

Where are we now? Where are we going? The demographic impact of HIV/AIDS in South Africa

B.G. Williams^a, E. Gouws^b and S.S. Abdool Karim^b

Demographic forecasting models of the South African population, incorporating geographical distribution and age prevalence data on HIV infection, have been used to predict future mortality due to AIDS. In the year 2010, approximately 500 000 AIDS-related deaths are predicted, up from 100 000 this year. If anything, these models have underestimated the course of the epidemic so far. There is a need for better models to understand the dynamics of AIDS as well as to measure the effects of co-factors, in order to marshal the most effective response nationally.

Background

The articles in this special issue cover many aspects of the epidemic of HIV/AIDS in South Africa. They range from the development of vaccines to the behaviour of adolescents. But they also show that we have failed so far to have a significant impact on the course of the epidemic. It is to be hoped that over the next 10 years this will change and interventions will significantly reduce transmission. But without detailed information concerning the future course and demographic impact of the epidemic, it will be difficult to plan our response and manage interventions such that they have the greatest possible influence. We need to know where, when, amongst whom and to what extent AIDS-related mortality and morbidity will have their effect. We need to understand how the demand for health services will change, how the productivity of labour will decline, how the dependency ratio will change and how this will affect social services.

Various demographic forecasting models have been constructed, of which the Doyle model is probably the most widely appreciated.^{1,2} Several other models have been developed and used to make predictions concerning the future course of the epidemic.³⁻⁷ Two particularly useful source documents are the HIV/AIDS and Human Development Report⁸ and the National STD/HIV/AIDS review compiled by the South African Medical Research Council.⁹ However, few demographic models have

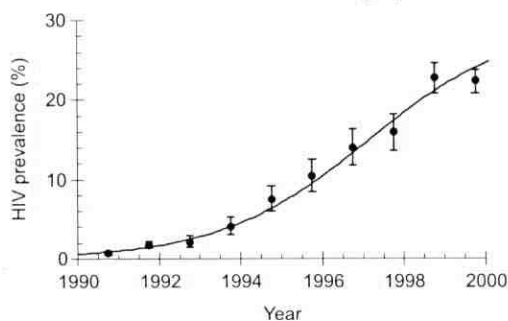


Fig. 1. Prevalence of HIV infection from national ante-natal clinic data. The fitted line is a logistic curve with a best fit asymptote of 30%.

^aCSIR MiningTek, P.O. Box 91230, Auckland Park, 2006 South Africa. E-mail: bgwillia@csir.co.za

^bMedical Research Council, P.O. Box 17120, Congella, 4013 South Africa.

been published in peer-reviewed journals and the need for more extensive modelling work remains urgent. In this commentary we consider what we know about the epidemic in South Africa, discuss what is needed to make reliable forecasts of its future course and effects given different kinds and levels of response, and discuss how such modelling activities should proceed.

What do we know?

The data on HIV infection rates in South Africa are among the best in the developing world, due largely to the efforts of Küstner, Swanevelder and Van Middelkoop, who, in 1990, had the foresight to start collecting and testing blood from women attending ante-natal clinics throughout the country and to repeat this every year.¹⁰ The change in the overall ante-natal clinic prevalence findings over the last 10 years (Fig. 1) and the age prevalence of infection for these data are discussed in detail in this issue.¹¹ Fitting a logistic curve to the statistics gives a best estimate of the asymptotic prevalence of 30% and an initial doubling time at the start of the epidemic of 15 months. Most model projections rely heavily on these data for their validity.

Understanding the geographical distribution of infection is equally important and the current provincial prevalences are given in Fig. 2.¹²⁻¹⁴ There is a marked gradient of infection starting from a high in KwaZulu-Natal, declining through some of the northeastern provinces and then the Eastern Cape with the lowest rates in the Western Cape. Figure 2 does not tell the whole story, however, as the population of South Africa is very unevenly distributed and a more instructive map is obtained by combining the provincial prevalence data with the population density¹⁵ to get an estimate of the distribution of people infected with HIV as shown in Fig. 3. Although the Western Cape has low rates of infection, Cape Town has a large population and so a high density of people infected with HIV. Furthermore, while the overall infection rates in KwaZulu-Natal are high, the population is patchily distributed, so that the infections do not occur evenly throughout the province. Infected people are spread over large areas of the former Transkei, to the northeast of East London. The big mining centres at Carletonville, Klerksdorp and Welkom show high densities of infected people as do the port cities of Port Elizabeth, East London and Durban, and the major industrial and commercial centre of Johannesburg.

The age prevalence of infection among men and women, discussed in detail in this issue,¹¹ is also important, since that determines age- and gender-specific mortality and hence the future age structure of the population. Here there are two points to be drawn from that study.¹¹ First, the rate of infection among both males and females at 15 years of age is close to zero but rises rapidly to a peak at about 26 years of age among women and at about 32 years of age for men. The peak prevalence among men is consistently about 25% lower than among women. Secondly, the age prevalence of infection among women at high risk and among migrant workers shows a flat age structure, so that the risk of infection in these adult groups appears to be independent of age.

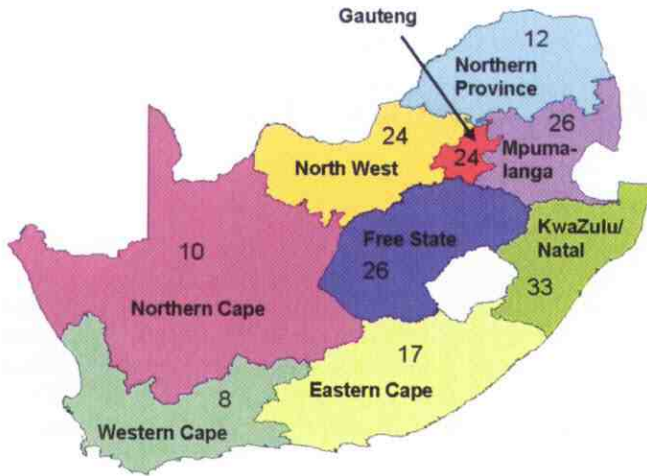


Fig. 2. Prevalence of HIV infection among women attending ante-natal clinics in the provinces of South Africa. The prevalences are the current values obtained by fitting logistic curves to the data for the last ten years.

Data concerning other sexually transmitted infections¹⁶ (which are important co-factors for the spread of HIV) and tuberculosis¹⁷ (which will be the leading cause of death amongst people infected with HIV) are also available from a range of sources. For example, a population survey in a mining town near Johannesburg¹⁸ found that 14% of men, 22% of women and 11% of migrant mineworkers are currently infected with syphilis, gonorrhoea or chlamydia. A recent study of tuberculosis in the world¹⁹ gave an estimate for South Africa of 392 new cases of the disease per 100 000 people per year but there are wide geographical and racial differences.¹⁷ For example, migrant gold mine workers, especially those with silicosis,²⁰ are at particularly high risk for developing tuberculosis and among HIV-positive workers with early silicosis there are 15 000 new cases per 100 000 men per year.²¹ The high levels of sexually transmitted diseases (STDs) and tuberculosis as well as the variations among population groups must be included in any attempt to model the impact of the HIV epidemic.

What do we think we know?

We can make an approximate estimate of the number of people infected with HIV in South Africa. We know that about 25% of women attending ante-natal clinics are infected (Fig. 1) and this is thought to give a reasonable estimate of the prevalence in adult women. We know that rates in adult men are about 75% of those in women¹¹ and that about half the South African population is over the age of 15 years. Therefore, approximately 10% of the whole population, or about four million people, are HIV positive. If the life expectancy of people living with AIDS is seven years, then we expect about 14% of infected people, or about 600 000 in total, to die each year as the epidemic matures.

We can also estimate the rate at which people are being infected. The fitted curve shown in Fig. 1 gives the best estimate of the prevalence. Between 1999 and 2000 the prevalence among women attending ante-natal clinics increased by 3% (from 21% to 24%). Among men the increase was probably about 75% of this or 2.3%. If there are 20 million adults in South Africa then this gives 2000 new infections per day. The actual figure must be higher than this since people dying of AIDS will reduce the rate of increase of infection.

A more sophisticated but still simple approach is to construct a mathematical model in which we estimate the incidence of new infections from the slope of the prevalence curve, allowing for

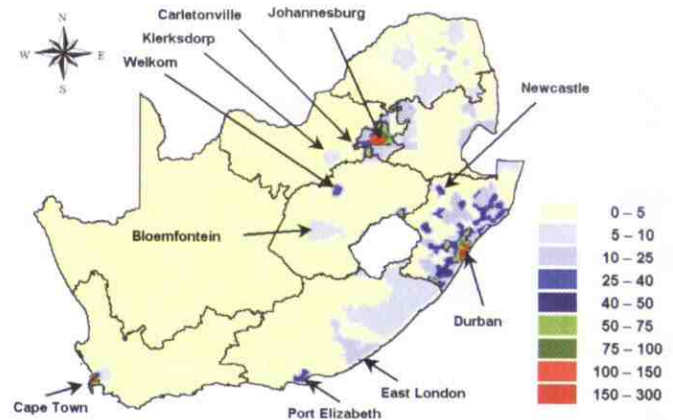


Fig. 3. People living with HIV infection per square kilometre. See text for details.

natural deaths and AIDS deaths and assuming a life expectancy after infection of seven years. This gives the mortality estimates shown in Fig. 4. It is probable that about sixty thousand adults will die of AIDS-related diseases in the year 2000 and nearly half a million will die in the year 2007. Given that the background adult mortality without AIDS is about 100 000 people annually, we are just beginning to see the impact of AIDS on adult death rates; the next decade will be devastating.

We can also estimate the impact of HIV on life expectancy. A recent study has used age-specific prevalence data to estimate age-specific incidence for women attending ante-natal clinics in a rural area of KwaZulu-Natal (Fig. 5a).²² These rates are confirmed by a study using a detuned ELISA assay to estimate incidence from the same samples (H.W. Sheppard, pers. comm.). If we assume that the incidence among men is about 75% of that for women and that the incidence curve is shifted to greater ages by about five years,¹¹ the incidence estimates can be used to obtain survivorship curves, allowing only for AIDS-related deaths in adults, shown in Fig. 5b. At these rates of incidence the life expectancy for women will fall to about 30 years and for men to about 34 years. In practice it is likely that the incidence of infection will fall over the next 10 years as people change their behaviour and, we hope, as good interventions take effect, so that the situation may never be quite as bad as shown in Fig. 5. These calculations do not include the dramatic impact that AIDS is already having on infant mortality.⁸ The calculations from which Figs 4 and 5 were derived were deliberately kept simple, since our aim is to indicate in broad terms the kind of demographic impact that the epidemic of HIV/AIDS could have in South Africa. The more extensive prognoses that have been developed, and in particular the Doyle model,^{1,8} bear

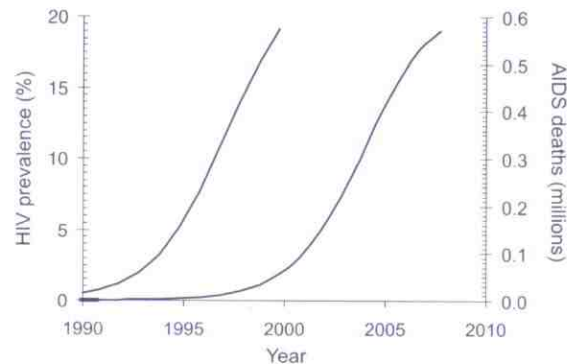


Fig. 4. Estimated adult prevalence of infection (left-hand line and axis) and estimated annual AIDS-related deaths (right-hand line and axis).

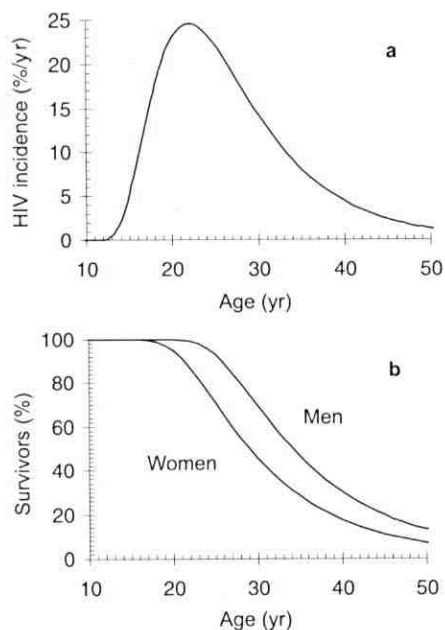


Fig. 5. a) Estimated age-specific incidence of infection for women attending ante-natal clinics in Hlabisa and b) survivorship for men and women, allowing for AIDS-related deaths among adults.

out these simple calculations, although some of the earlier predictions underestimated the growth of the epidemic. In 1997 the Doyle model predicted that by the year 2000 between about 8% and 10% of adults would be infected with HIV, increasing to about 22% in the year 2010, whereas the national prevalence has already reached about 20%. A different model applied to the epidemic in KwaZulu-Natal in 1995 by Whiteside³ predicted an adult prevalence of 21% in the year 2000, whereas it has already reached about 30% in adults. The Doyle model predicts about 100 000 excess deaths this year due to AIDS rising to about 500 000 annually by the year 2010, and about 200 000 AIDS orphans in the year 2000, rising to about two million in the year 2010.

What do we need to know?

The demographic models have proved to be depressingly accurate and when they have erred have tended to be on the optimistic side. The importance of good demographic models cannot be overstated, for without them it will be difficult to develop an effective response, to make sensible plans for the provision of health and welfare services, to manage the economic burden on the country's industries, or to assess the effect of interventions that are put into place. But the national ante-natal clinic data remind us that without statistics the best models in the world are merely informed guesses.

Data requirements

It is clear that more extensive and more detailed data are urgently needed and must be collected systematically over the long term. Prevalence data about women attending ante-natal clinics should be collected on a finer spatial scale, with greater sample sizes, so that the geographical distribution and spread of infection can be better understood. It is essential that the national ante-natal clinic surveys are supplemented by detailed studies at sentinel sites as is already being done in Carletonville¹⁸ and Hlabisa,²³ and these sites should be representative of the wide range of socio-economic conditions in different parts of the country and among different risk groups. We need to know how HIV/AIDS affects men and women, whoever and wherever they

are. Where possible, we must collect data that allow us to estimate the age-specific incidence of infection,²² as this is the most sensitive marker of transmission.

Although much is known about STDs in South Africa,¹⁶ it is essential to carry out systematic surveys both to help in understanding their contribution to the current state of the HIV epidemic and also so that interventions to manage these diseases can be assessed both in themselves and for their impact on the spread of HIV. These too should be collected in broad national surveys and at sentinel sites.

It is estimated that even before the epidemic of HIV/AIDS, one in seven black adults died of tuberculosis and the incidence of disease is increasing alarmingly. Although HIV infection increases the risk of developing tuberculosis by five times,²¹ HIV-positive people are more likely to develop disseminated tuberculosis, and therefore to be less infectious than HIV-negative people. We need models that allow us to estimate the likely rise in rates of tuberculosis, to plan and assess interventions which should be an integral part of the strategy to manage HIV.

Migrancy is one of the factors driving the epidemic in southern Africa. While many detailed studies have been done on migrancy,²⁴ only a few have investigated the relationship between migrancy and health.²⁵ The study described in this issue²⁶ is one that attempts to measure the impact of migrancy on the spread of HIV infection.

The models available have given us powerful advocacy tools, and have helped us to develop an understanding of the dynamics of the epidemic, and assess the potential impact and cost-effectiveness of various interventions. But much more is needed.

In future we need linked dynamical models for STDs and for tuberculosis, so that the interactions can be properly understood and the effect of managing these diseases can be correctly assessed. If possible they need to include descriptions of behaviour and sexual networking, since the patterns of infection vary strongly with age, between men and women, and between migrants and non-migrants, for example.¹¹

Once such models are developed they should be used to test the likely impact of possible interventions, from vaccines to persuading adolescents to use condoms.

What can we do?

Perhaps the most important lesson from modelling is also the simplest. Epidemiologists talk about the case reproduction number, R_0 , which is the number of secondary cases that arise from one primary case in a completely susceptible population.²⁷ This tells us the magnitude of the control problem, since if we can reduce R_0 to less than one then each infected person will infect less than one other person, on average, and the prevalence will fall. For HIV R_0 is easy to estimate. We have seen (Fig. 1) that at the start of the epidemic the prevalence doubled every 15 months. This means that each person with HIV infects one other person, on average, every 15 months. If the life expectancy of an infected person is seven years, then each person infected with HIV infects 7/1.25, or six, people before they die. If we can reduce transmission six times, the prevalence of infection will start to fall.

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Care and treatment to extend the working lives of HIV-positive employees: calculating the benefits to business

S. Rosen⁺, J.L. Simon^{*}, D.M. Thea^{*} and J.R. Vincent^{*}

Although HIV infection rates in South Africa have been high and rising for nearly a decade, the epidemic of HIV/AIDS-related morbidity and mortality is just beginning. As South African adults start to sicken and die, concern is mounting about the potential costs to companies of HIV/AIDS among employees. When a business recognizes the threat posed by HIV among employees, it can pursue three basic response strategies for mitigating short- and long-term financial consequences: (1) try to prevent new infections; (2) avoid or reduce the costs associated with existing and future infections; and (3) provide treatment and support for infected employees to extend their productive working lives and thus postpone the costs of infection. This paper assesses the potential benefits to South African businesses of the third strategy. We describe an approach and methods for analysing the benefits of interventions that extend the working life of employees and demonstrate such an analysis using published data on the costs of HIV/AIDS to companies. The analysis indicates that the benefits to companies of investments in treatment and care are likely to exceed the costs for some existing interventions. Further work is needed to identify effective and affordable interventions, assess the benefits to companies of implementing the interventions, and bring these benefits to the attention of business and government leaders.

Although HIV infection rates in South Africa have been high and rising for nearly a decade, the epidemic of HIV/AIDS-related morbidity and mortality is just beginning. As South African adults start to sicken and die, concern is mounting among business managers, shareholders and benefit providers about the potential costs to companies of HIV/AIDS among employees. These costs range from readily measurable impacts on employee benefits, absenteeism, and recruiting and training needs to effects on individual and work unit productivity, morale and discipline that are much more difficult to estimate. Although there is a dearth of reliable information about the true costs of HIV/AIDS to firms — Michael¹ cites South African press reports of employee productivity losses ranging from 2% to 50% — it is evident that the epidemic will impose serious hardships on some businesses in most, if not all, sectors of the economy.

When a company recognizes the threat posed by HIV among employees, it can pursue three basic response strategies for mitigating short- and long-term financial consequences. It can (1) try to prevent new infections; (2) avoid or reduce the costs associated with existing and future infections; and (3) provide

⁺Harvard Institute for International Development, 14 Story Street, Cambridge, MA 02138 U.S.A. E-mail: srosen@hiid.harvard.edu

^{*}Author for correspondence.

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