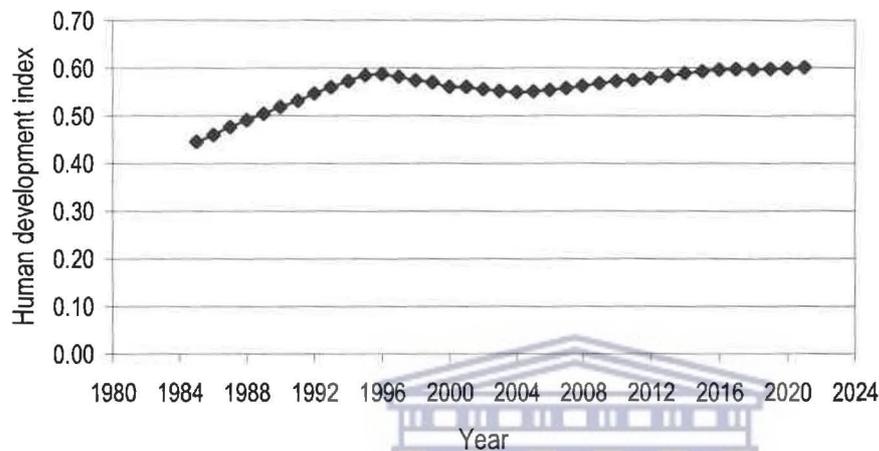
High, medium and low projections of the human development index are provided for the different assumptions of the NOT group. The NOT group percentage variations were titled either high, medium and low based on the relative impact of the assumptions.

High impact of HIV/AIDS (NOT = 38.8%)



A high impact of HIV/AIDS will reduce the HDI to a minimum value of 0.538 in 2004 compared to an estimated minimum of 0.549 for a medium impact and 0.562 for a low impact of HIV/AIDS.

Medium impact of HIV/AIDS [The most likely] (NOT = 48.8%)



From 1996 to 2004, the period in which the human development index is estimated to decline as a result of the impact of HIV/AIDS, the high impact is estimated to result in a 8.92% reduction in the HDI; the medium impact is estimated to result in a 6.90% reduction in the HDI and the low impact of HIV/AIDS is estimated a relatively lower 4.80% reduction in the HDI.

Projected high, medium and low human development index values

YEAR	HIGH IMPACT (NOT=38.8%)	MEDIUM IMPACT (NOT=48.8%)	LOW IMPACT (NOT=58.8%)
1985	0.446	0.446	0.446
1986	0.459	0.459	0.459
1987	0.476	0.476	0.476
1988	0.491	0.491	0.491
1989	0.504	0.504	0.504
1990	0.518	0.518	0.518
1991	0.532	0.532	0.532
1992	0.546	0.546	0.546
1993	0.560	0.560	0.561
1994	0.572	0.572	0.573
1995	0.583	0.584	0.585
1996	0.585	0.587	0.589
1997	0.579	0.581	0.584
1998	0.571	0.574	0.578
1999	0.565	0.570	0.575
2000	0.555	0.561	0.568
2001	0.553	0.561	0.569
2002	0.546	0.556	0.566
2003	0.541	0.551	0.563
2004	0.538	0.549	0.562
2005	0.538	0.550	0.564
2006	0.540	0.553	0.567
2007	0.544	0.557	0.572
2008	0.549	0.563	0.578
2009	0.554	0.568	0.584
2010	0.557	0.572	0.588
2011	0.560	0.575	0.592
2012	0.564	0.579	0.596
2013	0.568	0.584	0.601
2014	0.572	0.588	0.605
2015	0.576	0.593	0.610
2016	0.580	0.597	0.614

2017	0.580	0.597	0.615
2018	0.581	0.598	0.616
2019	0.582	0.599	0.617
2020	0.582	0.600	0.619
2021	0.583	0.601	0.620



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**Appendix II: Formulas used in computing HDI values from 1985 to 2021.**

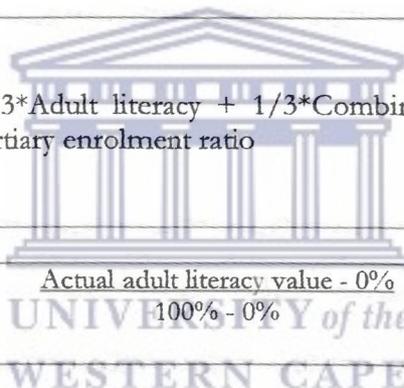
$$\text{Longevity} = \frac{\text{Actual life expectancy at birth value} - 25 \text{ years}}{85 \text{ years} - 25 \text{ years}}$$

$$\text{Standard of living} = \frac{\text{Actual GDP per capita (PPPS)} - \text{US\$100}}{\text{US\$40 000} - \text{US\$100}}$$

$$\text{Educational attainment} = \frac{2/3 * \text{Adult literacy} + 1/3 * \text{Combined gross primary, secondary and tertiary enrolment ratio}}{100\% - 0\%}$$

$$\text{Adult Literacy} = \frac{\text{Actual adult literacy value} - 0\%}{100\% - 0\%}$$

$$\text{Combined gross enrolment ratio} = \frac{\text{Actual combined gross enrolment (\%)} - 0\%}{100\% - 0\%}$$





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