The Demographic Impact of HIV/AIDS in Botswana: Modelling the impact of HIV/AIDS in Botswana

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EXECUTIVE SUMMARY

This report is one of the deliverables in a tender awarded to the Centre for Actuarial Research (CARe) at the University of Cape Town by the National AIDS Co-ordinating Authority (NACA) and the United Nations Development Programme, Botswana, to investigate the impact of HIV/AIDS on the population of Botswana.

The Terms of Reference included reviewing the previous report on the subject (done by Abt Associates in 2001); establishing a preferred model to be used in the investigations; to perform a series of population projections for the population of Botswana covering at least the period up to 2021; and to assess the impact of HIV/AIDS on key demographic indicators.

The 2001 report's projections were – even in the most 'optimistic' projections – far too pessimistic given the subsequent evolution of the epidemic. Some of this can be attributed to several key weaknesses and theoretical limitations of the methodologies applied in that report, but much of the error stems from the fact that projection is, at best, an imperfect science and much has happened (for example the roll-out of ART) and much knowledge gained on the dynamics and determinants of infection in the intervening six years to have fundamentally altered our understanding of the future course of the epidemic.

In deciding on the best model to use for this project, models were first divided into those which have been used to project the impact of HIV/AIDS in Botswana but are not in the public domain and those which are in the public domain. Although, by definition, one cannot use a model not in the public domain, it was interesting to note that without exception the projections based on these models are pessimistic.

Of the models in the public domain selection was made on a number of criteria, chief amongst these being the needs of the user and the availability of the data from which to parameterise the model. After assessing a wide range of publicly available models against these criteria the ASSA2003 AIDS and Demographic model of the Actuarial Society of South Africa was selected. This model was thought to be the most sophisticated (allowing, *inter alia*, for the modelling of five of the major interventions) that can be supported by the data available. Being Excel based and regularly updated, with documentation and training, also makes it one of the models most likely to be of use to users in future. The Spectrum suite of models was considered to be an alternative but its lack of sophistication in terms of a number of aspects, in particular

allowing for interventions, and the fact that it still has a number of bugs in it ruled it out of contention.

Based on our interpretation of the results, and making use of more sophisticated techniques than applied in the CSO's Analytical Reports fertility is higher than has been commonly assumed, with the TFR (total fertility rate) being around 6.6 in 1980 and still 4.3 children per woman in the year prior to the 2001 census.

Childhood mortality was also found to be significantly higher than has been previously estimated (e.g. the under five mortality rate in the year prior to the 2001 census was around 103 per thousand as opposed to 74 per thousand reported in the 2001 census analytical report). Unfortunately the indirect method that is commonly used to derive estimates of infant and under-five mortality in the absence of complete vital registration, and which appears to have worked well on the census data in the past, is severely compromised in an HIV/AIDS epidemic due to the violation of the assumption that the mortality of the mother and her children is independent.

Adult mortality is probably higher than is being measured possibly due to the disintegration of some households upon the death of a household member (resulting in there being no household left at the time of the census to report on the deaths in the reference period). We estimate that the probability of a fifteen year old not surviving to age sixty (if they suffered the period mortality rates, i.e. mortality rates in that year) was 64% in the year prior to the 2001 census.

As a result, we estimate that life expectancy in Botswana is lower than has been estimated from census data, namely around 46.5 years at the time of the 2001 census.

Owing to the higher fertility, despite the higher mortality, projections from the 1981 census population suggest that the 1991 and particularly the 2001 census undercounted the number of children. We estimate the population in 2001 to have been about 1.8 million. As a consequence of these estimates we project the population of Botswana to be higher than others have done to date. Although such a high undercount in the census is surprising, the numbers of children projected by these higher fertility rates appear to be consistent with the school enrolment data.

The single most important indicator of the extent of the epidemic is HIV prevalence. This has been chiefly monitored via surveys of women attending antenatal clinics, but in 2004 a national household prevalence survey as part of BAIS II was carried out. Comparison of estimates of

prevalence of the two show the prevalence of women attending antenatal clinics to have been some 5.5% higher than that of women 15-49 in the household survey. Attempts to reconcile these two estimates indicate that there is some degree of uncertainty about the estimates from the antenatal surveys since it would appear that confirmatory testing was only done on the most recent survey results. Thus although there is some evidence that rates may have peaked this conclusion has to be treated with caution. Reconciliation, allowing for the biases that can be quantified found the antenatal results to be about 1% too high (i.e. as a measure of the prevalence of women attending antenatal clinics in Botswana) and the BAIS results about 2% too low (i.e. as a measure of the prevalence of all women aged 15-49 in Botswana).

The major conclusions about the demographic impact of HIV/AIDS are as follows:

Prevalence in Botswana is lower than was being assumed prior to the BAIS II household prevalence survey. Reconciliation of the prevalence estimates from the antenatal survey and the household prevalence survey suggest that in 2004 around 14% of the population was infected while 24% of adults aged 15-49 were infected, and that antenatal prevalence probably peaked at around 35% shortly before this.

While HIV/AIDS has had, as would be expected, significant effects on mortality in Botswana, interventions, particularly the provision of antiretroviral therapy and the PMTCT programme, have significantly reduced the number of deaths in recent years. However, this is expected to reverse quite soon with the number of deaths again increasing year on year, but at a slower rate than previously. It is thus important to set in place systems to monitor the number of deaths accurately in future.

Because antiretroviral therapy prolongs the lives of people infected with the virus the number of infected people in Botswana is expected to continue rising over the projection period. The numbers on treatment will also rise over the period reaching around 124 000 by 2021.

HIV/AIDS is not expected to have a dramatic impact on fertility in Botswana although the number of births peaked in the late 1990s and is falling as a result of the deaths of adults in the reproductive ages.

Under five mortality peaked around 1999 and is expected to continue falling in future, while adult mortality peaked around 2002 and is also expected to fall gradually in future.

As a result of the peaking of the mortality rates life expectancy has bottomed (at around 45.5 years which, although lower than the CSO's estimate, is higher than many international agencies are projecting) and is now increasing very gradually.

And also contrary to most other projections the population of Botswana is expected to continue growing, albeit at a somewhat lower rate than in the past. As a result of this and the provision of ART the number of Batswana infected with HIV is projected to continue growing, reaching more than 350 000 by 2021.

The timing and magnitude of the epidemic varies considerably between sub-districts with prevalence of adults (15-49) ranging from less than 15% to over 35%. Not surprisingly the largest numbers of infected are found where there are concentrations of people, mainly, urban areas (which are also probably those best providing ART).

In order to explore the sensitivity of the model to certain assumptions and to compare the results of the model (default scenario) against what might have been without HIV/AIDS a number of scenarios were run. These comprised: the no-AIDS (S0), default (S1), default with no ART (S1.1), default allowing for behavioural change for those routinely tested for HIV (S1.2) and default with longer survival on treatment (S1.3).

Unsurprisingly, HIV/AIDS under all AIDS scenarios has a significant impact on the population, with the total being nearly 18% lower by 2021 than it would have been in the absence of the epidemic, the number of deaths doubling, and the number of orphans increasing more than fourfold.

In terms of the AIDS scenarios the most surprising result is possibly how similar the results were for the different scenarios in many instances, with the major differences being in terms of the numbers infected and dead between the no ART and longer survival on treatment scenarios. Deaths due to AIDS would currently be some two-thirds higher without ART than under the default scenario, and some 25% lower if people survive twice as long under treatment than is assumed in the default scenario. But the gains of a longer life expectancy on treatment come at a cost. Doubling the number of years survived on ART would lead to an increase of about 60% in the number on treatment by 2021.

GLOSSARY OF TERMS USED

Acquired immune deficiency syndrome (AIDS): a collection of illnesses that occur in the late stages of HIV infection, when the patient's immune system has been severely weakened by the virus. Common AIDS-defining illnesses include extrapulmonary tuberculosis, PCP (a type of pneumonia) and wasting syndrome. In the absence of treatment, most individuals die within a year or two of the first AIDS-defining illness.

Antenatal clinic (ANC) survey: a survey of HIV prevalence in pregnant women attending antenatal clinics.

Antiretroviral therapy: therapy which prevents HIV from replicating, thus bringing about a reduction in the HIV viral load and a restoration of the CD4+ count. Early antiretroviral regimens consisted of only one or two drugs (monotherapy and dual therapy respectively), but since the development of new classes of drugs in the mid-1990s, more effective regimens of three or more drugs (highly active antiretroviral treatment, or HAART) have been introduced.

ASSA AIDS and Demographic model: a mathematical model developed by the Actuarial Society of South Africa (ASSA) to simulate the spread of HIV in Southern Africa, and the demographic impact of AIDS.

Asymptomatic: not experiencing any signs of infection.

CD4+ count: a measure of the strength of the immune system. A healthy adult would usually have a CD4+ count of >800/μl, while an adult sick with AIDS would typically have a CD4+ count of <200/μl.

Doyle (or Metropolitan or Metropolitan Doyle) model: a model of the HIV/AIDS epidemic in South Africa. It was developed by Peter Doyle of Metropolitan Life, and was a precursor to the earliest ASSA AIDS and Demographic model.

Enzyme-linked immunosorbent assay (ELISA): a test commonly used to diagnose HIV infection. The test is based on the detection of antibodies to HIV, and will therefore yield

negative results in the first few weeks of HIV infection, when the individual has not yet started to produce antibodies to the virus.

Highly active antiretroviral treatment (HAART): See 'Antiretroviral therapy'. HAART regimens have been shown to reduce AIDS mortality rates by between 70 and 90%.

Human immunodeficiency virus (HIV): a virus which destroys the human immune system by fusing with human immune cells with CD4 receptors, and ultimately bringing about the destruction of these cells. The major mode of transmission is through sexual contact, but the virus can also be transmitted through injections with contaminated needles, through blood transfusion and in the process of childbirth and breast feeding.

Incidence: the rate at which new infections occur. The HIV incidence rate in year t would be calculated as the number of new HIV infections in year t, divided by the number of individuals uninfected with HIV at the start of year t.

Information and education campaigns (IEC): campaigns to increase awareness of the modes of HIV transmission, the consequences of HIV infection, and the methods individuals can employ to reduce their risk of infection.

Male circumcision (MC): removal of the foreskin of the penis. Studies have shown that this can significantly reduce the risk of HIV and other STDs.

Microbicide: a cream that a woman can apply intravaginally in order to reduce her risk of sexually transmitted infection. No microbicide product has yet been shown to be effective in reducing susceptibility to HIV, but roughly 20 products are currently being tested in clinical trials.