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The Impact of HIV/AIDS on Current and Future Population Characteristics and Demographics in Botswana

Study Two of the Investigation of the Socio-Economic Impact of HIV/AIDS In Botswana

FINAL REPORT
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EXECUTIVE SUMMARY

Botswana has one of the most severe HIV/AIDS epidemics in sub-Saharan Africa and the world. Women at 10 of the 14 Antenatal Survey sentinel sites had HIV infection levels of over 30% in the last two years, and all have levels over 20%. The epidemic has been hidden due to the long incubation period from HIV infection to onset of AIDS, and stigma that discourages disclosure of HIV/AIDS. However, it is clear that the epidemic is so severe that it will lead to dramatic changes in the population size and profile. Previous projections of demographic impacts in Botswana have used problematic assumptions around important micro-parameters and the shape of the epidemic curve for the country.

Objectives
The overall objective of this study is to provide Botswana with the best available projections of the demographic impact of HIV/AIDS on its population to 2010.

Methodology
A review of current HIV/AIDS data confirmed that antenatal survey provides the best available data to calibrate projections of the epidemic, and is likely to provide relatively good indications of levels and trends in infection rates despite a number of significant limitations. Other data of some usefulness includes reporting of AIDS cases to the AIDS/STD Unit, and data on behaviour and exposure to risk situations among Batswana. Demographic data in Botswana is relatively comprehensive and good quality. The 1991 Census is the main data source for making demographic projections. Family Health and Demographic and Health Surveys provide further estimates of fertility and mortality. Certain key parameters, particularly around adult mortality, are somewhat uncertain.

Available models for projecting HIV/AIDS demographic impacts were reviewed. The study Technical Group requested that the consultants use the Spectrum Model to make final projections for Botswana. The Doyle Model was used to produce the HIV prevalence curve needed to calibrate Spectrum, and for other comparison projections.

Scenario Assumptions
Two main Spectrum HIV/AIDS scenarios (S1 and S2) were generated as a "best estimate" and "best case" scenario. A "No-AIDS" scenario (S0) provides a reference point. Key common assumptions and methods used in scenarios included the following. 1) A common antenatal seroprevalence epidemic curve for all Districts, with District epidemics differing only in their timing. 2) Calibration of projections against male and female age profiles of antenatal and reported AIDS case data. 3) Median adult survival times of 8.5 years from infection to AIDS, and one year after developing AIDS. Median child survival was assumed to be just under 2 years. 4) An average reduction of fertility of 34% among HIV-infected women. 5) Mother-to-child transmission rates of 30%.

All scenarios add up projections for individual administrative districts to produce national figures. S2 assumes that rural populations have HIV infection levels consistently 20% below urban levels. Other scenarios (S3-10) show effects of interventions and sensitivity to changed assumptions. No projections incorporate migration trends.

Findings
In 1999 an estimated 15-17% of the total Botswana population were HIV-infected. Prevalence will potentially rise to 18-21.5% by 2005. Projected rates for adults aged 15-59 were much higher at 28-30% (240 000 adults), and could rise to 36% by 2005.

- *Prevention programmes, particularly among youth, will continue to be critically important in Botswana.* Rates of new infection are projected to stay above 2% of the population per year until 2010 without effective prevention. Even fairly modest prevention targets could reduce adult prevalence by 5% or 40 000 people in 2010.
- *The epidemic of AIDS cases and AIDS deaths is still at a relatively early stage.* The 18 000-19 000 AIDS cases projected for 1999, will increase to 39 000-41 500 in 2005. An estimated 1.6-1.9% of adults in Botswana had AIDS in 1999. This will rise to 4.5- 5% by 2010. Between 1.2 and 1.3% of adults were projected to die of AIDS in 1999, increasing to 3-3.5% of adults per year by 2010.
    - A total of 327 000-350 000 Batswana are expected to have died of AIDS between 1991 and 2010, equivalent to 20-25% of the current population
    - Preventing new adult HIV infections will have limited effect on AIDS cases and deaths before 2010, but longer-term benefits will be large. Programmes to reduce mother-to-child transmission could lower total AIDS deaths by about 6 % in 2010.
    - Most deaths are expected to cluster in the 25-40 year age group. Men will be affected at slightly older ages than women.
- *Botswana total population growth is declining rapidly due to HIV/AIDS.* Only in the best case (S2) will growth remain positive (at 0.2%) by 2010. By 2010 the total population is projected to be between 1,53 million (S1) and 1.72 million (S2)
- *HIV/AIDS will profoundly alter the population age profile.* The greatest reduction in numbers compared to a no-AIDS scenario by 2010 will be among adults aged 35-45 (a 40%- 50% reduction) and children aged 0-9 years (32-40% lower).
- *Under-5 and infant mortality will both increase.* Under-5 mortality is expected to be 67-98/1000 higher than in a no-ADS scenario by 2005. The IMR will be 20-25/1000 higher than in a no-AIDS scenario in 2000, rising to a 24-33/1000 increase by 2005..
- *Life expectancy is falling dramatically.* It is projected to be only around half (46-52%) of no-AIDS scenario levels in 2010.
- *Numbers of AIDS orphans will rise rapidly* from an estimated 36 000- 57 000 in 2000, 159 000- 214 000 in 2010.
- *Dependency ratios are expected to decrease slightly* as numbers of new births will be impacted more than the size of the population aged 15-64.

Interpretation of projections

The projections given in this report are likely to give the best available indication of the scale and types of HIV/AIDS demographic impacts. However, no model can represent or predict reality perfectly. Projections are also very dependent on the quality of demographic and epidemiological data used for inputs and calibration. In using the projections the following general issues should be considered.

- All assumptions and methods used should be noted and critically reviewed regularly.
- Projections do not accommodate all potential non-AIDS factors, such as migration, that could change the demography of Botswana or districts.
- Aggregated, national projections are probably more reliable than district projections.
- Projections further into the future have more potential for error, but AIDS cases and deaths to 2010 are determined mainly by existing infections and will be fairly reliable.
- No scenarios except D3, S3 and D4 assume effective interventions. A vaccine or very effective new HIV/AIDS treatments are unlikely to be widely available before 2010.
- Many local communities will be hit much worse or less than indicated by projections.
- Projections indicate <u>susceptibility</u> to impacts and may not adequately reflect <u>vulnerability</u> of many districts, communities or groups to effects of death and illness.

Several specific issues should also be considered in interpreting the projections.

- *General adult infection levels may be considered to be optimistic.* Overall rates for people aged 15-49 average around 90% of antenatal estimates.
- *Uncertainty exists about the appropriate values for several parameters in Botswana.* These include: median survival times from HIV infection to death; fertility reductions among HIV infected women; rates of mother-to-child HIV transmission; realistic estimates of prevention programme effects; and the age distribution of infection.
- *The S2 "best case scenario" may be too optimistic.* Even if rural communities currently have lower levels of infection, they may reach high levels after a time lag.
- *The Doyle model tends to project less severe impacts than Spectrum.* Precise reasons for this are difficult to identify. In most areas however, the two models project very similar AIDS-related trends and magnitudes, and Doyle projections often reach similar values to Spectrum within 1-3 years. Many policy and planning decisions are likely to be fairly insensitive to which model is used.

The 1996 FHS and 1998 DHS preliminary results do not show clear evidence of HIV/AIDS impacts on mortality, despite projected impacts that would be expected to be discernible. However, data from Health Statistics and Vital Registration pilots, while problematic, strongly suggest rising mortality. There is also widespread anecdotal evidence of rising death rates among young adult Batswana, and increasing evidence to support results of similar modeling in other countries. Sensitivities of projections to changes in several parameters are illustrated and result in relatively limited changes in magnitudes of impacts, which are unlikely to fully explain differences in survey and projection results. Declining underlying trends in mortality or inaccurate timing of epidemic curves in projections may be part of the explanation. Further scrutiny of DHS data and methodology may also reveal reasons for the apparent discrepancies.

Conclusions

Botswana antenatal survey data clearly indicates that the country faces HIV/AIDS demographic impacts of massive proportions. Projections are subject to many limitations but are likely to give a good indication of the size of various HIV/AIDS impacts. There should be no complacency about absence of clear HIV/AIDS impacts in the preliminary 1998 DHS results and 1996 BFHS. In so far as experience truly differs from projections so far, it is safest to assume that projections have inaccurately predicted the *timing* rather than the *scale* of impacts.

Adequate information on the HIV/AIDS epidemic and its impacts must be ensured to inform planning. This will require devotion of greater resources and effort to both demographic and HIV/AIDS data collection. Several specific recommendations to improve data collection and modeling are made.

In the interim, planning and action must commence to respond effectively to new and changing needs. All government sectors are likely to face substantial changes in the scale and types of needs to be met. HIV/AIDS impacts on employees will also reduce their capacity to promote development and meet specific HIV/AIDS-related need. Planning and implementation of responses cannot wait for "perfect" data or empirical confirmation of projections. Planners should be aware of the assumptions used in projections that they use in planning. They should incorporate risk analyses in to planning to identify whether low or higher impact projections will provide the lowest risk basis for specific plans.

1   INTRODUCTION

Botswana is experiencing one of the most severe HIV/AIDS epidemics in sub-Saharan Africa, the region which has the world's worst HIV/AIDS epidemic. The epidemic began to spread in Botswana during the 1980s. In the 1990s, HIV prevalence has risen dramatically. Since the first survey of HIV prevalence among pregnant women attending antenatal clinics was conducted in 1992, prevalence has climbed from 23.7% to 42.9% in Francistown and 14.9% to 39.1% in Gaborone. Other sentinel sites have also shown dramatic increases. Ten of the 14 sentinel sites have had a prevalence of over 30% in the last two years' surveys, and all sites have a prevalence of over 20%.

Due to the long incubation period between HIV infection and onset of AIDS, the impact of AIDS among Batswana has only become more visible since the mid-1990s, and is still obscured by stigma and barriers to disclosure of HIV/AIDS status. The full impact of AIDS deaths and other impacts will only be felt around or after the end of the coming decade. However, it is clear that an HIV epidemic as severe as experienced in Botswana will lead to dramatic changes in population size and profile.

The overall objective of this study is to provide Botswana with the best available projections of the demographic impact of HIV/AIDS on its population. Specific objectives included the following:

- Review current data on HIV prevalence, AIDS cases and AIDS related mortality
- Review key demographic variables and trends
- Review current assumptions used for HIV/AIDS projections in Botswana
- Recommend the most appropriate projection models for use in Botswana
- Demonstrate the magnitude of impacts using various models
- Identify the best available projections of current and future demographic impacts
- Identify potential behavioural changes which may alter the course of the epidemic and demographic projections

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2   CURRENT DATA ON HIV PREVALENCE, AIDS CASES AND MORTALITY

2.1   HIV seroprevalence and AIDS data

The main objectives of the HIV surveillance systems are to look at geographic spread of HIV, monitor trends over time, provide some indication of levels of infection in communities, and mobilise political support and plan for HIV/AIDS impacts. Several types of HIV/AIDS surveillance have been practiced in Botswana to date.

2.1.1   National HIV Sentinel Surveillance Survey

The National HIV Sentinel Surveillance Survey has been conducted annually since 1992 among pregnant women attending public sector antenatal clinic services. The survey provides the best available calibration data for projection modeling. The survey has in most respects been conducted in accordance with WHO guidelines. Sample sizes have generally been considered to be adequate, and laboratory HIV testing standards have been found to be good.

Antenatal survey trends and key features

Table 1: Antenatal Surveillance - seroprevalence by site 1992-8

Site	1992	1993	1994	1995	1996	1997	1998
Francistown	23.7	34.2	29.7	39.6	43.1	42.9	42.96
Gaborone	14.9	19.2	27.8	28.7	31.4	34	39.08
Serowe/Palapye		19.9		29.9		34.4	
Maun	12.7		19.4		33.1		33.53
Selibe Phikwe			27		33.1		49.89
Chobe		18.3		37.9		38.8	
Lobatse		17.8		37.9		33.7	
Southern			16		21.8		24.67
Kweneng		13.7		18.9			37.2
Tutume			23.1		30		37.45
Ghanzi		9.5		18.9			22.3

Antenatal data suggests several important trends in the Botswana epidemic.

- Prevalence levels have been above 33% in 9 of 11 sites included in the 1997 and 1998 surveys (Table 1). The other two sites are over 22%. These prevalences are as high or worse than those found in most regions of the worst affected countries in the world such as Malawi, Zimbabwe and Zambia. They are substantially higher than many other countries with more advanced epidemics such as Uganda, Tanzania and Kenya, where prevalence reached a plateau at lower levels.
- Only in Francistown, the leading site, has the epidemic shown repeated evidence of reaching a plateau.
- There is some indication that prevalence rates may be levelling off among the youngest age group in Francistown. This is often the first sign of success in reducing risk behaviour. However, sample size for youth tends to be small, which limits ability to identify such trends.

The epidemic prevalence curves generated in each survey site to date have a very similar pattern once allowance is made for time lags between the start of the epidemic in different areas. This suggests that epidemics as severe as those in the leading sites should be anticipated in all areas unless behaviour changes substantially (see *Section 6).*

However, several uncertainties about the information provided by the Survey should be noted.[1]

1) *The Survey may not be fully representative of all pregnant women in Botswana.* Several possible sources of bias exist, although their significance is not known.

•   Several clinics are included per site, rather than a single clinic, as conventionally used in the WHO methodology. This is necessitated by Botswana's small population.
•   Biases may be introduced because the survey does not cover private sector antenatal service users (some, mainly urban, women) or other pregnant women who do not attend public sector antenatal clinics. Different data sources give differing estimates of levels of coverage.
•   Certain sites are not covered every year. This makes it more difficult to identify trends and patterns in epidemics in different communities at sub-national level.
•   Data to rigorously track possible differences in HIV infection levels and trends between pregnant women in urban and rural communities is not available. Botswana appears to have rural prevalence that is unusually high relative to urban areas, when compared to some other countries.[2] Good communications infrastructure and highly mobile populations with oscillatory migratory patterns may explain this. Nevertheless, some difference is apparent and rural prevalence in North, South and Central Botswana have been estimated at an average of 83% of the urban prevalence in those areas.[1] [3] However, there is still lack of clarity on the issue:
    •   Lower rural rates could reflect lower risk behaviour in rural populations and thus lower level epidemics in the long term. However, they may also simply reflect delayed development of epidemics in rural areas, a hypothesis made more plausible by the similar overall shapes of curves in all sites (see Section 6.1.3), or a combination of these factors. Only 1998 Survey raw data has been made available for analysis, giving no indication of trends
    •   Definitions of urban and rural areas used in the Census and the Surveillance Survey differ. Neither consider proximity to transport routes, which may be a stronger determinant of risk than urban-rural classification in itself.

2) *Women in the general community may not be represented by Antenatal attenders.* There are multiple, conflicting influences on this relationship. Their relative significance is unclear.

•   Overestimation of community rates could occur if some lower risk behaviours (e.g. increased condom use, fewer partners)[a] are associated with lower pregnancy rates. This may be the case among teenagers, where Antenatal data may capture those with higher general rates of risk behaviour. Lower fertility among women in age

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[a] Family Health Surveys indicate that contraceptive rates for all methods rose from 24% in 1984 to 41.7% in 1996. In 1996, 11.3% of women reported using condoms compared to 1.4% in 1988, and 1% in 1984.

groups with lower prevalence (e.g. older women) would also lead to underestimation of community rates unless data is age standardised.

- Underestimation of community rates would occur if HIV infected women have lowered fertility. This has been suggested by several studies.[4] Lower fertility may be due to HIV infection itself and its complications, high STD prevalence and associated infertility, or high use of contraceptives other than condoms, as occurs in Botswana.

  Most recent studies suggest that Antenatal surveys tend to underestimate community prevalence.[5] The net effect of the various factors in Botswana is not clear, but it seems likely that Antenatal data could, if anything, underestimate community female prevalence.

  Antenatal Survey data may also have limitations in tracking population trends if various biases change over time (e.g. the impact of HIV on fertility increases with increasing average duration of infection).

For demographic projection and planning purposes specifically, the following extra limitations need to be noted:

- The sampling approach used in the Survey is designed mainly to track *trends* in HIV prevalence in populations served by the sentinel sites, rather than to provide accurate estimates of *levels* on HIV prevalence in the Botswana population overall.
- The survey sites do not correspond ideally with Districts used for planning purposes, and for which Census data and population projections are usually reported. This limits ability to project HIV/AIDS impacts at these sub-national levels, which are sensitive to the local HIV prevalence.
- HIV prevalence data is not linked to variables such as education and employment status. More detailed analysis of data including health facility data, age and marital status is not performed routinely, even where sample sizes may allow for this. This may limit ability to identify current or emerging trends in sub-groups which may influence projections of impacts. It may also limit ability to target preventive interventions more effectively, evaluate interventions and identify likely social and economic consequences of HIV/AIDS.

Recommendations

Strong consideration should be given to the following.
- Community based surveys to assess the relationship between Antenatal prevalence and community prevalence, and possible changes over time in this relationship. Surveys could also assess impacts on fertility in HIV infected women, which has a major influence on demographic projections.
- Having a sampling system (Probability Proportional to Size) to obtain improved estimates of trends and absolute levels of infection nationwide.
- More frequent surveys in all sites that are currently not surveyed annually, to provide clearer information on levels and trends in infection, including whether epidemic curves in different areas differ substantially.
- Strengthening capacity to analyse Antenatal and other HIV data to allow for more detailed analysis, including trends in, for example, infection levels in rural and urban populations, and other sub-groups.
- Including other select data in survey data collection e.g. level of education.

Consideration should also be given to strategies to validate apparent declines in HIV infection rates once these begin to occur. In mature epidemics, AIDS deaths can result in declining prevalence while incidence rates are persistently high, even in young adults.[6]

- Sequential cross-sectional surveys of STD prevalence to monitor effectiveness of STD and HIV prevention strategies, may also be somewhat easier than studies of HIV prevalence or incidence.

2.1.2 Other HIV prevalence data

HIV prevalence among STD patients

Male sexually transmitted disease (STD) patients have been a sentinel population since 1992 and have documented very high levels of HIV prevalence among this group. Data from this source is of very limited value to guide assessment of HIV/AIDS impacts in the broader community. STD patients are not clearly representative of particular communities. The profile of clinic attenders may also change over time, making trends difficult to interpret.

TB patients

Some surveys of HIV prevalence among male and female TB patients have been conducted in Botswana. These can provide useful information to tackle the TB epidemic and understand its relationship with HIV/AIDS. However these surveys give little information that can be extrapolated from the patients surveyed to more general populations, and thus are not likely to be helpful to calibrate demographic projections.

Blood donation screening

Blood donations in Botswana are screened for HIV to ensure safety of blood supplies. Data from this source is however of very limited use in surveillance. Blood donors are not clearly representative of the broader community or particular sub-groups, and levels of infection are not reliably similar to the general population.[7] Biases are introduced by factors that include efforts to reduce donations by people at high HIV risk, and self-selection among donors, including using donation as a means of testing, which has been reported anecdotally in several instances in Botswana and South Africa. These biases may also change over time, so that not only levels of infection, but also trends, are difficult to extrapolate to broader populations.

2.1.3 AIDS data

Information on AIDS and AIDS deaths is less important than information on HIV infection rates to monitor the epidemic and impact of interventions. However, the data is potentially useful for advocacy purposes, and to validate various assumptions made in projecting impacts of the epidemic.

Data on AIDS cases, HIV cases/carriers and AIDS deaths are potentially available from three main sources:

- Data collected by the AIDS/STD Unit, linked to laboratory requests for testing for HIV.
- Reports from hospitals, primary care services and on deaths outside of institutions, which are reported in the Health Statistics documents.
- Vital Events data, produced annually by the Civil Registration system.

All of these sources of data suffer from shortcomings. The most important is under-reporting. A significant number of AIDS cases and deaths may not come to the attention of health facilities or be reported. In 1996 3028 deaths were reported by Civil Registration compared to 1480 in Health Statistics. Furthermore, only cases with confirmed laboratory test diagnoses are reported. ASU estimates that around half of people with clinical indications for HIV testing refuse to be tested, a proportion supported by responses of hospitals surveyed as part of the health sector impact study. Patients at facilities staffed by nurses only, who cannot draw blood, and at private facilities, are also under-represented.

Figure 1: AIDS cases reported to the ASU[b]
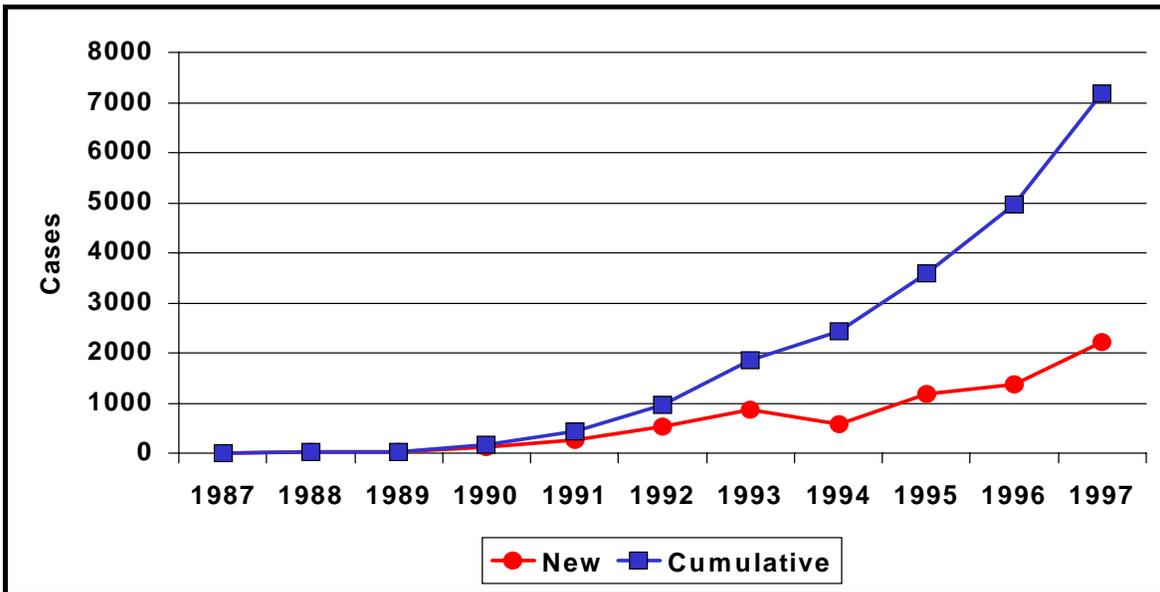
In addition, the reported cases may not be a representative sample of people in the population with AIDS/HIV. This means that the data may not give an accurate reflection of e.g. age and gender profiles of AIDS cases. Specific biases may include:

- Double counting, recognised as a problem by the AIDS/STD Unit.
- Possible, but untested, differences in health care seeking and test acceptance behaviour between different groups (e.g. age, sex, occupation). Anecdotal reports by some health service staff suggested, for example, that women tend to present earlier in the course of HIV disease than men and often leave hospitals without HIV testing, with a greater tendency to remain at home in the terminal stages of their illness. Many men on the other hand, were reported to often have very limited family ties and support systems. This meant that they tended to stay longer in hospital with late stage illness, at which time they were more likely to agree to HIV testing.

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[b] Source: AIDS update April 1998, HIV/STD Unit, Ministry of Health

▪ Studies and anecdotal evidence from elsewhere indicates that people with late stage disease may increasingly not present at health facilities. This may be because of factors such as increased crowding in facilities, emerging alternative care strategies or lower optimism about benefits of medical care among people with AIDS.[8]

2.1.4   Other mortality data

Other sources of mortality data, without a diagnostic link, include the Census, and the Family Health Surveys   (conducted 8-10 yearly), and the Demographic and Health Surveys (10 yearly) which are conducted between Census'. These may be able to pick up trends in mortality that can be ascribed to AIDS in inter-censal periods. A recent review of mortality trends in sub-Saharan African countries' household surveys and census' has found that these can be used effectively to monitor HIV mortality impacts. [9] However, difficulties in interpreting trends, or lack of expected trends, in infant and childhood mortality have been noted in other countries even with very advanced and severe epidemics, where other trends appear to mask the influence of HIV. [c] [10]

- The 1991 Census was too early in the course of the epidemic to be expected to identify any HIV related trends. In addition, the Census questions in relation to adult mortality were somewhat ambiguous in definition of the household, leading to difficulty in interpreting adult mortality data.

- The 1996 FHS preliminary analyses do not show an obvious impact on infant or child mortality: infant mortality declined from 39.5/1000 (1978-1988) to 39/1000 (1986-1996). Childhood mortality rates declined from 17/1000 (1978-1988) to 10/1000 (1986-1996).

- Analyses of the 1998 DHS is not yet complete. Preliminary analyses report no clear increase in adult, infant and child mortality.

Use of existing Civil Registration data is limited by incomplete coverage of the country (in certain areas registration has not been compulsory), under-reporting at the time that events occur, and delays in submission of data in certain areas. Significant biases in the Registration data of relevance to HIV/AIDS projections cannot be excluded. Four districts have participated in a pilot project to increase coverage and reliability of vital statistics registration. These show strong evidence of rising mortality in the two larger pilots but it is not completely clear what biases may influence this data.

The forthcoming Census should provide key data sufficiently far into the AIDS epidemic to provide good indications of mortality levels and trends.

Recommendations

Mortality data that is not linked to HIV/AIDS specifically will be a cornerstone of monitoring HIV/AIDS impacts and validating projections as the epidemic progresses. Fertility trends, which are measured in many of the same surveys or mechanisms, will also be important to monitor as many determinants of fertility cannot be predicted easily in a population heavily affected by HIV/AIDS.
- Adequately frequent, timeous and reliable mortality data for adults and children must be available. Capacity should be assured so that surveys can be performed rigorously and analysed quickly.

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[c] See **Section 9** for further discussion.

- Vital Registration pilots can provide useful information. Potential biases of data from the pilots, in the absence of a more general, improved system of reporting which helps to clarify denominator populations in particular, may however make it difficult to interpret their data.

- Given the importance of the issue for planning, there may be justification for increasing the frequency of large surveys such as the FHS or DHS. Alternatively, more specific surveys or sentinel sites may be required to provide more detailed and frequent information in interim years to identify and track trends. This is particularly important to consider as the AIDS epidemic is now in a rapid growth phase when AIDS deaths will become much more discernable in standard surveys and surveillance systems.

- All methods should be scrutinised to avoid possible biases introduced by the nature and scale of the HIV/AIDS epidemic. For example, some methods may not pick up data relating to households that dissolve due to death of adults. This factor is likely to become increasingly prominent as adult deaths will occur on a much larger scale than before, and AIDS deaths will tend to cluster among adults in the same household.

2.2 HIV/AIDS related behaviour and risk factors for the Botswana population

For calibration of certain HIV/AIDS demographic models, and to inform estimates of future progress of the epidemic, two broad sets of information are relevant.

2.2.1 Socio-economic and other factors affecting population risk of HIV infection

The Botswana population has several underlying features that suggest particularly high risk of a severe epidemic:
- High levels of mobility and good infrastructure.
- A tradition of high levels of movement of the population, particularly men, between their different homes in urban areas, villages, lands where crops are planted and cattle posts.
- High levels of STDs other than HIV[11].
- High levels of unemployment, particularly among youth[12].
- Poverty and inequality[13].
- Low status and poverty of women, which makes it more difficult for them to protect themselves from infection.[14]
- Low rates of marriage, which may predispose to less stable sexual partnerships.[15]
- Reportedly high rates of alcohol abuse, which can make people less careful or able to avoid high risk sexual behaviour, and may occur in social environments with more access to high risk sex.

These factors are likely to predispose Batswana to the high rates of casual sex and partner change reported among them (see below).

2.2.2 Information on risk behaviour and trends

Several Knowledge, Attitude and Practice (KAP) studies have examined risk behaviour among young Batswana.[16] Some changes in risk related knowledge, attitudes and behaviour/practice among young Batswana do seem to be occurring.

The degree to which reported attitudes and practices reflect consistent behaviour or behaviour change is unclear. Sampling differences and other methodological issues limit ability to compare studies conducted in different years. However, there is evidence of improved knowledge, attitudes and practice which may lead to reduced infection rates and affect the course of the epidemic.

- In 1996, around 80% of a sample of rural and urban youth knew of at least two valid ways to protect themselves from HIV infection. This level of information is higher than found in women and men in the 15-59 and 30-34 year age groups in Malawi in 1996, when there was little evidence of decline in youth HIV incidence.[17]

- The percentage of sampled sexually active people who had casual partners was 75% in the 1994 samples and 50% in 1996.

- Condoms have become more acceptable as a form of protection against HIV/AIDS. Condom use in casual relationships during the last sexual encounter reportedly was around thirty percent in 1992 and 85% in 1996. Condom use in regular relationships was over 50% in 1996. However, condom use in regular and casual relationships still seems to be inconsistent. The 1996 FHS also suggests significant increases in condom use, and that it accounts for over 50% of reported contraceptive use in 15-19 year olds.

3   KEY DEMOGRAPHIC VARIABLES AND TRENDS

Botswana has shown marked changes in demographic variables and trends in previous decades. For population projections, the 1991 Census will remain the main data source for the foreseeable future. Botswana Census data is generally considered to be reliable, and the "gold standard" for demographic use. Census data provides information broken down for populations of districts, the major urban areas, urban villages and rural communities.

No substantial deviations from previous fertility and mortality trends have been reported by CSO staff in preparation of BFHS III preliminary results. As a sampling approach is used in the BFHS and the focus of the survey is somewhat different, there are inherent limitations on the ability of such surveys to provide a reliable substitute for Census information on all key demographic parameters, although the data derived from them is still informative.

Several key, recent demographic features of Botswana are critical to projecting HIV/AIDS impacts. (Further details of demographic parameters are provided in sections on methodologies used in projecting HIV/AIDS impacts below).

3.1.1 Fertility

Fertility in Botswana has shown marked declines over recent decades. Total fertility rates in both Census and each BFHS have shown persistent reductions since the early 1980s, from over 7 in 1980 to an estimated 4.2 in preliminary 1996 BFHS results *(Table 2).* Fertility has persistently been highest in women aged 20-24 and 25-29 years.

Table 2: Total fertility rates among women

a) Census

	1981	1991
TFR	7.1	4.23

b) Botswana Family Health Surveys

	1984	1988	1996
TFR	6.5	5	4.2

c) Adegboyega 1998

	1981	1991
TFR	7.07	4.73

3.1.2 Mortality

Botswana has experienced a substantial decline in childhood mortality rates in recent decades, although trends over the 1990s await further information from final BFHS and DHS results. Data on adult mortality is considered to be less reliable than for children. The relevant questions in the 1991 Census are thought to have led to double counting of adult deaths. Current best estimates of mortality profiles are thought to be those

produced by E. Udjo in *Population and Housing Census Analytic Report CSO 1998,* but require confirmation in further surveys. Various published estimates of key mortality indicators are given in *Table 3.*

Table 3: Published mortality estimates for Botswana

	1981 *	1988**	1991***	1991 *	1996**	1996*
IMR	85.9m; 65.1f	39.5	38 (51m; 27f)	48	39	42
CMR		17	53 m; 27f		10	
Under-5 MR		52.7			49	
Life expectancy			57 m; 65 f	63m; 67f	69.9	64.8m; 68.4f
CDR			11.5 (13.4m; 9.5f)	7.7		6.6

Sources: * Population Projections (1997); ** Family Health Surveys (1988; 1996 provis); ***Udjo (1998)

3.1.3 Migration

International migration is not expected to be a major influence on demographic profile or the effects of the HIV/AIDS epidemic in Botswana going forward. Only 2.2% of the population were non-citizens in 1991. This proportion is expected to decline under current projections. Declining migration of Batswana to South African mines is expected to be offset by increased migration of citizens due to socio-political changes in the region.

Urban population growth is not expected to be as fast as in the 1980s, when it averaged 13% per annum, largely due to reclassification of many large villages as urban areas. 1991 Census data suggests that urban-urban migration has tended to be the main type of migration (34.4%), followed by rural-urban (25.5%) and urban rural (20.9%).

4 PREVIOUS HIV/AIDS IMPACT MODELING IN BOTSWANA

4.1 Annual estimates of numbers of HIV infected people

Previous Sentinel Survey reports have estimated the number of infected adults and children in Botswana in the given year, based on estimates for Gaborone, Francistown, other urban and rural areas. Several important assumptions are used in these estimates.

1. *Antenatal prevalence equals prevalence in the adult female population aged 15-49*. This assumption is defensible in the absence of population survey data, although age standardisation may have improved estimates, all else being equal.
2. *Male:female prevalence ratio.* This is assumed to be 0.83:1, which seems reasonable in the absence of a population based survey to validate the figure. Population-based studies provide limited and divergent information on expected male:female ratios, for example, 0.97:1 (95%C.I. 0.70:1; 1.35:1) in Ethiopia , and 0.68:1 (95% C.I. 0.59:1; 0.73:1) for urban and 0.89:1 (0.87:1; 0.90:1) for rural areas in Zambia.[18] A recent UNAIDS review of 15 community seroprevalence studies in Africa suggests that on average the ratio of infected men to women in Africa is in the region of between 0.77:1 and 0.83:1.[19] The ratio differs with age, and age standardisation is required for rigorous comparisons. In addition, the ratio tends to change according to the stage of the epidemic. Typically differences are greater between men and women in younger age groups, and prevalence in older age groups (>30 years) becomes more similar for men and women, or may become higher in men.
3. *Rural prevalence.* This has generally been estimated at around 50% of urban areas, an assumption which appears likely to significantly underestimate rural prevalence (see above).
4. *Assumptions of prevalence over the age of 50.* This is assumed to be 1%, a figure with no substantial justification and possibly an underestimate (projections suggest 1.8% in 1999). However, this is unlikely to have biased estimates to a large extent, in view of the low prevalence and relatively small proportion of the adult population aged over 50.
5. *Infections in children aged 0*-4. These are reportedly estimated as 15% of adult infections, based on the assumption that for every six infected adults (3 partnerships) there would be one infected child. This figure is clearly problematic and the estimated 37000 infected children in 1998, is high relative to other estimates based on current knowledge of mother-to-child transmission and mortality rates.

Three models have previously been used for HIV/AIDS projections in Botswana. The major features and limitations of these models are reported in Annexure 1.

4.2 Projections using EpiModel

EpiModel has been used for the population projections made for Botswana in 1997, and by the AIDS/STD Unit to produce projections included in various reports on the HIV/AIDS epidemic in Botswana. The model has been used extensively by UNAIDS in projections for Botswana and other countries.

Previous population projections in 1997 incorporated several important assumptions.
- The epidemic is assumed to have begun in 1983.

- The estimate of median survival time to AIDS is 10 years, with 100% mortality 2 years after development of AIDS.
- The peak incidence of HIV is assumed to occur one year from the reference year.
- The vertical transmission rate is 33%
- Antenatal prevalence is representative of the general population in sexually active age groups
- Rural HIV prevalence is 50-100% of that in urban areas for high and low estimates.
- The ratio of infected women to men is 1:0.83

Three HIV/AIDS epidemic scenarios were projected in the 1997 Population Projections:
- The Low Variant assumed a gradual decline in prevalence of 2% per annum from an estimated adult prevalence in 1991 of 10.49%.[d]
- A Medium Variant assuming a constant 10.49% adult prevalence for the duration
- A High Variant assuming a 5.2% annual increase in prevalence until a plateau at prevalence of 50% in the 15-49 year age group.

In general, previous projections using Epimodel have been made with assumptions which HSU and CSO staff involved in modeling feel are too arbitrary, particularly in relation to the position of any calibration point on the epidemic curve and the shape of the curve. The Low and Medium variant prevalence assumptions are, with hind-site, too low. In addition, the model can only be used for short-term projections, and provides no substantial differentiation of impacts in terms of age group or sex.

4.3   Actuarial Society of Southern Africa Model (Version 500) projections

This has been used by the Botswana Insurance company. Various aspects of calibration have been changed to reflect the experience of Botswana, and the model has reportedly performed adequately in relation to claims experience of the insurer.

Details of the projections and claims experience are not in the public domain and overall demographic projections for Botswana have not been the focus of the modeling by the company. However, the company has indicated that when compared to calibrations of the model based mainly on South African data, their Botswana calibrations suggest:
- Earlier commencement and more sustained levels of sexual activity
- Overall higher risk behaviour (numbers of partners and levels of STDs)
- Potentially higher levels of infectivity due to cofactors such as other STDs.[20]

4.4   Vensim

Vensim has been undergoing final adaptation and calibration by Dr Warren Sanderson, as part of a broader study of environmental and demographic factors in development in Southern Africa. The robustness of projections and technical aspects of the model and its calibration are not available for close scrutiny. Certain initial projections (specifically HIV prevalence trends) seem out of line with experience in other epidemics and the reasons for this are not clear.

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[d] This appears to have been a mainly arbitrary adjustment to an estimated overall Antenatal prevalence of 14% in 1991.

5   REVIEW OF AVAILABLE PROJECTION MODELS

Seven widely recognised models were reviewed for potential use by Botswana for HIV/AIDS projections, and comments on several others were made (see Annexure 1 for further details)**.** A summary of the features of these models is provided in *Table 4.* While the review was not exhaustive, it provided a sufficient range of approaches to modeling the Botswana epidemic to allow for informed choices of model(s) for further work.

Several overall issues in choosing the most appropriate model for use in Botswana were identified.

- As the real world is complex, no model will be able to simulate it perfectly. All models involve many assumptions. It is possible that two different models can be equally successful in describing reality. The superiority of any particular model is difficult or impossible to establish conclusively.
- Some good models of reality, based on solid theory, may perform less well if supporting data and tools are inferior.
- The outputs of any model and tool are highly dependent on available input data, and can impose greater limitations on projections than the logic of models themselves.
- Whatever model is chosen, it is likely to be desirable to establish the sensitivity of projections to key assumptions.

Major criteria in making final choices between models included:

- *The needs of the user*. In general, models are designed to meet a specific need. A model should be chosen which is able to produce the relevant, reliable projections for planning and advocacy purposes in Botswana.
- *Availability of calibration data and ability to use all relevant data as fully as possible*. In Botswana, where antenatal data is probably the best available input, a macro model has strong advantages. However it is also important to have sufficient micro parameters to reflect epidemic characteristics which may be unique to Botswana, allow study of potential interventions and provide a stronger basis for longer-term projections. Sufficiently detailed outputs that can be tested against available data are also desirable to validate projections.
- *Ongoing maintenance and technical support.* Current data on the Botswana and other sub-Saharan epidemics is limited. Projections and calibrations will probably need to be revised as new data becomes available. Unless relatively simple models are chosen, there might be constraints on availability of staff to maintain and update the model within the Botswana government.

After reviewing these and other considerations *(see e.g. Table 4)* the study Technical Group opted to rely on Spectrum as the main model for projections in the immediate future. The Group suggested that the Doyle model be used to generate plausible epidemic curves for calibration of Spectrum projections and comparison projections.

Table 4: Summary of performance of models in terms of set criteria

*** Strongly compliant, * Weak compliance, ? Some uncertainty , No entry in cell = non-compliance with criterion

Criterion	Epimodel	Spectrum	IwgAIDS	SimulAIDS	Vensim	ASSA	Doyle
1. Input/calibration data							
Population profile (by age, gender)		***	***	**	***	***	***
Fertility rates (by age, change over time)		***	***	*	***	***	***
Impact of HIV on fertility		*	?		*	***	**
Non-AIDS mortality rates (age, gender, over time)		***	***	*	**	***	**
Antenatal HIV prevalence data	*	*	?	**	?	***	***
AIDS cases	*	**	**	**	**?	*	***
AIDS deaths	*	***	**		**?	***	***
STD patient HIV prevalence			**	*		***	***
Consideration + pooling of sub-group/ region data							***
Medical and behavioural interventions	*	*	***	**	*	*	**
Availability of reasonable input data for Botswana	***	***			**	**	**
Ease of calibration	*	*			*?	**	**
2. Outputs							
HIV prevalence (by gender, age)	*	**	***	***	**?	***	***
HIV incidence (by gender, age)	*	*	***	*	*?	**	***
AIDS cases (by gender, age)	*	**	***	*	***?		***
AIDS deaths (by gender, age)	*	**	***		***?	***	***
Outputs by sub-group (e.g. district)						*	***
Infant, child, young adult mortality		**	***		**?	***	***

Criterion	Epimodel	Spectrum	IwgAIDS	SimulAIDS	Vensim	ASSA	Doyle
Total population (by gender, age)		***	***	**	***?	***	***
Fertility		***	*	*	*?	*	*
Dependency ratios		***	***	***	***?	***	***
Life expectancy at birth (by gender)		***	*?	***	***?	***	***
Defensible long term projections		*	*	*	**?	***	***
Other							
General flexibility					*	***	**
Availability	***	***	***	?	**	***	(*)
Easy future adjustment to new information	*	***	*	*	*?	**	**
General acceptance in Southern African context	**	**			*	**	***
Ease of use	***	***	**	*	**?	**	(**)
Access to ongoing support	***	*?	?	?	**?	**	***
Internal validity/integrity	*	**?	**?	**?	*?	**?	**?
Robustness to changes in input parameters	*	**	*?	*?	*?	**?	**?
Cost	***	***	*	?	*	***	**

6 METHODS AND ASSUMPTIONS IN DEMOGRAPHIC IMPACT PROJECTIONS

The Metropolitan Life Doyle model was used to provide an HIV prevalence input curve to AIM, a Spectrum module for modeling HIV/AIDS impacts on demographic variables. Spectrum was then used to provide projections that were further manipulated in spreadsheets where necessary.

6.1 Doyle Model Projections

6.1.1 Scenarios

Three Scenarios were produced with the Doyle model to provide estimates of various HIV/AIDS demographic impacts and to calibrate Spectrum projections. (See Section 8 for discussion of scenarios and their calibration, and issues to be borne in mind in interpreting and using them.)

- *Scenario 230 (D1)* is the "best estimate" for Botswana and assumes no significant intervention into the epidemic over the projection period. The scenario is calibrated against Botswana Antenatal Survey data, the country's best available data, as described below. Micro parameters are calibrated in line with the best available current knowledge from ongoing review of studies internationally and are reviewed in Section 6.2.[e]
- *Scenario 231 (D0)* is a "no AIDS" scenario which has the same underlying demographic parameters as scenario 230, but no HIV-related mortality and fertility impacts.
- *Scenario 232 (D3)* is based on scenario 230 but illustrates the effect if the following interventions are implemented linearly between 2000 and 2005, to illustrate the effect on the epidemic:[f]
  - 15% average reduction in numbers of different partners per year
  - 15% average reduction in infectious contacts due to increased condom use
  - 15% average reduction in the infection rate per sexual contact due to effective treatment of other STDs.[21]
- *Scenario 233 (D4)* based on Scenario 232, but assuming a mother-to-child-transmission intervention involving formula feeding and antiretroviral drugs which reduces transmission rates by 50%, introduced widely from the year 2000.

In each scenario, separate projections were made for individual administrative districts, which were then aggregated to produce national level projections.

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[e] Intrinsic dynamics and calibration of the model have been robust in projecting many macro- and sub-group scenarios in South Africa. Thus the curve is considered to be the most defensible "best estimate" in terms of both macro and micro-parameters, subject to limitations of available macro and micro data

[f] These reductions can be considered to be realistic targets for the NACP, given behaviour reported in KAP studies and potential to increase effectiveness of STD treatment. Even larger effects could be feasible. However, the scenario is intended mainly to be illustrative of the effects of interventions on demographic parameters in the short to medium term, rather than to predict the scale of behaviour change.

6.1.2 Demographic input parameters

Key parameters for a "no-AIDS" scenario such as population size, age, gender and geographic distribution are based on 1991 Census data. Age specific and total fertility rates, and infant, child and adult mortality rates are based on those reflected in the *1991 Population and Housing Census Analytic Report (1998).* Other assumptions such as migration, were based on assumptions used in 1997 CSO Population Projections.

Total Population

Unadjusted 1991 Census data, broken down by sex and age, was adjusted and smoothed over the age range 0 to 79, to correct for the undercount in the age bracket 0 to 5, in line with correction factors suggested by Adegboyega (1998). A best estimate was then made of the 1980 population profile (the starting year for projections), so that a projection to 1991 would yield the profile as per Census 1991, given fertility and mortality calibrations.[9] *Figure 2* illustrates the resulting 1991 population profile. As shown, the calibration closely approximates raw census data in older age groups. For children aged 0-9 the projected 1991 population lies between the raw data (generally thought to be an underestimate of children aged 0-5) and a smoothed curve - which would probably not adequately reflect any recent fertility decline which may have occurred. [22]

In all scenarios, individual district projections were produced and then aggregated to national level.

Figure 2: 1991 Population Profile (% of population by age)
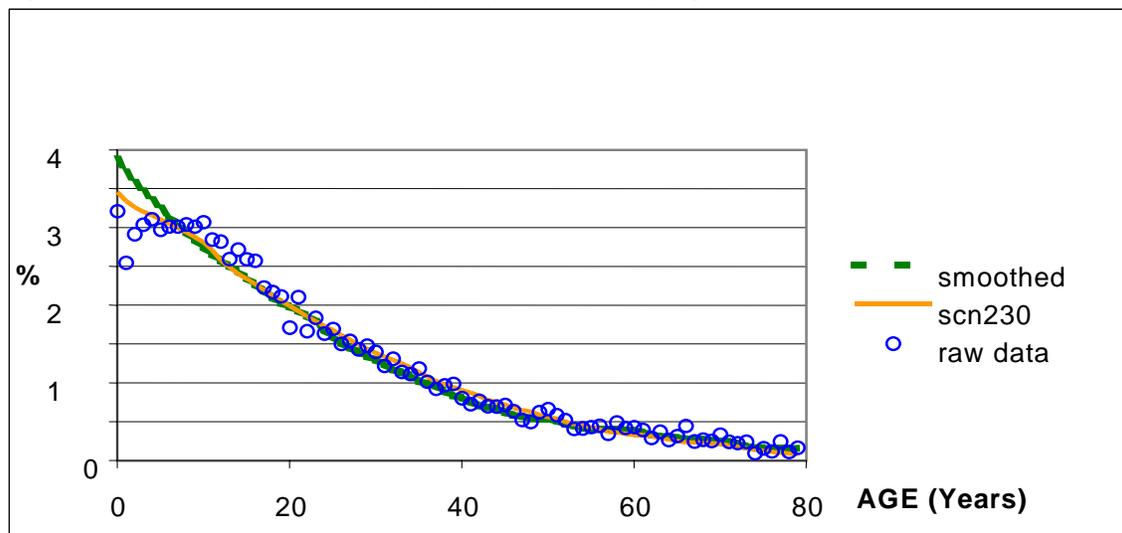

Mortality

1990 mortality is used as the base and is assumed to have no AIDS mortality incorporated. The mortality rates are taken from Udjo (1998, Chapter 4, Table 5).

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[9] The structure of the models requires inputs of a 1980 population.

These rates have been extrapolated and smoothed over the age range 0 to 79 *(Figure 3).* This base mortality is assumed to remain constant over the projection period.

Figure 3

Base Mortality Rates (q_x)
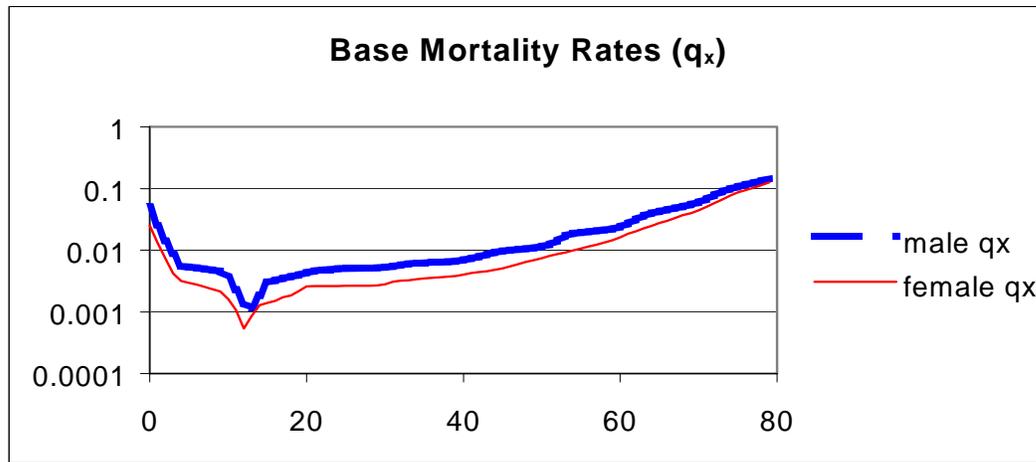
Fertility

Fertility assumptions for 5 year age bands are based on Adegboyega (1998, Chapter 3 Tables 1, 4 and 6). The input to the model *(Table 5)* is an average of various TFR's and ASFR's derived from the Census, Adegboyega and BFHS.[h] Rates have been extrapolated over the projection periods but are not smoothed over individual age bands. Fertility rates for 1980 were adjusted to bring the population profile produced by underlying fertility and mortality rates in line with the Census 1991 profile

Table 5: total and age specific fertility rates used in modeling

age	1980	1990	2000	2010	1980 adj.
Total	7.41	4.85	3.97	3.24	6.23
10 to 14	0.000	0.000	0.000	0.000	0.000
15 to 19	0.592	0.505	0.461	0.396	0.497
20 to 24	1.521	1.031	0.857	0.706	1.278
25 to 29	1.497	0.998	0.823	0.676	1.257
30 to 34	1.388	0.885	0.713	0.579	1.166
35 to 39	1.130	0.746	0.611	0.500	0.950
40 to 44	0.796	0.442	0.328	0.255	0.669
45 to 49	0.488	0.247	0.172	0.128	0.410
50 to 54	0.000	0.000	0.000	0.000	0.000
55 to 59	0.000	0.000	0.000	0.000	0.000

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[h] These use different techniques and are not strictly comparable. The demographic modeling required TFR and ASFR for 1980, 1990, 2000 and 2010 for calibration. The greater number of reference points probably provides as reasonable a calibration as one derived from official Census figures alone. The only available ASFR's were those produced by Adegboyega (1998).

Migration

Migration was not considered for any of the demographic projections and is expected to be accommodated by post hoc adjustments where necessary.

6.1.3   Epidemiological parameters: macro-calibration

Projections were calibrated against Antenatal Survey data. Antenatal HIV prevalence curves from the various sites have similar shapes, subject to statistical variation, when Antenatal HIV prevalence curves of the various regions have been shifted in time (whole year steps) to superimpose them on each other *(see Figure 4 and Table 6).* Although some differences would be expected because the population is not completely homogenous, the current data does not suggest any clear alternative to the assumption of a common underlying epidemic and similar epidemic curves in different regions. The Figure 4 illustrates the plausibility of the pattern of the epidemic in each area falling within a similar envelope around the "average" curve, differentiated mainly by time lags. However, it also illustrates the difficulty of excluding the possibility that different areas do in fact have different epidemics: some districts have very few calibration points either because they are early in their epidemics or due to infrequent inclusion in the Survey.

An average of all these curves was assumed to gives a "best available estimate" of the underlying epidemic's HIV prevalence curve (referred to as "average" prevalence curve in future).   This average HIV prevalence curve has been used for the calibration of scenario 230 of the model *(see Figure 5)* as it is likely to reflect best the information provided by the antenatal survey, which is the best available HIV prevalence data in Botswana. The curve suggests that a plateau in national antenatal prevalence will be reached quite shortly. This is consistent with recent trends in Francistown, and is plausible in terms of underlying epidemic dynamics generated by the Doyle model.

A similar curve to the "average" curve, over a more limited time span, was generated when published Botswana Antenatal prevalence data *(Table 7)* were matched to relevant Census 1991 regions and weighted according to population *(see Table 8)* to give an estimated "national" Antenatal HIV prevalence curve *(see Figure 4).* This curve generally corresponds very closely to the average curve, but was not used in calibrations.

Calibration also assumes that:
- Sampled antenatal clinic attendees are representative of all pregnant women, including pregnant non-clinic attendees.
- Pairing of census districts with antenatal sites for calibration of district level epidemics has not introduced significant biases.

Figure 4: Epidemic curves of various antenatal sites adjusted for delays in local epidemics
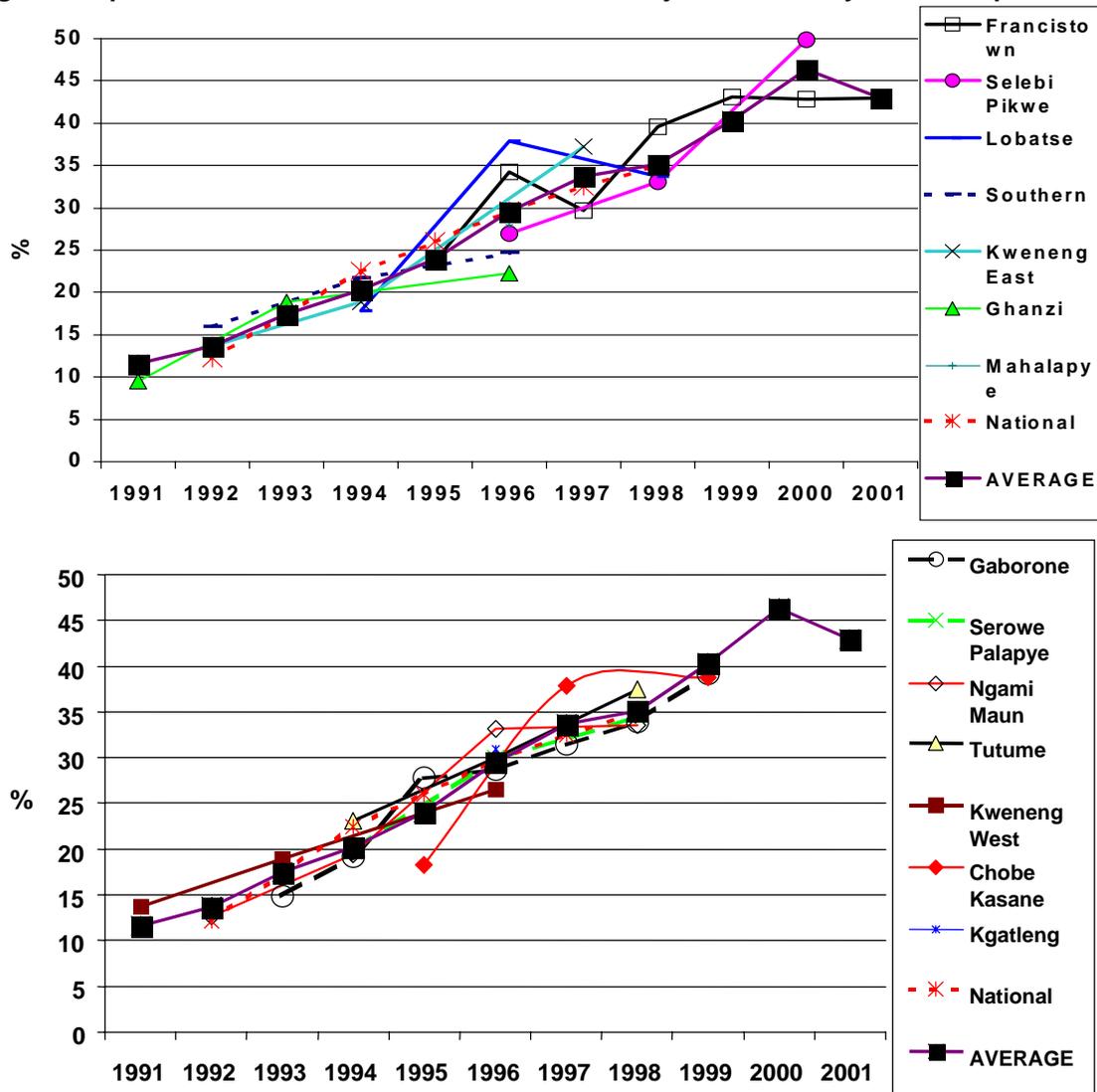
Table 6*: Site Antenatal HIV prevalence curves adjusted for time lags* [i]

	LAG	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Gaborone	-1			14.9	19.2	27.8	28.7	31.4	34.0	39.1		
Francistown	-3					23.7	34.2	29.7	39.6	43.1	42.9	43.0
Serowe Palapye	-1				19.9		29.9		34.4			
Selebi Pikwe	-2						27.0		33.1		49.9	
Lobatse	-1				17.8		37.9		33.7			
Ngami Maun	0		12.7		19.4		33.1		33.5			
Tutume	0				23.1		30.0		37.5			
Southern	2		16.0		21.8		24.7					
Kweneng East	1		13.7		18.9			37.2				
Kweneng West	2	13.7		18.9			26.5					
Chobe Kasane	-2					18.3		37.9		38.8		
Ghanzi	2	9.5		18.9			22.3					
Kgatleng	1						31.0					
Mahalapye	1						28.0					
National	0		**12.2**	**17.4**	**22.5**	**26.0**	**29.7**	**32.5**	**35.0**			
AVERAGE	**0**	**11.6**	**13.7**	**17.5**	**20.3**	**24.0**	**29.5**	**33.7**	**35.1**	**40.3**	**46.4**	**43.0**

* Lags given in years

Figure 5: Antenatal HIV prevalence rates (%) and Scenario 230 proxy*
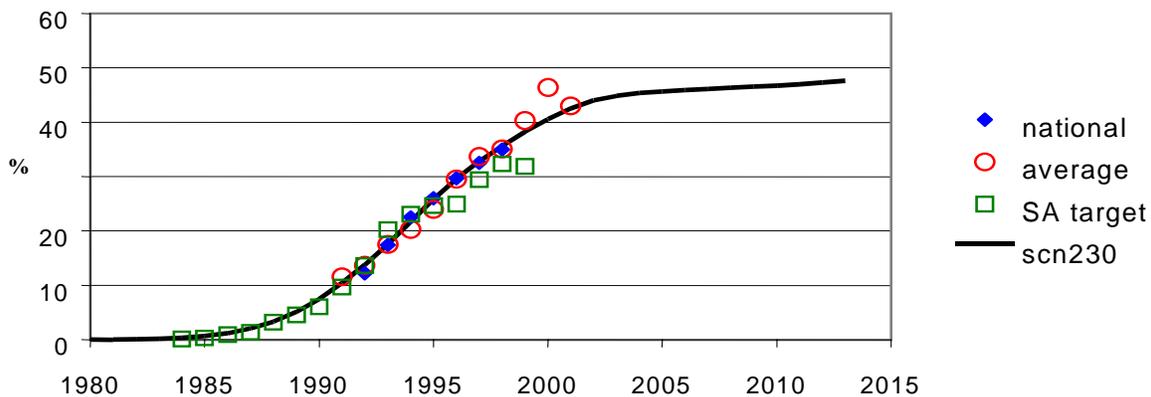
*SA target - calibration curve based on several Southern African countries

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[i] Years refer to the <u>average curve</u> used to calibrate the epidemic and include projected rates for the national figures in 1999, 2000 and 2001. Thus the actual 1998 Survey figure for Francistown, with the most advanced epidemic, gives a calibration point for the national curve in 2001.

Table 7: Antenatal HIV prevalence*

	1998	**1997**	**1996**	**1995**	**1994**	**1993**	**1992**
Gaborone	39.1%	34.0%	31.4%	28.7%	27.8%	19.2%	14.9%
Francistown	43.0%	42.9%	43.1%	39.6%	29.7%	34.2%	23.7%
Serowe Palapye	*34.4%*	34.4%	*32.2%*	29.9%	*24.9%*	19.9%	*14.9%*
Selebi Pikwe	49.9%	*41.5%*	33.1%	*30.1%*	27.0%	*19.2%*	*14.9%*
Lobatse	*33.7%*	33.7%	*35.8%*	37.9%	*27.9%*	17.8%	*12.8%*
Ngami Maun	33.5%	*33.3%*	33.1%	*26.3%*	19.4%	*16.1%*	12.7%
Tutume	37.5%	*33.7%*	30.0%	*26.6%*	23.1%	*18.1%*	*13.1%*
Southern	24.7%	*23.2%*	21.8%	*18.9%*	16.0%	*11.0%*	*6.0%*
Kweneng East	37.2%	*31.1%*	*25.0%*	*18.9%*	*16.3%*	*13.7%*	*8.7%*
Kweneng West	26.5%	*23.9%*	*21.4%*	*18.9%*	*16.3%*	*13.7%*	*8.7%*
Chobe Kasane	*38.8%*	38.8%	*38.4%*	37.9%	*28.1%*	18.3%	*13.3%*
Ghanzi	22.3%	*21.2%*	*20.0%*	18.9%	*14.2%*	9.5%	*4.5%*
Kgatleng	*31.0%*	31.0%	*25.0%*	*18.9%*	*16.3%*	*13.7%*	*8.7%*
Mahalapye	*28.0%*	28.0%	*25.0%*	*18.9%*	*16.3%*	*13.7%*	*8.7%*

* Values in italics are extrapolations

Table 8: Weighting for various antenatal testing sites

Antenatal Clinic	**Census 1991**	
	District*	**Population**
Gaborone	1, 20	177052
Francistown	2, 60	108598
Serowe Palapye	5, 50	137298
Selebi Pikwe	4, 52	93330
Lobatse	3	26052
Ngami Maun	53, 70	93270
Tutume	7, 54	102277
Southern	6, 10, 11	158577
Kweneng East	31	141611
Kweneng West	32	28826
Chobe Kasane	71, 72	50849
Ghanzi	80, 90, 91	55853
Kgatleng	40	57770
Mahalapye	51	95433

     * 1991 Census code

Age profile of AIDS and HIV prevalence

Scenario 230 was also calibrated to ensure reasonable consistency with the age profile of reported AIDS cases and HIV positive Antenatal attenders *(see Figures 6 and 7).* Limitations of both antenatal and AIDS age profile data should be considered in interpreting areas of apparent discrepancies.

Figure 6: **Percentage of AIDS cases in each age band – 1997 reported and projected cases**

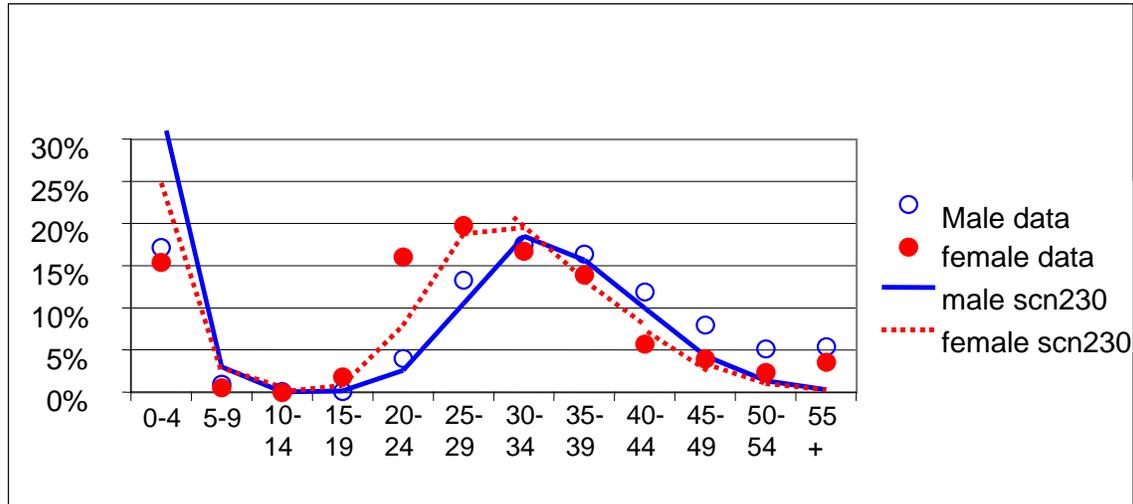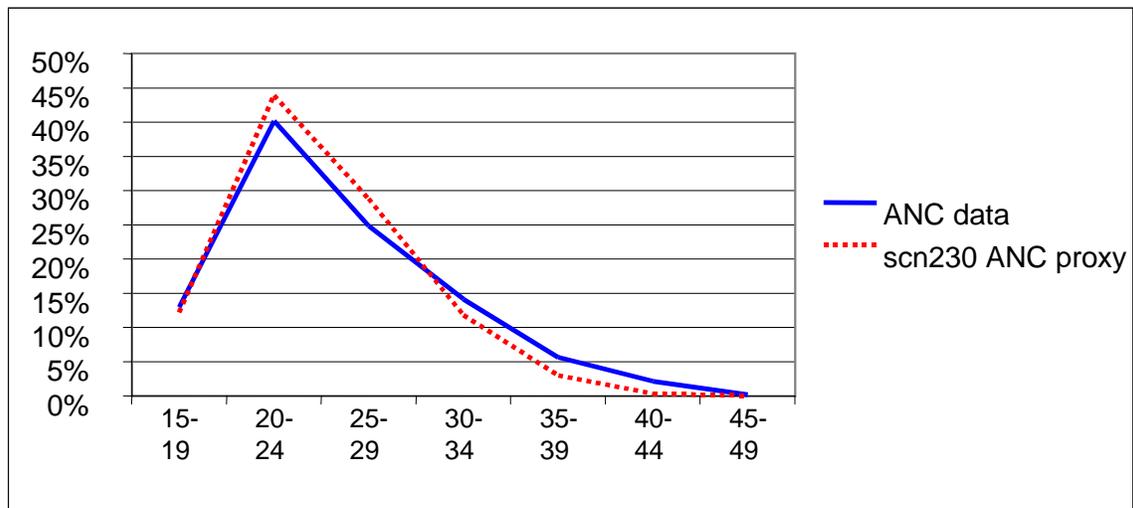*Figure 7:* **1998 antenatal seroprevalence age profile: reported and projected**

6.1.4   Other epidemiological and clinical calibration parameters

Assumptions around parameters such as survival times after infection, vertical transmission rates, fertility in HIV infected women and male:female distributions of new infections are given in the discussion of Spectrum epidemiological calibration parameters below.

6.2   Spectrum projections

6.2.1   Scenarios and HIV prevalence calibration

Adult (15 to 79) HIV prevalence curves produced by Scenario 230 and 232 of the Doyle model were used to provide input curves for AIM, a Spectrum module. (see *Figure 8* below). Four scenarios were produced with AIM:

- Botsw1 makes use of the best estimate scenario 230 from the Doyle model. It assumes that rural and urban populations experience the same pattern of epidemic, differentiated only by time lags between the epidemic in different communities.
- Botsw 2 projects impacts for communities defined as non-urban in the 1991 Census. It assumes that rural communities differ from urban ones by having adult HIV prevalences that are consistently 80% of those of urban regions at any stage in development of the epidemic.[23]
- Botsw 3 assumes some intervention into the epidemic starting in the year 2000. This is based on the adult HIV prevalence curve generated by Doyle scenario 232. All other parameters are the same as for "Botsw 1".
- Botsw0 is a no-AIDS scenario based on "Botsw 1", but with zero HIV infection and associated parameters. This scenario starts with the same total population as other scenarios as at 1980 and not 1991.

Subsequently, data produced by these AIM projections was manipulated in spreadsheets to produce the full range of parameters and scenarios reported. In all scenarios, individual district projections are produced and then aggregated to national level. The final four scenarios were:

- *Scenario 1 (S1)*. This *"best estimate"* scenario applies the same epidemic curve to urban and rural populations, differing only in the lags between relevant populations' epidemics.
- *Scenario 2 (S2)*. This *"best case"* applies the Botsw1 scenario to urban communities and the Botsw2 scenario to non-urban communities. This generates an overall "best case" scenario for the country in so far as rural areas are assumed to consistently have a 20% lower prevalence, rather than simply lagged epidemics, and fertility in rural areas is assumed to be higher. Due to lack of data, this scenario cannot be considered to provide a reliable best estimate of the epidemic in non-urban areas.
- *Scenario 3 (S3)*. This shows impacts of interventions (condom use; STD treatment and reduced numbers of partners) described in scenario D3 above, on Scenario 1.
- *Scenario 0 (S0)*. This no-AIDS scenario is based on the Spectrum no-AIDS scenario.[24]

In all projections, assumptions of underlying epidemiological and demographic parameters were kept in line with those assumed in Doyle model projections.[j]

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[j] As some of the inputs parameters and formats of the models differ, some input parameters had to be manipulated or reconfigured, but should remain substantially consistent with each other.

Figure 8: Adult HIV prevalence curves for calibration of AIM scenarios
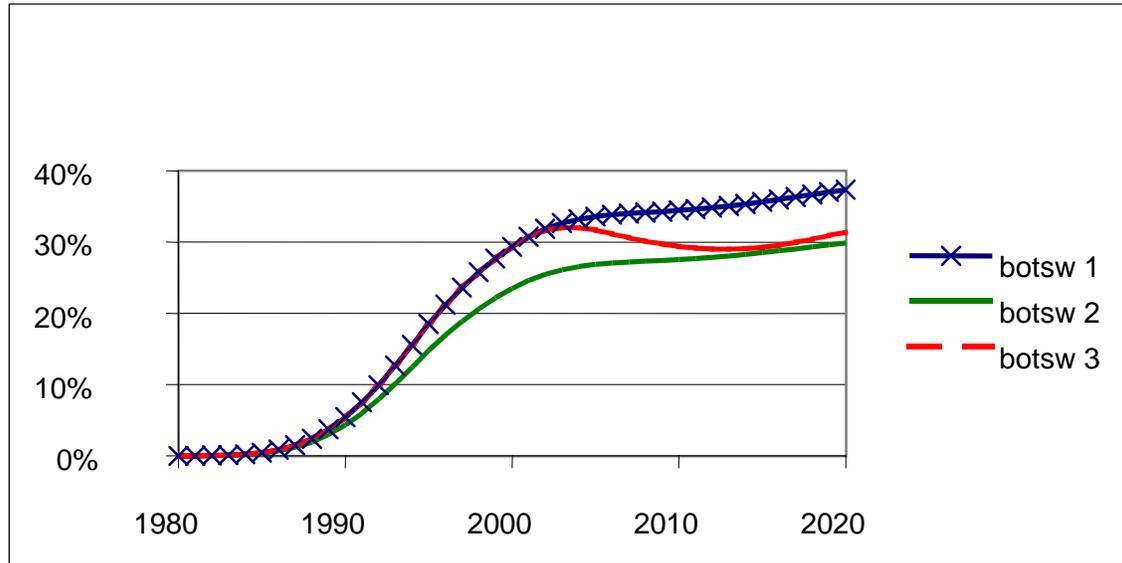
6.2.2   Demographic parameters

Total population

The 1980 start population broken down by age group and gender as per scenario 230 of the Doyle model is given in Table 9. The total population has been scaled to give the Census population in 1991. Relative values are more important than absolute values in this breakdown, as final results were weighted against the populations of all individual districts in producing individual district projections.

Fertility

For Scenarios 1, 3 and 0 the total and age specific fertility rates for 1980 to 2020 are the same as for Scenario 230 of the Doyle model (see Table 5 Section 6.1.2 and also 3.1.1). Scenario 2 assumes a 30% higher fertility rate in rural regions.[25] The "rural" scenario also assumes the same ratios of age specific fertility. 103 male births are assumed for each 100 female births

Life expectancy

Non-AIDS scenario life expectancy for males and females from 1980 to 2020 are given in *Table 10.* The 1990 figures are based on the mortality curves given in *Figure 3* above and the other years' data are based on a UN working model to project generally improving mortality. The in-built Coale-Demeny West life table in Spectrum has been used. This table has been used for Botswana by the UN and original CSO population projections to 2021.

Migration

International and internal migration have not been incorporated into the projections.

Table 9: **Botswana population in 1980**

age group	male	female
0 to 4	88778	88692
5 to 9	71905	74572
10 to 14	60357	63563
15 to 19	49680	54778
20 to 24	40744	46507
25 to 29	31800	37624
30 to 34	25654	30469
35 to 39	20691	23791
40 to 44	16624	18208
45 to 49	13013	14467
50 to 54	11109	12304
55 to 59	9649	10605
60 to 64	8153	8978
65 to 69	6650	7000
70 to 74	4704	5430
75 to 79	3250	3969
80 +	3910	4853

Table 10: **Whole life expectancies (e_0)**

year	male	female	year	male	female
1980	50.4	59.6	1998	59.4	68.3
1981	50.9	60.1	1999	59.9	68.7
1982	51.4	60.6	2000	60.4	69.1
1983	51.9	61.1	2001	60.8	69.4
1984	52.4	61.6	2002	61.2	69.7
1985	52.9	62.1	2003	61.6	70.0
1986	53.4	62.6	2004	62.0	70.3
1987	53.9	63.1	2005	62.4	70.5
1988	54.4	63.6	2006	62.8	70.8
1989	54.9	64.1	2007	63.2	71.0
1990	55.4	64.6	2008	63.6	71.3
1991	55.9	65.1	2009	64.0	71.5
1992	56.4	65.6	2010	64.4	71.7
1993	56.9	66.1	2011	64.8	72.0
1994	57.4	66.5	2012	65.2	72.2
1995	57.9	67.0	2013	65.5	72.5
1996	58.4	67.4	2014	65.8	72.7
1997	58.9	67.9	2015	66.1	72.9

6.2.3 Epidemiological parameters

Adult HIV prevalence curves for various scenarios obtained from scenario 230 of the Doyle model used to calibrate AIM projections are discussed above and shown in *Figure 8.* The epidemic is assumed to have started in the most advanced districts in 1980.

Vertical transmission

The perinatal transmission rate is set to 30%, the same rate as used by scenario 230. This rate may be somewhat low, given the relatively high rates of breast feeding (probably with a mixed feeding component in many cases) in Botswana. The 1996 FHS indicated that 32% of women did not breast feed their last under-5 child. Among women who breast fed, the average duration was at least 12 months.

Incubation and survival periods

The HIV incubation period for adults and children is given in *Table 11*, which approximates assumptions in Scenario 230 of the Doyle model as closely as possible. Median time to development of AIDS is 8.5 years. There is increasing evidence that survival among African adults with HIV is much closer to survival time for people in developed countries than has conventionally been thought. It is possible that the incubation period may be somewhat longer. In the Doyle model, life expectancy differs for different ages, with young adults surviving longer than older adults, in line with findings in many studies. The median incubation period has been estimated at 10 years for young adults based on several studies in developed and developing countries.[26]

Table 11: **Cumulative percentage developing AIDS**

Years since infection	Adults	Children
1	3.1	71.0
2	4.9	78.0
3	7.7	83.0
4	11.8	89.0
5	17.5	91.0
6	24.8	93.0
7	33.7	93.7
8	43.6	93.8
9	54.0	94.0
10	64.2	94.1
11	73.5	94.2
12	81.3	94.3
13	87.4	94.4
14	91.8	94.4
15	94.8	94.5
16	96.7	94.6
17	98.0	94.7
18	98.8	94.8
19	99.2	94.9

Median survival in adults after onset of AIDS is assumed to be one year, in line with average values used in Scenario 230 of the Doyle model. In developed countries, reviews suggest a median survival time of 13 months without antiretroviral drugs, but median survival in some developing country studies has been as low as 5 months.[27]

34% of infants infected with HIV are assumed to die in the first year and 56% have died by the end of the second year. This is in line with scenario 230 of the Doyle model and findings in Spira et al (1997) and Gray et al. (1997).[28]

Fertility in HIV infected women

The fertility in HIV positive women is reduced by 34% across the board in Spectrum. In Doyle projections fertility in HIV positive women is adjusted for estimated reductions in fertility compared to uninfected women as shown in *Table 12*.[29] The figures overall reductions used by scenario 230 of the Doyle model can be summarised to approximately 39%, 35%, 33% and 32% for 1980, 1990, 2000 and 2010, respectively, declining due to a different age profile of women over time. Both Spectrum and Doyle assumptions may overestimate differences in fertility in so far as existing data is derived from more mature epidemics. They may however underestimate differences in Botswana due to high rates of contraception by means other than condoms, and due to high rates of other STDs and possibly STD associated infertility.

Table 12: Ratios by which normal fertility is adjusted for HIV positive women

Age Group	Fertility Adjustment Ratio
15 to 19	1.51
20 to 24	0.91
25 to 29	0.69
30 to 34	0.51
35 to 39	0.32
40 to 44	0.16
45 to 49	0.00

Distribution of new HIV infections

The distribution of new HIV infections by age group for each gender is kept constant over all the years in line with scenario 230 of the Doyle model (*see Table 13*).[k] The gender ratios are given by interpolation of the following: 70% male in 1980, 60% male in 1985, 50% male in 1990 and 45% male from 2000 onwards.

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[k] Both Doyle and Spectrum models require input tables specifying the age distribution of new infections. The final age distribution of new infections is decided by checking consistency with data on age profiles of HIV infection from antenatal data and AIDS cases reported to the AIDS/STD unit.

Table 13: **Distribution of new infections by age and sex**

age group	male	female
15 to 19	13.93%	35.51%
20 to 24	35.34%	32.69%
25 to 29	28.01%	17.96%
30 to 34	14.03%	8.56%
35 to 39	5.82%	3.62%
40 to 44	2.18%	1.22%
45 to 49	0.61%	0.36%
50 to 54	0.08%	0.07%
55 to 59	0.00%	0.00%
Total	100.00%	100.00%

7   RESULTS

7.1   HIV/AIDS parameters.[i]

7.1.1   HIV prevalence

Best estimate projections indicate that 17% of the total population of Botswana were infected with HIV in 1999, and even in a best case scenario 15% would have been infected (*Graph 1*). Despite this already high level, in the absence of effective interventions to reduce transmission, particularly in areas with relatively low prevalence at present, the population prevalence could rise to between 18 and 21.5% by 2005.

Infection rates among adults aged 15-59 are substantially higher, estimated at around 30% (240 000 adults), or 28% in a best case scenario in 1999 (*Graph 2*). These rates could rise to 35.5 and 31% within 5 years without behaviour change.

Interventions will have a significant impact on infection levels if they reduce levels of partner change, increase condom use and increase effective treatment of STDs, all by a factor of 15%, introduced gradually over the next five years (*Graph 3*). While adult prevalence may seem to have only changed marginally, from 37.5 to 32% in the year 2010, this would imply a reduction in the number of adult infections of around 40 000 people, a massive reduction in suffering and social impact.

7.1.2   AIDS cases

Graph 4 (a) illustrates that the AIDS epidemic in Botswana is still at a relatively early stage despite high prevalence. Between 18 000 and 19 000 AIDS cases are projected for 1999, but the burden will double within 5 years to between 39 000 and 41 500. This will place a huge burden on health services and communities already under strain.

The graph also illustrates that, as the number of AIDS cases is largely determined by existing levels of HIV infection, primary preventive interventions (S3 and D3) will have little impact on the number of AIDS cases before 2010, although the benefits over the longer term will be substantial.

Graph 4(b) shows AIDS cases for *selected districts*. Some districts with advanced epidemics are projected to be relatively close to a plateau in annual AIDS cases. Francistown's number of people with AIDS per annum is expected to increase by around 50% and then stabilise after 2005. However, other districts with later epidemics such as Kweneng East can still expect numbers of AIDS cases to more than double before stabilising towards the end of the decade.

Graph 5 shows the burden of AIDS among *adults*. Between 1.6 and 1.9% of adults in Botswana would have had AIDS in 1999. This will rise to between 4.5 and 5% by 2010.

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[i] Full sets of district projections are available on spreadsheets.

7.1.3 AIDS deaths

Graph 6 shows the projected AIDS and non-AIDS deaths per year. The rapid increase in AIDS deaths currently being experienced will continue. By 2001, there will be over 15 000 AIDS deaths in Botswana per year, overtaking all other causes of deaths. By 2010, over 30 000 AIDS deaths per annum are projected. An intervention to reduce mother-to-child transmission by 50% is projected to reduce total AIDS deaths by about 6 % in 2010 (D4 vs D1). The effect of AIDS on crude death rates is shown in *Graph 7.*

Graph 8 indicates that between 1.2 and 1.3% of adults were projected to die of AIDS in 1999, and that this will rise to between 3 and 3.5% of adults per year by 2010.

Graph 9 shows the cumulative number of AIDS deaths that will have occurred by each year. The cumulative number of AIDS deaths between 1991 and 2010 is expected to be between 327 000 and 350 000, equivalent to around one fifth to one quarter of the current Botswana population.

The number of AIDS deaths by age for men and women is shown for 2010 in *Graph 10.* Most deaths are expected to cluster in the 25-40 year age groups. Women tend to die of AIDS at earlier ages due to their earlier ages of infection, although their average survival time is expected to be somewhat longer than for older people. A substantial number of children in the 0-4 year age group will die of AIDS, although numbers could potentially be halved through widespread interventions reduce mother-to-child transmission.

7.1.4 Total population

Projections indicate that the Botswana total population growth rate will decline rapidly due to HIV/AIDS. Within the next decade growth is likely to become static and may well become negative (G*raphs 11 and 12*). Only in the best case S2 scenario will growth remain positive to 2010, and even in this case will have dropped to 0.2%.

 When compared with previous 1997 population projections, even under a "high AIDS variant", the projected impacts of HIV/AIDS are more severe. This is mainly due to several factors assumed in the 1997 scenario.

- Direct HIV effects on fertility of infected women were not considered. This has a major impact on estimates of community HIV infection rates derived from Antenatal data. It also impacts directly on population growth as changed fertility tends to be stronger determinants of growth than changes in mortality.
- Underlying assumptions of life expectancy and mortality in the 1997 projections were more optimistic than those suggested by Udjo (1998).
- HIV-prevalence (short and medium term) was much lower than current estimates.
- Average survival time to AIDS was assumed to be 10 years in 1997 projections, somewhat delaying HIV/AIDS mortality impacts.

Similar effects on population growth are projected at the level of most individual districts, separated mainly by lags between their epidemics, but also by different fertility and infection rates in rural areas in S2.

7.1.5   Population age profile

HIV/AIDS will profoundly affect the age profile of the Botswana population over time. At present, some impact of HIV/AIDS is expected to be apparent mainly in the youngest age groups. This is due to HIV-related reductions in women's fertility and the short incubation period for children infected at birth., which both impact before adult mortality due to AIDS rises very substantially *(Graph 13(a)).*

Over the next decade the effects of increased adult mortality and reduced fertility will become much more obvious *(Graphs 13(b) and 13(c))*[m]. By 2010, the number of adults aged 35-45 is projected to be around 50% (D1) and 60% (S1) of that projected in a no-AIDS scenario. The number of children aged between 0 and 9 is projected to be in the region of 32% (D1) to 40% (S1) below a no-AIDS scenario.

7.1.6   Under-5 and infant mortality

HIV/AIDS will increase both under-five and infant mortality. The extra Under-5 mortality due to HIV/AIDS was projected as between 29 and 50/1000 by 1997, with the extra mortality rising to between 67 and 98/1000 by 2005 *(Graph 14).*[n] HIV/AIDS is projected to add an extra 20-25 infant deaths per 1000 in the year 2000, rising to 24-33/1000 increase over a no-AIDS baseline by 2005 *(Graph 15).* In addition to the direct impact due to AIDS deaths among infants and older children, higher mortality from other causes may well occur among orphans and other children disadvantaged by deaths of adults.

7.1.7   Life expectancy

Life expectancy is expected to fall dramatically in Botswana, with the largest reductions in women, who tend to be affected at a relatively young age. Life expectancy will fall due to young adult deaths, as well as infant and child deaths, to which life expectancy is very sensitive. *Graph 16* shows that current projections indicate that life expectancy will fall by around 50% over the next decade for women. Combined life expectancy for both male and female Batswana is projected as being between 46% (S1/S0) and 52% (D1/D0) of no-AIDS scenario life expectancies in the year 2010.[o]

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[m] The Doyle projections suggest slightly less severe impacts in the 30-44 year and 0-4 age group as the model does not generate prevalences in the 20-30 year age group which are as high as Spectrum. However, Doyle does project greater impact in age groups over 44.

[n] The Doyle and Spectrum models projected IMRs and U-5MRs that are not directly comparable to previous official estimates of IMR and U-5MR for Botswana. This could not easily be rectified due to input formats and values (Udjo mortality data for Doyle, and in-built assumptions of high but declining mortality rates in Spectrum). However, the scale of projected rates is close enough to official estimates for them to not substantially influence overall parameters such as total population, even in younger age groups, or the scale of AIDS-specific impacts on IMR and U-5MR. Thus the "extra burden" due to HIV/AIDS (AIDS Scenario – No-AIDS) should remain a reasonable measure of the scale of impacts which can be combined with different assumptions of underlying non-AIDS mortality rates.

[o] Doyle projections are based on the mortality estimates of Udjo (1998) and assume that underlying non-AIDS mortality profiles do not improve over time (this may be appropriate due HIV/AIDS socio-economic and health service impacts). Spectrum uses Coale Demeney West life tables as inputs, combined with assumed increases in life expectancy. Projected life expectancies thus differ from estimates derived from various other Botswana data sets and methods. However, the magnitude of AIDS *impacts* on life expectancy and IMR is likely to still be similar. Small falls in base life expectancy are also introduced by the methods in modeling HIV/AIDS impacts, such as lags between epidemics and aggregation of district projections to national level.

7.1.8 Births and birth rates

Adult mortality and lower fertility in HIV-infected women, will cause a marked fall in the number of births in Botswana, resulting in between 12 000 (S2) and 24 000 (S1) less births than in a no-AIDS scenario in 2010 *(Graph 17).*[p] The crude birth rate is projected to fall by around 22% between 1991 and 2010 in a no-AIDS scenario, and by around 31-32% under AIDS scenarios *(Graph 18).*[q]

7.1.9 AIDS orphans

Botswana needs to prepare to meet the needs of rapidly increasing numbers of children orphaned by AIDS (*Graph 19*). By 2000 projections indicate that there will be between 36 000 and 57 000 children under 15 in Botswana who have lost their mothers to AIDS. This number will have risen to 159 000 and 214 000 in 2010.

Support for orphans represents a huge challenge to Botswana. Full functional and planning implications of these projections is not however clear without deeper understanding of nuclear and extended family dynamics and responses to orphans.[r]

7.1.10 Dependency ratios

Graph 20 illustrates that HIV/AIDS may slightly decrease dependency ratios.[s] This is mainly due to a combination of a) AIDS impacts on fertility, which reduces the number of new entrants into dependent age groups, and b) movement of a relatively large cohort of 5-15 year olds into the non-dependent age groups over the next decade. This group will not yet have been heavily impacted by AIDS deaths.

7.1.11 Sex ratios

Graph 21 illustrates that HIV/AIDS may lead to a slight increase in the male:female ratio. at aggregate level due to lower levels of infection among men. However, under current assumptions, this impact is unlikely to be substantial.

7.1.12 Rates of new HIV infection

Rates of new HIV infections (HIV incidence) are likely to remain high at over 2% of the population per year for the foreseeable future, unless people are empowered to change risk behaviour *(Graph 22).* Even in areas where prevalence levels have reached a plateau, new infections still occur to replace people who die of AIDS and therefore keep prevalence rates at the plateau level. *Prevention programmes, particularly among youth, will therefore continue to be critically important in Botswana for the foreseeable future.*

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[p] In S2 non-urban women have lower HIV prevalence <u>and</u> higher fertility rates, hence the wide divergence.

[q] Births and birth rates are sensitive to assumed fertility impacts of HIV and the growth of HIV-prevalence in future. In addition, many other determinants of fertility such as desired number of children and contraceptive use may alter due to HIV/AIDS. Thus any planning based directly on these projections should consider the various factors which have not been incorporated in producing them.

[r] Many Botswana households are female-headed or do not involve formal marriages. HIV/AIDS also tends to cluster in households, so both partners in many relationships will die of AIDS. Thus defining orphanhood as children who have lost their mothers should indicate the scale of need quite well, despite limitations.

[s] Dependency ratio is defined here as the ratio of people aged below 15 and over 64 to adults aged 15-64.

8   INTERPRETATION OF PROJECTIONS

8.1   General considerations

The projections presented above can be assumed to provide a good indication of the size and types of HIV/AIDS demographic impacts. However, as indicated above, no model can represent or predict reality perfectly. In addition, projections are highly dependent on the demographic and epidemiological data used for inputs and calibration. There are limitations on the accuracy and representativeness of both kinds of data in Botswana.

The following general issues should be considered when interpreting projections for planning and advocacy purposes.

- Assumptions and methods noted in *Sections 6.1 and 6.2* should be noted and critically reviewed as new information becomes available.
- *Projections do not accommodate all potential non-AIDS factors that could change the number or demographic profile* of people in Botswana or particular districts. Population migration is a particular factor that has not been considered. There is no conclusive evidence as yet of how AIDS *per se* will impact on migration trends.
- *Aggregated projections at national level are likely to be more reliable than district level projections.* This would be expected for statistical reasons, and because those projections may not adequately reflect HIV/AIDS-related characteristics of sub-populations that could influence impacts eg different risk behaviour, fertility or mortality rates, and socio-economic influences on risk.
- *Projections of average levels of impacts even at district level do not adequately reflect the susceptibility of individual communities.* Some local communities and households will be impacted by AIDS much more or less severely than the average level of impacts. For example, communities on major transport routes would typically be expected to be at higher risk that those far from them.
- *Projections further into the future have greater margin for error.* It is difficult to anticipate the plateau level of epidemics. This could have a large effect on prevalence levels in future years. However, expected numbers of *AIDS cases and AIDS deaths* over the next decade, particularly among adults, will to a large extent be determined by infections which already exist, and can thus be expected to be more reliable.
- *No scenarios except D3, S3 and D4 assume effective interventions.*
  - The detailed projections presented do not assume significant *behaviour change or a vaccine.* A vaccine to prevent new infection cannot be assumed to be available for 8-10 years. As indicated, the impacts of behaviour change or even a vaccine would have a quite limited influence on rates of AIDS and deaths before 2010.
  - No scenarios assume that any *new treatments* to cure or dramatically slow disease progression will be available to most Batswana within next 10 years. This seems justified as current antiretroviral therapies are very problematic in terms of cost and potential for treatment failure due to viral resistance and non-compliance.
- *Demographic projections indicate <u>susceptibility</u> to impacts and may not adequately reflect <u>vulnerability</u> of certain districts, communities or sub-groups.* Poor communities would, for example, be expected to be more vulnerable to the effects arising from deaths and illness.

8.2   Calibration of scenarios and sensitivities

The following comments and data are likely to assist in interpreting the various scenarios presented above.

1)   *General adult population infection levels extrapolated from antenatal data may be considered to be too optimistic*

Projected prevalence among adults aged 15-49 is generally of the order of 10% below estimated antenatal rates in S1 and D1. Antenatal rates are not assumed to be below those of women in the general community, despite fertility impacts among HIV-infected women and relatively high levels of contraceptive usage in Botswana.[t]

2)   *Some uncertainty persists about the time from infection to AIDS and death*

Recent studies indicate that survival among adults in Africa is fairly close to survival times in developed countries once underlying, non-HIV/AIDS mortality risk is taken into account. Nevertheless, some uncertainty about incubation periods in Botswana persists and many people may consider 8.5 years median survival time to AIDS to be too long.

Scenarios S5 and S6 show effects of different survival time assumptions on projections.[u] They assume a longer (10 year) and shorter (7 year) median incubation period for adults, respectively.[30] All other S1 parameters, including incubation period in children, have been kept constant. *Graphs 23, 24 and 25* show that shorter incubation periods result in a more rapid, severe epidemic in terms of AIDS cases, mortality and population size. A longer incubation period results in less severe, more delayed impacts but does not avoid a major decline in population growth and negative growth rates before 2010.

3)   *The average reduction of fertility among HIV infected women of 34% may be considered too severe*

Projections assume that HIV infected women have approximately 34% lower fertility, on average, than uninfected women.[v] While this is based on the best available data, extrapolation from other sub-Saharan African countries to Botswana must be recognised as potentially problematic. The relatively early stage of the AIDS epidemic in Botswana may not yet have resulted in as high a fertility differential as in other countries. Factors such as contraceptive use and preexisting STD levels may also differ, although relatively high rates of both in Botswana would suggest a larger rather than a smaller differential.

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[t] In general, projections by the Metropolitan Life AIDS Research Unit using the Doyle model in South Africa have, if anything, been criticised for projecting impacts which are lower than other models and modelers.

[u] **These and other sensitivity analyses should not be considered to be reliable projections**, but rather illustrations of potential effects of micro-parameter changes given a certain adult HIV prevalence curve. No recalibration of the epidemic curve has been performed for these projections. This means that the scenarios just show the influence of different incubation periods or fertility on projections based on the original calibration curve. This is defensible in terms of the logic of the Spectrum model, if the adult prevalence curve produced by Doyle Scenario 1 is taken as given and plausible. Strictly speaking, in terms of the Doyle and other more micro- models a change in one micro-parameter will require changes to other parameters. For example, to ensure consistency with antenatal data, new assumptions of survival time would require changes in assumed levels of risk behaviour in the population. Levels of general adult prevalence would also need revision if different assumptions of impacts on fertility in HIV-infected women.

[v] Doyle allows for age specific reductions (and higher rates in young age groups) of fertility in HIV- infected women. Spectrum allows only for the same average reduction to be applied across all age groups.

Behavioural responses to HIV/AIDS are also uncertain. Infection could possibly result in increased contraception among HIV infected and other women, or could even lead some women to decide to have more children.[31]

An overestimate of impacts on fertility would have two main effects.
- *Over-estimated prevalence among women and men in the general community*. However, as indicated, the projected levels of adult infection may be considered to be low by many despite the assumption of a 34% reduction.
- *Under-estimated numbers of births*
- *Under-estimated IMR and Under-5 MR* as more infected women would give birth.

Both of the last two factors will, over the next decade, influence numbers of children in the population more than numbers of adults.

Scenarios S7 and S8 illustrate effects of assuming that the average fertility reduction is 17% or 0% respectively.[w] All other S1 parameters are held constant.[u] These assumptions result in *higher* mortality as more children are infected around the time of birth, but lower overall impact on population as more children will be born *(Graphs 26, 27 and 28).[x]* Nevertheless, negative population growth is still projected for years after 2006.

4) The S2 "best case scenario" may be too optimistic

Even if rural communities currently have lower levels of infection, it is not clear that this will result in lower longer term plateau rates. In South Africa, Swaziland and some areas in Tanzania, there are indications that rural prevalence rates may be even higher than in urban areas. Rural communities tend to be more difficult to reach with information and education on HIV/AIDS prevention, and may be less empowered to change any community norms and behaviour that reinforce risk. High mobility in Botswana will also tend to expose rural communities to import of infection from high prevalence areas. Thus, non-urban communities may just reach high prevalence levels after a time delay.[y]

5) Mother-to-child HIV transmission rates may be above 30%

Due to high levels of breast- and mixed-feeding in Botswana, projections may under-estimate vertical transmission rates and thus infant and child mortality. Interventions may however reduce transmission rates to lower levels in future.

6) The models project age specific prevalence in certain age groups which is very high and possibly implausible after 2005

The age profile of the epidemic calibrated for S1 and D1 is based on the age profile of antenatal infections and reported AIDS deaths. This results in projections with very high, probably implausible, levels of infection (over 70%) among younger age groups by the end of the next decade in S1. D1 projects prevalence up to around 70%. Implications of this would be as follows:

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[w] The reduction is spread across age groups in the same proportions as for S1 and D1.

[x] If the lower fertility impact among HIV-infected women implied lower general adult population prevalence than in S1, overall mortality increases would be moderated and the decline in population would be smaller.

[y] The S2 projection is also not fully adjusted to compensate for lower rural prevalence by assuming increased rates in urban areas to maintain consistent estimates of adult infection rates nation-wide.

- Difficulties using these calibrations for projections beyond 2010. Adult demographic parameters up to 2010 are not expected to be very substantially affected by these high projected levels of prevalence, but high projections of adult mortality would result after 2010.
- Possibly inflated levels of infant and child mortality and exaggerated reductions in fertility after 2005.

Scenarios 9 and 10 test sensitivity of projections to recalibration of the age distribution of infections towards older age groups, within plausible limits. All other S1 parameters are held constant.[32] To fit overall prevalence to the epidemic curve, this again results in prevalence levels that are very high, but now in older age groups. Rates of AIDS and AIDS deaths show patterns almost identical to S1. Overall population size and growth prove relatively insensitive to this adjustment *(Graph 29)*. However, population age structure, infant and Under-5 mortality rates show quite marked changes *(Graphs 30, 31 and 32)*.

7) The assumption in S1 and D1 of similar epidemic curves in districts with less developed epidemics and non-urban areas may not be borne out by new antenatal data

Epidemic patterns in certain districts with relatively early epidemics may be different due to underlying risk behaviour patterns or responses to prevention programmes. There is no clear evidence of this from Botswana antenatal data thus far, but this assumption should clearly be monitored. Once again, changes due to this factor would mainly affect demographic parameters beyond 2010.

8) Impacts of prevention programmes

The interventions illustrated in Scenario S3, D3 and D4 can be argued to be achievable in Botswana and viable targets for NACP. The scenario is illustrative of the important long term effectiveness of what some might be considered to be quite modest prevention programme targets. More immediate benefits in terms of AIDS deaths would be achieved through a mother-to-child transmission intervention. However, the S3 and D3 scenario also illustrate that interventions to prevent new infections will have relatively little impact on population demographics over the next 10 years, as they will not avoid the impacts of existing infections.[z]

9) Comparison of Doyle and Spectrum projections

As shown by many parameters, Doyle model projections tend to be somewhat less severe than those produced by Spectrum. This may be due both to the way inputs are configured and have to be manipulated, as well as the way in which the models calculate impacts.[aa] In most respects however, the two models indicate very similar trends due to AIDS in various demographic parameters. Projections of many HIV/AIDS demographic

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[z] Typically, models tend to suggest that, for similar percentage changes in each of these three parameters, reduction in rates of partner change has the greatest impact on prevalence, followed by increases in the number of sexual encounters involving condoms. STD treatment tends to reduce overall prevalence least (see Eg World Bank. Confronting AIDS. 1998).This ranking does not necessarily mean that any of the interventions should not be an important priority.

[aa] Spectrum does not give users access to all the aspects of the model that might help to understand reasons for divergence.

impacts are of similar magnitude for both D1 and S1. Several Doyle projections reach similar values to Spectrum within 1-3 years. As many factors may lead to divergence in the projections of the two models, it is difficult to judge which set of projections is most accurate without further data to validate projections. However, many of the policy and planning decisions to be made using the projections are likely to be similar.

9   VALIDATION OF PROJECTIONS

9.1   Empirical mortality data

Limited data is available to validate projections in Botswana. Routine data is often problematic due to under-reporting and possible changes in levels of under-reporting. There are also problems in identifying appropriate denominator populations for comparisons with projections, as populations covered by antenatal, health and Vital Registration pilot statistics do not correspond well to administrative Districts.

A general problem in validating projections is that most data relates to years in which the AIDS epidemic was at a relatively early stage, where greater errors purely due to chance would be expected and where trends would be more difficult to identify with certainty.

9.1.1   Family Health and Demographic and Health surveys

The 1996 BFHS and preliminary 1998 DHS results have shown no increase in adult, infant and child mortality rates in Botswana. Final, appropriately weighted DHS are not yet available to allow for closer examination of parameters such as confidence intervals around mortality estimates and trends in particular districts.

Projections suggest that AIDS would by 1996 result in a rise in the IMR of 12- 16/1000 in 1996, with an increase of 16-21/1000 by 1998. For Under-5 mortality, increases of 22 to 42/1000 were projected for 1996, and 36-47/1000 in 1998. Reasons why no rise in IMR or U5MR was apparent in the 1996 FHS, or preliminary 1998 DHS results, are not clear. Lack of discernible impacts is particularly puzzling and as infant and child mortality should be closely linked to antenatal prevalence in the recent past, and survival times of infected children are relatively well documented. Several possible explanations for this may be relevant.

- *Underlying trend decreases in mortality among children, infants and adults* could obscure HIV/AIDS related increases.
- *Methodological issues in the FHS and DHS* may have obscured changes. Firstly, statistical chance could obscure HIV/AIDS deaths.[bb] Biases in sampling, recall and response may also be relevant. For example, households that have dissolved due to deaths of adults may not be sampled, or certain age or other important groups may not be adequately represented in the sample. Is possible that some of the deaths of children and adults in dissolved households would not be reported by the households into which survivors move. However, discussions with CSO staff suggest no clear evidence so far of any biases that may explain the discrepancy between projected rates and empirical data. Once results based on weighted DHS data are available, a review of these factors seems to be warranted. Comparison of data and projections for districts with more advanced epidemics may be particularly useful.
- *Inaccuracy of projections.* Several assumptions incorporated into projections could have resulted in over-estimation of HIV/AIDS mortality, as shown in S2 and sensitivity analyses involving changes in other parameters. However, it seems that none of them alone would be adequate to explain all of the divergence without having to adopt implausible values for various parameters. Of note, even S2

[bb] Confidence limits for the FHS and DHS mortality estimates are not available at this stage.

suggests increases in mortality parameters that might be expected to show up by 1998.

9.1.2 Health statistics and Vital Registration pilot data

Health statistics are widely recognised as having major shortcomings in terms of under-reporting of deaths. The degree of under-counting may also change as the epidemic progresses. For example, people with terminal illness may reduce their utilisation of health services due to crowding of facilities and fatalism, and reporting may suffer as the burden of AIDS mortality and illness on staff increases. Thus, ability of Health Statistics to reflect mortality *trends* reliably may also be problematic.

Vital Registration Pilot sites have potential to provide valuable information on mortality trends. Interpretation of data is complicated by unclear levels and trends in under-reporting and small samples in Kanye and Gumare. In addition, denominator populations covered by the pilots are not directly comparable with District populations used in projections.

Overall therefore levels and trends in mortality indicated Vital Registration Pilot and Health Statistics data should be interpreted with some caution.

Adult mortality

Health statistics data strongly suggest a rising trend in the absolute number of deaths and death rates among adults in the 15-44 year age group, which seems similar to the trajectory of projected HIV/AIDS deaths *(Graphs 33 and 34).*[cc]

Vital registration pilot data also suggest rising trends in adult mortality although these trends may also reflect reductions in under-counting over time *(Graphs 35 and 36).* [dd]

In so far as they can be considered to reflect trends adequately, both sets of data suggest that the epidemic of AIDS deaths may be at an earlier stage in the epidemic curve than indicated by the projections. This could arise from factors in modeling, such as survival time and timing of epidemics in different areas.

Infant and Under-5 mortality

Vital registration pilots also suggest a rising trend in Francistown and perhaps Serowe, although denominator population data or data on births would be required to verify this *(Graph 37).* Interestingly, the linear trend in Francistown appears steeper than projected. Also, in Kanye, where no clearly comparable District projection is available but which would be expected to have a relatively delayed epidemic, there appears to be a declining underlying trend in under-5 mortality. If this has occurred in other areas, it may provide an explanation for inability to identify overall increases in IMR and Under-5 mortality rates in the FHS and DHS.

[cc] Note that denominator populations for comparisons of rates are consistent, but are quoted per 10 000 population for confirmed AIDS deaths for graphing purposes. Certain of the rates and absolute numbers of deaths are not directly comparable and are inserted into the graph only to gain an impression of trends.
[dd] Exponential trend lines are shown in graphs. Several other types of trend lines might be more valid, although exhaustive testing does not seem to be warranted due to underlying data limitations.

No clear trends of any sort in infant or child mortality could be identified from available Health Statistics data.

9.1.3 Orphans

A drive to register orphans in a number of districts occurred in mid-1999. Due to incomplete coverage, data from this source is not directly comparable with national level projections. Informants also indicated that under-reporting may have occurred due to some suspicions among carers about the purpose of registration and other factors. G*raph 38* shows that S1 orphan projections are fairly insensitive to various parameter changes.

9.1.4 Recent data from other countries

Data to allow rigorous, general-population based validations of projections using Spectrum or other models in other African countries has been limited. Timaus et al have noted methodological problems in identifying IMR and U-5MR changes. However, a 1999 UNAIDS workshop on HIV/AIDS demographic projections indicated that large demographic changes are occurring in other Sub-Saharan African countries which are broadly consistent in magnitude with projections made with models calibrated against similar parameters to those used in the above projections (J Stover and R Anderson, pers comm.).[ee] However details of these proceedings are not yet available to allow for more detailed comparison with assumptions and approaches used in the Spectrum and Doyle projections for Botswana

In South Africa, projections of the ASSA 600 model, have recently been compared with routine Department of Home Affairs death registrations for 1997/1998. This model is calibrated and constructed in a very similar manner to the Doyle model, although in South Africa it tends to project more severe impacts on mortality than the Doyle model. Death registrations show marked increases in mortality among younger adults and remarkable consistency with projections, particularly when expected levels of under-reporting are considered as shown in *Figure 9.*
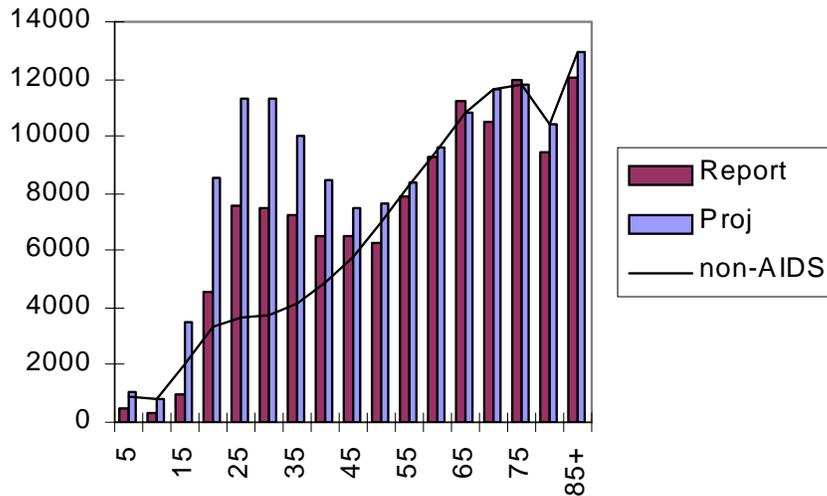

[ee] Overall dependency ratios have also not shown any marked tendencies to increase.

Figure 9: Routinely reported deaths in South Africa compared to No-AIDS and AIDS projections produced by the ASSA 600 model.[ff]

a) Male deaths
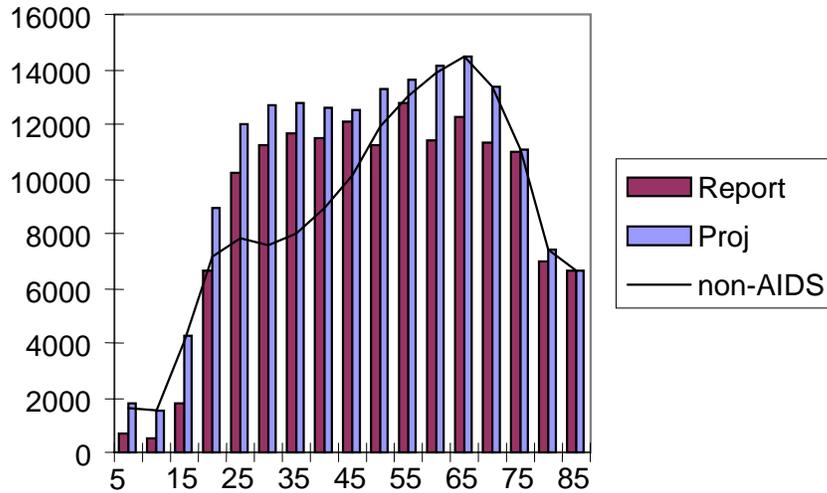
b) Female deaths

[ff] Source: Dorrington R (2000). AIDS Then, Now, Tomorrow. In preparation. Department of Actuarial Science, School of Management Studies, University of Cape Town.

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10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

- *Botswana is facing an HIV/AIDS epidemic of massive proportions.*
- *Accuracy of projections is limited both by the nature of models and uncertainties in both demographic and HIV/AIDS data inputs for modeling. Nevertheless, the projections are likely to give a good indication of the size of various HIV/AIDS impacts.*.
- *There should be no complacency about absence of clear HIV/AIDS impacts in the preliminary 1998 DHS results and 1996 BFHS.* Anecdotal evidence and data from several other sources indicate a substantial rising trend in mortality.
  - Antenatal Survey data indicates clearly that Botswana's epidemic is worse than that in nearly all other sub-Saharan African countries. Countries with more advanced epidemics show how devastating even less severe epidemics can be.
  - Levels of infection suggested by the extremely high prevalence among pregnant women must inevitably lead to major demographic impacts of the magnitudes illustrated by projections. This will only not occur if Batswana or HIV viral strains in Botswana differ fundamentally from people or strains in other countries. There is *no* good reason to support this possiblity so far.
  - In so far as experience truly differs from projections at this stage, it is likely to be safest to assume that projections have inaccurately predicted the *timing* rather than the *scale* of impacts.
- *The S1 and D1 projections seem likely to give the best estimate of demographic parameters over the next decade*, based on available data for calibration of projections. The main assumptions which may prove to be too "pessimistic" are the assumption of similar urban and rural epidemics, separated only by a time lag, and the assumption of 34% fertility reduction among HIV infected women. However, these may be offset mainly by potentially optimistic assumptions around prevalence in the general adult population, but also assumed survival times among adults and rates of vertical transmission.
- *The S2 scenario may well be too optimistic a "best case".* Data on rural infection rates and trends over time are very limited and indications of 20% lower infection rates in rural areas may well not persist over time. Experience in other Southern African countries with highly mobile populations, and the fact that urban prevalence assumptions have not been fully adjusted upward to compensate for lower rural rates in S2, also suggest that projections may be too optimistic.
- *Programmes to prevent HIV infections, particularly among youth, will remain critically important for the foreseeable future.*

10.2 Recommendations

Adequate information on the HIV/AIDS epidemic and its impacts must be ensured. A better understanding is needed of the epidemiology, demographic impacts and other dimensions of the HIV/AIDS epidemic in Botswana. As HIV/AIDS is the single greatest threat to development in Botswana, improving information on the scale and trends of the epidemic must be prioritised if planning is to result in effective, cost effective and sustainable action.

10.2.1 HIV/AIDS data

Serious consideration should be given to the following.

- Community based surveys to assess the relationship between Antenatal and community prevalence.
- Moving to a more rigorous Antenatal survey sampling system (Probability Proportional to Size) to obtain better estimates of trends and absolute levels of infection nationwide.
- Aligning sampling and analysis with administrative district boundaries to provide data that can more easily be incorporated into projections and planning.
- More frequent surveys in Antenatal sites that are not currently surveyed each year.
- Strengthening capacity to analyse Antenatal and other HIV data to allow for more detailed analysis, including trends in infection levels in rural and urban populations, and other sub-groups.
- Including other select data in survey data collection e.g. level of education. Some relevant data is already included but has not been analysed.
- Strategies to validate apparent declines in HIV infection rates once these begin to occur. Incidence surveys among key target groups such as scholars may be feasible to track effectiveness of behaviour change and prevention programmes.
- Sequential cross-sectional surveys of STD prevalence to monitor the effectiveness of STD and HIV prevention strategies. These may be easier to conduct than HIV seroprevalence surveys and are likely to be more valid than KAP studies.
- Research into other aspects of the epidemiology and natural history of HIV/AIDS in Botswana. This should be encouraged to increase understanding of the epidemic.

Monitoring of HIV/AIDS cases that is currently conducted is likely to provide some data on issues such as age and gender of AIDS deaths but is susceptible to very large scale under-reporting and biases. In view of the significant burden that this system places on health and NACP staff, routine collection and analysis of this data should be reviewed.

10.2.2 General mortality and fertility data

Mortality data that is not linked to HIV/AIDS specifically will be a cornerstone of monitoring HIV/AIDS impacts and validating projections as the epidemic progresses. Fertility trends will also be important to monitor as many determinants of fertility cannot be predicted easily in a population heavily affected by HIV/AIDS.

- Capacity should be assured so that surveys are performed rigorously and analysed quickly.
- Vital Registration pilots should be continued and rolled out to avoid biases due to incomplete reporting and unclear denominator populations for existing pilot data.
- Consideration should be given to increasing the frequency of large surveys such as the FHS or DHS, particularly as Botswana is entering a rapid growth phase of the AIDS epidemic. Alternatively, more specific surveys or sentinel sites may be needed to give more detailed, frequent information to identify and track trends.
- All survey and reporting methods should be scrutinised to avoid possible biases introduced by the nature and scale of the HIV/AIDS epidemic, such as dissolution of households affected by AIDS.

- Once final, weighted DHS data are available, a review of factors that may help to explain divergence of DHS results and projections is warranted. Comparison of data and projections for districts with more advanced epidemics may be particularly useful, despite limitations on the accuracy of district level projections.

10.2.3 Modeling and models

- All the major assumptions used in the above projections should be subjected to regular scrutiny as new information becomes available in Botswana or internationally.
- Development of new models or refinement of existing ones should be monitored to identify potential to improve modeling of Botswana's epidemic and its impacts.[gg]
- Regular updating and validation of projections is desirable to incorporate any significant new information.

10.2.4 Use of projections for planning and action

Various uncertainties involved in projections mean that their accuracy should not be over-stated. However, action and informed planning are critical to respond effectively to the new and changing needs created by HIV/AIDS. In the interim, planning and action must commence to respond effectively to new and changing needs. The most obvious impacts are likely to occur on needs facing the health, education and social welfare sectors. However, all government sectors are likely to face substantial changes in the scale and types of needs to be addressed. HIV/AIDS impacts on employees will also reduce all sectors' capacity to promote development and meet specific HIV/AIDS-related need. Planning and implementation of responses cannot wait for "perfect" data or empirical confirmation of projections.

- *Planners should be aware of the key assumptions used* in projections of demographic parameters which they use in planning.
- *Each sectoral and other planning process should adopt a "least risk" approach to using projections.* This will firstly involve establishing a range of estimates of relevant impacts from the available projections. A risk analysis should then be performed to establish whether there is lower risk in assuming either a high, mid- or lower estimate of each type of impact for planning purposes. Once the risks associated with assuming each scenario have been established, a "least risk" choice of scenario(s) can be made and plans made accordingly.
- *Certain districts and certain communities within districts will be much worse or less affected by HIV/AIDS impacts.* Plans should thus incorporate approaches and mechanisms that ensure flexibility, where necessary, to respond to different and somewhat unpredictable levels of impacts.
- As strategies to address *needs of orphans* will be a critical part of the AIDS response, it will be important to gain greater clarity on how to interpret orphan projections for planning purposes in the particular context of Botswana.

[gg] WHO is reported to be replacing Epimodel with a new model for general use in the near future.

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11 NOTES

[1] See also: a) Mugabe M. (1997). Meeting Report: National Consultative Meeting on HIV Sentinel Surveillance and AIDS Data in Botswana, September 1997. a) BIDPA. Study 1: Review and Evaluation of HIV/AIDS Related Data for an Expanded National Response to the HIV/AIDS Epidemic in Botswana. Interim Report. Oct 1999.

[2] See eg Fylkesnes K, Musonda RM, Kasumba K (1997). The HIV epidemic in Zambia: socio-demographic prevalence patterns and indications of trend among childbearing women. AIDS 1997,11:339-345.

[3] CSO categorises communities as urban; rural-urban; rural-medium; or rural-rural. The lower HIV prevalence applied to all categories of rural area.

[4] Fertility reduction in HIV positive women is only one of the factors that may bias Antenatal estimates downwards. However, the most comprehensive analysis to date, using data from several studies, suggestsed that the average total fertility rate ratio is 0.677 for HIV positive women (Zaba B, Gregson S. Measuring the impact of HIV on fertility in Africa. AIDS 1998;12(Suppl 1):S41-S50). Overall, fertility of HIV positive women has been found to be 25-40% lower than for HIV negative women. A linear relationship between HIV prevalence and total fertility attributable change is suggested; a 10% prevalence of HIV associated with decrease in total fertility of about 4%. Fertility differentials are greater for older women while in young HIV infected women fertility is higher than among uninfected peers. Fertility differentials are thought to increase with duration of infection.

[5] Formal validity assesments in Tanzania (Borgdorff 1993) and Zambia (Kigadye 1993) found that Antenatal data underestimated HIV prevalence in all women of reproductive age by a factor of 0.75 (95% C.I. 0.58;0.98) and 0.92 (95% C.I. 0.89;0.98) respectively. Other estimates have put HIV prevalence among pregnant women an average of 5% lower than the prevalence in all women in reproductive age, ranging from 2-8%. Applicability of these findings to other settings depends on factors such as a country's stage of the epidemic (a more mature epidemic and a greater proportion of women with later stage HIV infection, may be associated with a larger fertility reduction), patterns of contraceptive use and age structure of the population. See also Kwesigabo et al 1996.

[6] See eg. Wawer MJ,. Sewankamo NK, Serwadda D et al (1997). Control of sexually transmitted diseases for AIDS prevention in Uganda: a randomised community trial. Lancet 1999;353(9152):1-23.

[7] See eg Kwesigabo et al 1996.

[8] Arthur G Bhatt SM Mhundi D et al. (1999) *The changing impact of HIV/AIDS on Kenyatta National Hospital, Nairobi from 1998/9 to 1997.* Submitted for publication.

[9] see Timaeus IM. Impact of the HIV Epidemic on Mortality in sub-Saharan Africa: evidence from national surveys and censuses, AIDS 1998, 12 (Suppl 1): S15-S27 <u>and</u> BIDPA. Study 1: Review and Evaluation of HIV/AIDS Related Data. Interim Report Oct 1999

[10] In several countries under-five mortality had stagnated or worsened but could not clearly be linked to HIV/AIDS. Adult death rates had doubled or tripled between the 1980s and mid 1990s in Uganda, Zambia and Zimbabwe, and the rise concentrated in young adults, suggesting that in countries which had Antenatal prevalence of over 10% by the late 1980s, massive rises in adult mortality had occurred by the mid 1990s.

[11] See eg SIAPAC. Sexual Knowledge Attitudes and Practices in Botswana 1992-96. April 1997; This indicated that in many areas in 1994, symptomatic STD prevalence among males aged 18-25 exceeded 25%. Also Sheller JP Sexually transmitted diseases in Maun Village Botswana. Ministry of Health 1995

[12] The 1993/4 Household Income and Expenditure survey indicated unemployment rates of 27% among males aged 20-24 and 40% among females in the same age group. Overall unemployment rates were 14 % for males and 22% for females in economically active age groups.

[13] The Gini coefficient for cash income is 0.683, and for all income, including income in kind, is 0.54. (Household Income and expenditure survey 1993/4. CSO 1995)

[14] In urban male-headed households the average monthly cash income was twice that for female headed households in 1993/4. When income in kind is considered, income of female headed households is 80% of male headed households. Income per capita within male and female headed households has not been reported.

[15] Lesitedi GN Ngcongco NL. A demographic and socio-economic profile of women and Men in Botswana. Report on 1991 Population and Housing Census Dissemination Seminar. CSO 1995. Certain Surveys have suggested that married Antenatal attenders tend to have lower HIV prevalence than single or cohabiting women, although the significance of these figures has not been rigorously tested.

[16] Social Impact Assessment and Policy Analysis Corporation (Pty) Ltd: *Sexual Knowledge, Attitudes and Practices in Botswana 1992-1996.* SIAPAC *Monitoring trends in Youth Sexual Behaviours* 1994,

[17] National Statistics Office. Malawi KAP Health Survey 1996.

[18] see Fontanet 1998, Burgdorff 1993, Fylkesnes 1998.

[19] UNAIDS AIDS Epidemic Update December 1999. UNAIDS/WHO

[20] Information was kindly provided by Mr D Schneider to assist in calibration of the ASSA and other models.

[21] This represents somewhat less than half the impact on transmission rates of the Mwanza intervention in Tanzania.

[22] One possible factor predisposing to this is that reductions in fertility due to HIV/AIDS may have already have been occurring by 1991. Thus, the raw Census data may have been more accurate than anticipated

[23] The assumption is based on cross-sectional data supplied by R Greener of BIDPA

[24] This no AIDS scenario is more directly comparable to Scenario 1 than scenario 2 due to slightly different fertility rate assumptions in scenario 2.

[25] Based on data in Adegboyega,o. "Fertility levels and trends", Analytical Report of the 1991 census, where much higher increases for rural regions are demonstrated.

[26] see eg Cheques P, Hest N, Hudes ES et al. Determinants of survival in adult Brazilian AIDS patients, 1982-1989. AIDS 1992,6:483-487. and Deschamps MM, Paper JW, Desvarieux M et al. A prospective study of HIV-seropositive asymptomatic women of childbearing age in a developing country. J Acquir Immune Defic Syndr 1993;6:446-451. and Morgan D, Malamba SS, Maude GH, Okongo MJ, Wagner HU, Mulder DW, Whitworth JA. An HIV-1 natural history cohort and survival times in rural Uganda. AIDS 1997;11:633-640. and Morgan D, Ross A, Mayanja B, Malumba S, Whitworth J. Early manifestations (pre-AIDS) of HIV-1 infection in Uganda. AIDS 1997;12(6):591-596. and Morgan D, Maude GH, Malamba SS et al. HIV-1 disease progression and AIDS-defining disorders in rural Uganda. Lancet 1997;350:245-250. and UK Register of HIV Seroconverters Steering Committee. The AIDS incubation period in the UK estimated from a national register of HIV seroconverters. AIDS 1998;12:659-667.

[27] see eg Deschamps 1993; Cheques 1992; Morgan 1997; Mocroft 1996.

[28] Gray GE, McIntyre JA, Lyons S. Effect of breastfeeding on vertical transmission. Paper presented at 4th International Congress on AIDS in Asia and the Pacific. Manila, Phillipines 1997. Spira R, Msellati P. Natural history of paediatric HIV infection in developing countries. Paper presented at Care of HIV infected children in developing countries: a Workshop for clinical research. Paris 1997.

[29] These fertility adjustments are in line with age specific fertility reductions in HIV infected women derived from a review of all available studies in Zaba B, Gregson S. Measuring the impact of HIV on fertility in Africa. AIDS 1998;12(suppl 1):S41-S50.

[30] **Resulting survival curves for adults under each scenario are shown below.**

Cumulative percentage of adults developing AIDS (Spectrum)

years since infection	scen 1	scen 5	scen 6
1	3.1	1.5	6.2
2	4.9	2.4	9.6
3	7.7	3.9	14.4
4	11.8	6.2	21.0
5	17.5	9.6	29.1
6	24.8	14.4	38.6
7	33.7	21.0	48.8
8	43.6	29.1	59.2
9	54.0	38.6	69.0
10	64.2	48.8	77.6
11	73.5	59.2	84.6
12	81.3	69.0	89.8
13	87.4	77.6	93.4
14	91.8	84.6	95.8
15	94.8	89.8	97.4
16	96.7	93.4	98.4
17	98.0	95.8	99.0
18	98.8	97.4	99.4
19	99.2	98.4	99.6
20	99.2	98.4	99.6

[31] see eg Bedimo AL et al. *Reproductive choices among HIV-positive women.* Soc Sci Med 1998 46(2) 171-9. Campbell EK Campbell PG. *Family size and sex preference and eventual fertility in Botsw*ana. J Biosoc Sci 1997 29(2) 191-204.

[32] Distributions of new HIV infections in *Scenario 9 and 10* are as follows*.*

age group	Botsw 1		botsw 9		botsw10	
	male	female	male	female	male	female
15 to 19	13.93%	35.51%	9.5%	25.7%	5.0%	16.1%
20 to 24	35.34%	32.69%	25.2%	27.2%	15.4%	21.7%
25 to 29	28.01%	17.96%	24.4%	19.5%	20.7%	20.9%
30 to 34	14.03%	8.56%	17.0%	12.4%	19.9%	16.0%
35 to 39	5.82%	3.62%	10.6%	7.7%	15.3%	11.7%
40 to 44	2.18%	1.22%	6.6%	5.4%	11.0%	9.6%
45 to 49	0.61%	0.36%	4.7%	2.1%	8.9%	3.9%
50 to 54	0.08%	0.07%	2.0%	0.0%	3.8%	0.0%
55 to 59	0.00%	0.00%	0.0%	0.0%	0.0%	0.0%