

ASSA600

The ASSA600 AIDS and Demographic model¹⁸ of the Actuarial Society of South Africa (ASSA) has been selected to model the impact of AIDS on mortality in this report. Described as a model of the "third kind", it is neither limited to a simple functional extrapolation of the past development of the epidemic (e.g. Epimodel) nor involves a complex micro-simulation of individual behaviour. It is rather a behavioural demographic component projection model, which models the heterosexual epidemic for the country as a whole, ignoring race and geographical heterogeneity. One advantage of this approach is that as well as modelling the impact of HIV on mortality it produces population estimates which can be assessed against those derived from elsewhere.

This particular model was chosen for two main reasons. Firstly, although ASSA is in the process of developing an improved model (ASSA2000), the latter model is not yet fully calibrated. When it is, it will be calibrated, *inter alia*, on the reported deaths, and hence comparison with the reported deaths will be of limited usefulness. Secondly, the main alternative, the Metropolitan-Doyle model, is proprietary, and is anyway similar in structure to the ASSA models. However, the ASSA600 projections are compared with those from other models as a check on their plausibility.

ASSA600 models the demographic impact of HIV/AIDS on the national population by assuming that the population (those aged 15 to 59 at the start of the epidemic and those subsequently turning 14 in each future year) can be split into four risk groups depending on the risk of transmitting/contracting the virus. These comprise the following:

1. a small, high risk group comprising sex workers and clients;
2. a much larger group, assumed to be at similar risk of transmitting/contracting the virus as people who regularly contract STDs;

3. an even larger group who are at risk because of their sexual behaviour, but don't have STDs; and
4. a similarly sized group who are assumed never to be at risk.

The model allows for the impact of HIV infection on fertility and further details are given in Appendix C.

As a default the projections assume no behavioural changes or interventions. The processes incorporated in the model are illustrated schematically in Appendix C, Figure C1. It has a very similar conceptual basis to the Metropolitan-Doyle model but it is non-proprietary and accessible on the internet¹⁹. It has been widely used in South Africa and also used to model the epidemic in some neighbouring countries.

Assumptions

The starting level of non-HIV mortality has been set to the level estimated for 1985 by Dorrington *et al*⁶ with an annual decline ranging from 2,5 - 3% for young adults to about 0.5% at the oldest ages. Mortality in childhood is assumed to decrease at between 3% and 3,5% a year.

The probability of transmission of HIV infection from mother to child is assumed to be 25% at birth and 10% after birth. These infants are assumed to die at a rate of 30% per annum. A median survival time from HIV infection to death of 10 years is assumed for adults.

Calibration of ASSA600

The model has been calibrated to reproduce the antenatal data, as they are the most representative and reliable data available concerning the HIV epidemic in South Africa. In particular, the model was calibrated to reproduce the prevalence of HIV recorded by the national antenatal care (ANC) surveys up to 1997²⁰. While there was a significant difference between the model and the 1998 survey results, the fact that model estimates pass between the point estimates for

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1998 and 1999²¹ (Figure 3) and are reasonably close to the age-specific 1999 survey results²¹ (Figure 4), suggests that the inconsistency may

originate in problems with the recent survey results^{22,23,24} rather than inadequate calibration of the model.

Figure 3: Prevalence of HIV amongst antenatal attendees, ASSA600 estimates and annual antenatal survey

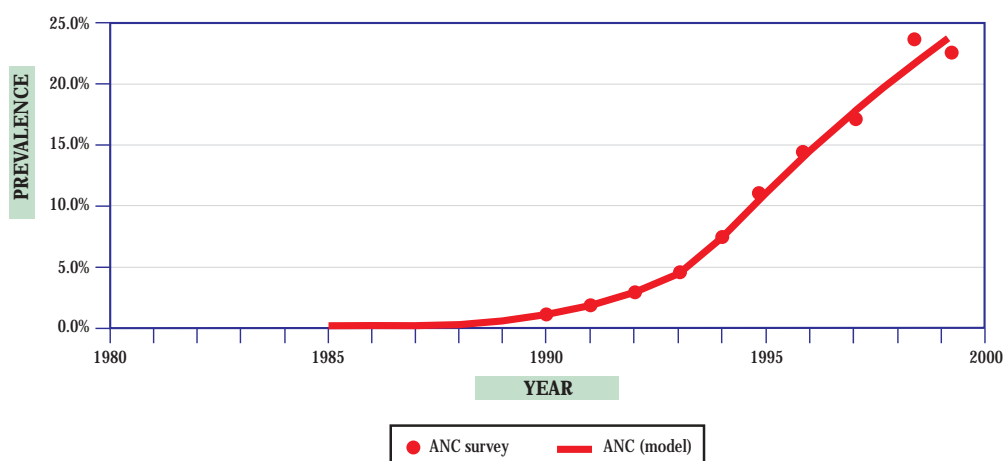
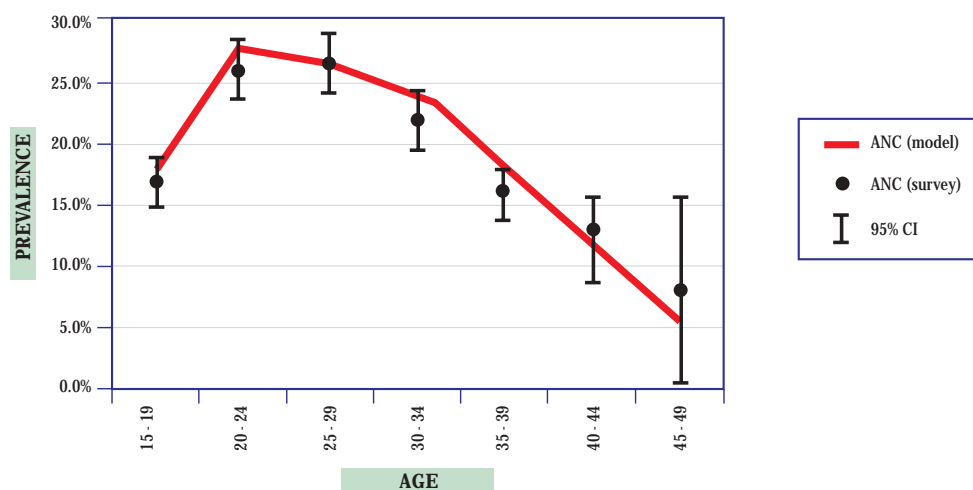


Figure 4: Age-specific prevalence of HIV amongst antenatal attendees, ASSA600 estimates and annual antenatal survey, 1999



Further the model was parameterised to produce a population of 42.2 million as at the date of the 1996 census. It assumes net immigration,

increasing rapidly from the early 1990s and levelling after 1996.

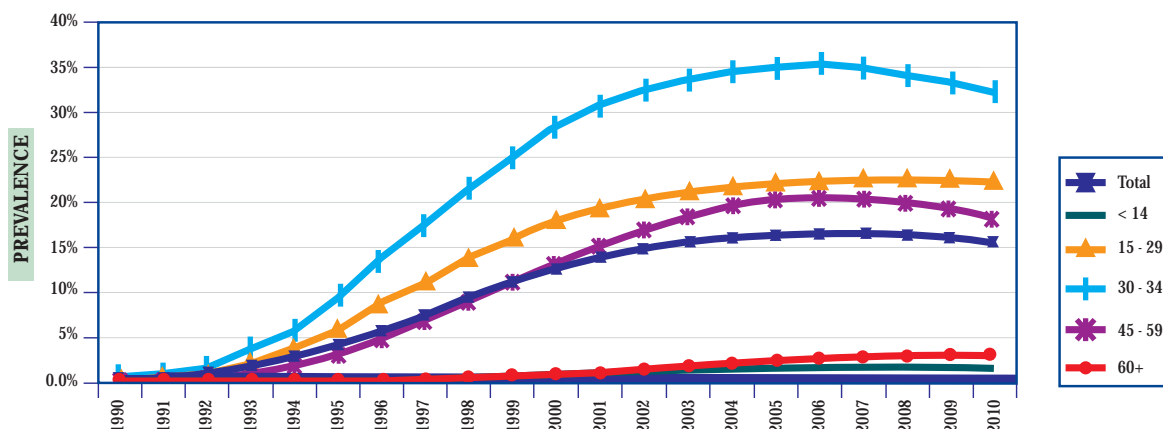
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ASSA600 Projections

The ASSA600 model suggests that the population prevalence of HIV in 2000 is about 12% and that this proportion will stabilise by 2005/6 at

about 15% (Figure 5). Infection will be most widespread in the 30-44 year old group, peaking at 35%.

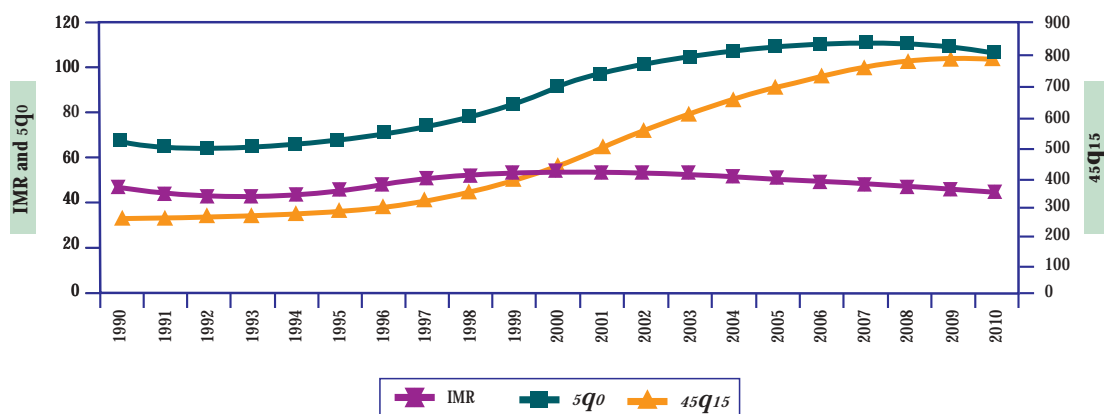
Figure 5: Projected overall HIV prevalence by age group, ASSA600



The epidemic will have an early impact on infant (IMR) and under-5 mortality ($5q_0$). As a result of paediatric AIDS the death rate for infants under the age of 1 year will increase slightly rather than continuing to decline. Under-5 mortality will increase

to double current levels (Figure 6). Premature adult mortality, indicated by the probability of a 15 year old dying before the age of 60, ($45q_{15}$) will more than double, rising to as high as 800 out of 1000, i.e. 80%.

Figure 6: Projected mortality rates per 1000, ASSA600

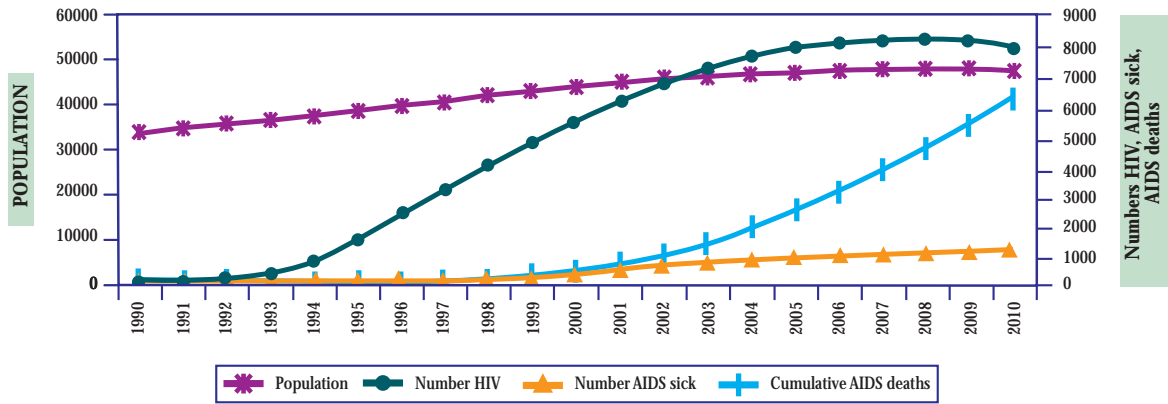


From Figure 7 one can see that by the year 2010 the cumulative number of HIV/AIDS deaths is expected to exceed 6 million, while the number of AIDS sick people will be well over 1 million. The

population growth rate will fall significantly such that while the population rises to 49 million in 2010, by that time it is barely growing.

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Figure 7: Projected numbers of people living with HIV, AIDS sick and accumulated AIDS deaths (thousands), ASSA600



The changing pattern of ages at death and the proportion of deaths due to AIDS, as projected from 1990 to 2010, are shown in Figure 8. The increasing

proportion of deaths due to AIDS, and the shift in the age structure can be clearly observed.

Figure 8: Projected age and sex pattern of number of deaths for 1990, 2000 and 2010, ASSA600 (note the axes differ for each graph)

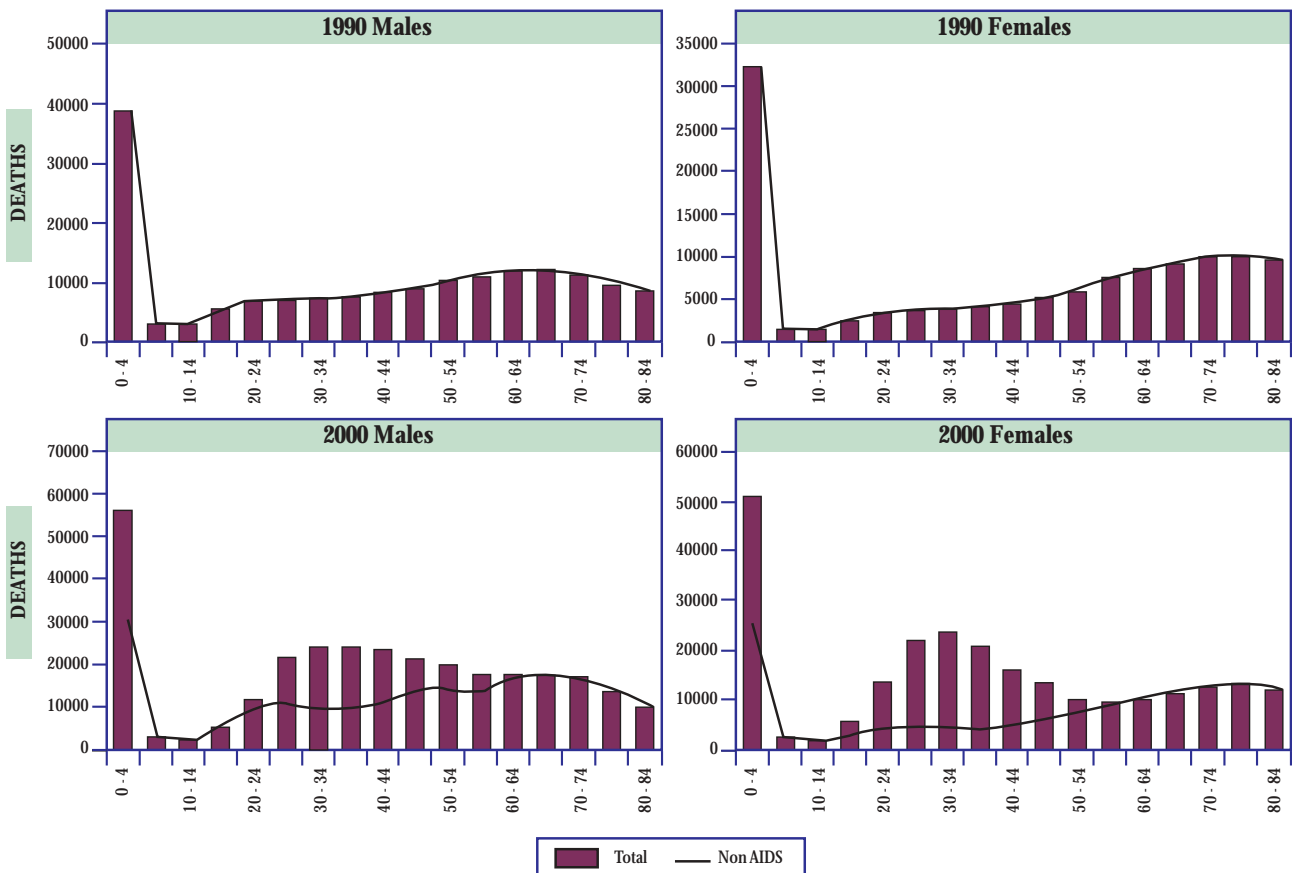
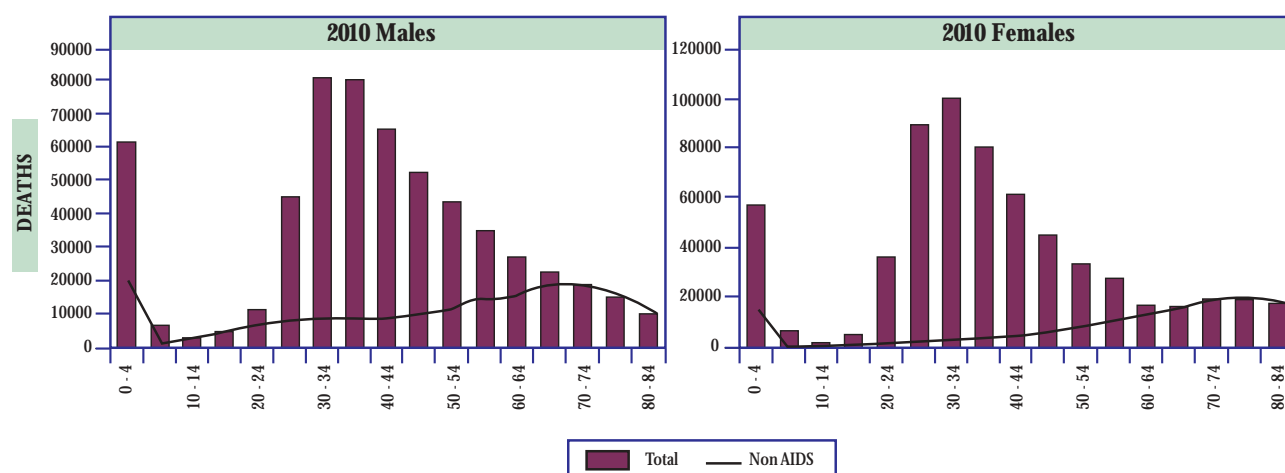


Figure 8 continues on following page

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Figure 8 (continued): Projected age and sex pattern of number of deaths for 1990, 2000 and 2010, ASSA600



Comparison of ASSA600 projections with other models

In order to assess the plausibility of the projections made with the ASSA600 model, they were compared with those from three other models, one South African (the Metropolitan-Doyle model⁵) and two international world population projections (that used by the US Bureau of the Census⁶, and that used by the UN⁷). None of the forecasts assumes any behavioural change or significant interventions over the period under consideration.

The balance equations of the four models between the years 2000 and 2010 are presented in

Table 3. From this comparison we can see that the projections differ significantly in terms of the base population estimate. (In particular, the UN estimate for the year 2000 is below the 1996 Census estimate, which itself is thought by many demographers to be an underestimate.) The level of migration assumed also differs significantly (with, in particular, the US Bureau of the Census assuming net out migration). These differences in migration undoubtedly explain a large part of the difference in the midyear population estimates.

Table 3: Balance equations (figures in thousands)

	US Bureau of the Census	United Nations	Metropolitan-Doyle	ASSA600
Midyear population 2000	43 421	40 377	42 719	46 079
+ Births	8 327	10 125	9 573	11 072
- Deaths: non-AIDS	3 173	2 598	3 911	3 399
- Deaths: AIDS	6 999	5 402	3 755	5 931
+ Net immigration	-468	13	0	1 515
Midyear population 2010	41 108	42 515	44 626	49 336

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In order to better compare the forecasts, the figures were recast assuming the same base population and level of migration as for the ASSA600 projections (Table 4). The latter figures suggest:

- the impact of HIV/AIDS is projected to be significant (between 4 and 7 million deaths in the next 10 years)
- the number of non-AIDS deaths in the Metropolitan-Doyle model appears to be high
- the number of AIDS deaths forecast by both the UN and the US Bureau of the Census models appears high
- the number of births in the UN forecasts appears high (this might explain why their projections do not forecast a drop in population despite assuming high mortality), while the number of births in the US Bureau of the Census forecasts appears to be on the low side
- given the pattern of deaths exhibited by the ASSA600 model (Figure 10 on pages 26-27) the ASSA600 estimate of non-AIDS deaths is probably a little on the low side (as shown by the under-estimate of male deaths) and the AIDS deaths a little exaggerated (as shown by the exaggeration of the female deaths).

Table 4: Recast of balance equations to ASSA600 base population and migration (figures in thousands)

	US Bureau of the Census	United Nations	Metropolitan-Doyle	ASSA600
Midyear population 2000	<i>46 079</i>	<i>46 079</i>	<i>46 079</i>	46 079
+ Births	<i>9 626</i>	<i>13 451</i>	<i>11 341</i>	11 072
- Deaths: non-AIDS	<i>3 668</i>	<i>3 451</i>	<i>4 633</i>	3 399
- Deaths: AIDS	<i>8 091</i>	<i>7 176</i>	<i>4 449</i>	5 931
+ Net immigration	<i>1 515</i>	<i>1 515</i>	<i>1 515</i>	1 515
Midyear population 2010	<i>45 461</i>	<i>50 417</i>	<i>49 853</i>	49 336

Figures in italic have been estimated by the authors

Comparison of the estimates of the impact of HIV/AIDS

The HIV/AIDS related output of the models (where available) for the years 2000 and 2010 are shown in Table 5 and Figure 9. These results suggest that:

- the models all project a significant increase in mortality and a drop in life expectancy of between five and 16 years over the next 10 years;
- the forecasts of HIV prevalence from the Metropolitan model, particularly in the oldest age groups, appear low;
- according to the US Bureau of the Census forecast, over a million AIDS deaths have already occurred in South Africa. This seems unlikely;
- the US Bureau of the Census estimates for child mortality are much higher than the estimates from the other models;
- so is the US Bureau of the Census's estimate that nearly a quarter of the total population will be HIV positive by 2010, with over 50% of the 30-44 year olds being infected; and
- as a consequence, their estimate of life expectancy of 35 years seems low (while the UN's estimate of 46 years may be on the high side).

Projections of mortality in South Africa-Summary

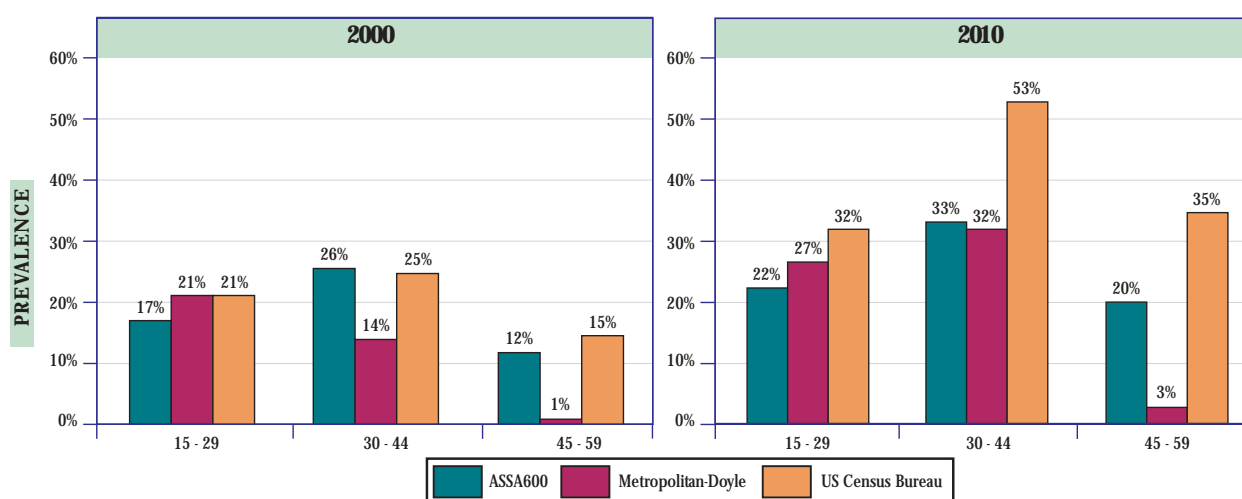
Table 5: Comparison of output of the models (figures in thousands)

2000	Total HIV	Total HIV (recast)	Total Mortality				
			AIDS deaths to date	IMR	Child _{5q0}	Adult _{45q15}	Life expectancy
ASSA600	5 437	5 437	517	54	95	419	55
Metropolitan	3 755	<i>4 050</i>	352	<i>60</i>	<i>97</i>	n/a	55
US Bureau of Census	<i>5 578</i>	<i>5 919</i>	1 043	59	120	498	51
United Nations	<i>4 335</i>	<i>4 947</i>	1 069	61	96	n/a	51

2010	Total HIV	Total HIV (recast)	Total Mortality				
			AIDS deaths to date	IMR	Child _{5q0}	Adult _{45q15}	Life expectancy
ASSA600	7 992	7 992	6 449	48	106	790	40
Metropolitan	6 484	<i>7 168</i>	4 107	<i>59</i>	<i>120</i>	n/a	39
US Bureau of Census	<i>10 135</i>	<i>12 164</i>	8 042	67	147	840	35
United Nations	<i>6 692</i>	<i>7 766</i>	6 471	58	103	n/a	46

Figures in italic have been estimated by the authors
n/a - Figures could not be supplied

Figure 9: Age-specific prevalence of HIV projected by ASSA600 and Metropolitan/Doyle Models in 2000 and 2010



It is interesting to contrast the above mortality estimates with those recently published by the WHO²⁸. The WHO estimates for 1999 are:

- child mortality (*5q0*) of 76 per thousand (i.e. lower than any of the preceding estimates for 2000)
- adult mortality (*45q15*) of 567 per thousand (i.e. higher than any of the preceding estimates for 2000)
- life expectancy of 48 (i.e. lower than any of the preceding estimates for 2000).