Epidemiology of HIV in South Africa — results of a national, community-based survey

Catherine Connolly, Mark Colvin, Olive Shishana, David Stoker

Objective. To determine HIV prevalence in the South African population and to investigate risk factors for HIV.

Methods. A national sample of 10 197 households was selected. One child (aged 2 - 14 years), one youth (15 - 24 years) and one adult (25 years and older) were randomly selected from each household. Consenting respondents were interviewed about their socio-demographic characteristics and asked to give an oral mucosal transudate sample to test anonymously for HIV.

Differential response rates were compared using unweighted data. The Orasure HIV-1 device in combination with the Vironostika HIV UNI-Form II plus O enzyme-linked immunosorbent assay kits were used to collect oral fluid specimens for HIV testing. HIV prevalence within subgroups was compared using Rao and Scott's adjusted chi-square. Relative risk was calculated using Poisson regression. All analysis was on the weighted data.

Results. Of the 10 197 households selected, 7 249 (71.1%) were included in the study. Of the 13 518 individuals selected, 9 963 (73.7%) were interviewed. Of these, 8 428 (62.3%) agreed to HIV testing and had valid results.

HIV prevalence in the general population was 11.4% (12.8% in females and 9.5% in males). Blacks had the highest prevalence (12.9%), compared with whites (6.2%), coloureds (6.1%) and Indians (1.6%). Informal settlements in urban areas had the highest HIV prevalence (21.6%).

The findings of this study are consistent with South African Department of Health estimates based on the 2002 antenatal survey.

Conclusion. The Nelson Mandela/Human Sciences Research Council survey included all race, sex and age groups. It is therefore the most reliable and valid source of information on the extent and distribution of the HIV epidemic in South Africa.

S Afr Med J 2004; **94:** 776-781.

The five countries with the highest HIV prevalence rates in the world are situated in southern Africa, and South Africa, with an estimated 4.7 million people living with HIV, has more cases of HIV/AIDS than any other country.[1] The impact of the epidemic on all sectors of society, from urban industries to rural villages, is already being felt and will worsen as more people progress from asymptomatic HIV to AIDS. Information on the extent and distribution of HIV is vital for planning and is the main reason why workplaces, institutions and sectors such as public service, health and education are conducting HIV seroprevalence studies.

Until recently, few national community-based HIV surveys had been undertaken. Instead, most estimates on general prevalence had been extrapolated from annual antenatal surveys. While the antenatal survey has been useful in determining trends over time, it is less reliable for generating population-level estimates.[2,3] This is because the study population consists of pregnant women who use public sector health services. It therefore excludes pregnant women who use private health care, women who are not pregnant, and all men and children. Antenatal surveys in South Africa yield data that can be generalised to 1.8 million pregnant women per year, while population-based surveys generalise to an estimated 44.5 million people.[4]

The Nelson Mandela/Human Sciences Research Council (HSRC) study of HIV/AIDS[5] is the first study of HIV prevalence data drawn from the whole population aged 2 years and older. In addition, data on demographic, socio-economic and behavioural risk factors associated with HIV provide a detailed picture of the distribution and determinants of this devastating epidemic.

Methods

A complex, multi-stage random sample of 1 000 census enumerator areas (EAs) was drawn from a total of 86 000 such areas. From these EAs, clusters of 11 visiting points were identified from census maps and aerial photographs. Of the 10 197 households selected, 7 249 (71.1%) were included in the study.

A census of all persons over the age of 2 years was taken for

Medical Research Council, Durban
Catherine Connolly, MPH

CADRE, Durban
Mark Colvin, MB ChB, MS

Human Sciences Research Council, Cape Town
Olive Shisana, ScD

Private Consultant
David Stoker, Math et Phys Dr

each household, and 1 child (aged 2 - 14 years), 1 youth (15 - 24 years) and 1 adult (25 years and older) living in each household were randomly selected. HIV prevalence in these three age groups was of particular interest. Children were included because little is known about HIV prevalence in children. Youth were chosen because the United Nations General Assembly HIV indicator adopted globally is to measure a reduction in HIV infection among the youth, defined as those aged 15 - 24 years. The remaining persons aged 25 years and older reflects HIV status in the adult population. Three questionnaires were designed, with some overlapping questions and some specific to each age group. Retired nurses were trained as data collectors and were matched culturally with the community in which they were working. The Orasure HIV-1 oral specimen collection device in combination with the Vironostika HIV UNI-Form II plus O enzyme-linked immunosorbent assay (ELISA) kits were used to determine HIV status. There was no repeat on positive HIV tests. This is in line with the World Health Organisation (WHO) strategy designed for populations where HIV prevalence is over 10%.

Ethical approval was obtained from the HSRC. Written informed consent was obtained from all participants over the age of 14 years and verbal assent was obtained from children aged 2 - 14 years.

Of the 13 518 individuals selected, 9 963 (73.7%) were interviewed. Of these, 8 428 agreed to HIV testing and had valid results. A more detailed description of the methodology and analysis of non-response has been reported in a previous paper.[6]

Demographic data were collected for all sampled individuals as part of the household census. Table I presents the demographic characteristics of persons refusing both the questionnaire and HIV test, those refusing HIV testing only, and those who were fully compliant. The most common reasons for non-participation were: (*i*) not willing to participate in any survey (25%); (*ii*) not available now (17%); (*iii*) too busy to grant an interview (8.8%); (*iv*) apprehensive about a saliva sample being taken (8.2%); and (*v*) objection to the topic of the survey, viz. HIV/AIDS (4.5%). Non-participation rates were

Table I. Comparison of characteristics of non-participants (those refusing both questionnaire and HIV testing) and respondents (those agreeing to both questionnaire and HIV testing) (all ages)

	Non-participants		Participants who refused HIV testing		Fully compliant respondents	
	N	%	*N*	%	*N*	%
Age group (yrs)						
2 - 14	851	22.8	531	14.2	2 348	63.0
15 - 24	1 029	29.8	329	9.5	2 099	60.7
25 - 49	1 178	27.3	443	10.3	2 696	62.5
50+	497	24.7	232	11.5	1 285	63.8
Sex						
Male	1 833	29.1	704	11.2	3 772	59.8
Female	1 722	23.9	831	11.5	4 656	64.6
Race						
Black	1 875	24.0	871	11.2	5 056	64.8
White	634	42.0	176	11.7	701	46.4
Coloured	613	23.5	221	8.5	1 775	68.0
Indian	433	27.1	267	16.7	896	56.1
Locality type						
Rural (tribal)	666	23.4	367	12.9	1 818	63.8
Rural (farm)	185	22.0	84	10.0	572	68.0
Urban (formal)	2 255	27.2	946	11.4	5 103	61.5
Urban (informal)	449	29.5	138	9.1	935	61.4
Province						
Western Cape	486	26.9	56	3.1	1 267	70.0
Eastern Cape	389	20.8	265	14.1	1 221	65.1
Northern Cape	184	20.2	35	3.8	694	76.0
Free State	184	22.9	81	10.1	540	67.1
KwaZulu-Natal	620	23.5	445	16.8	1 579	59.7
North West	306	29.4	110	10.6	626	60.1
Gauteng	612	28.6	255	11.9	1 272	59.5
Mpumalanga	410	39.8	70	6.8	550	53.4
Limpopo	364	28.9	218	17.3	679	53.8

higher among persons aged 15 - 24 and lower among those aged 2 - 14. Refusal to participate was more frequent among males, whites and persons in Mpumalanga province. This is likely to reflect problems of accessibility and absenteeism in spite of repeat visits to the household.

Persons who agreed to be interviewed but who refused an HIV test represent a greater potential bias because the reason for refusal may have been linked to HIV status. These data have been presented by Shisana *et al.*,[6] who conclude that while differences in demographic factors exist, the reasons given for test refusal were not related to HIV status. More importantly there were no differences between participants and non-participants in behavioural risk factors associated with HIV.

Statistical analysis

Differential non-response was analysed using unweighted data. Prevalence rates were calculated using weighted data. The sampling weight was a product of the EA, household and individual sampling weights and was adjusted for non-response. Standard error calculations used procedures that account for stratification and clustering in the survey design. HIV prevalence in subgroups was compared using Rao and Scott's adjusted chi-square.[7] Relative risk (RR) was calculated using Poisson regression on the unweighted data. The 95% confidence intervals (CIs) reported are based on a logit transformation and are not symmetrical. A multivariable logistical model was used to identify independent risk factors associated with HIV.

Results

HIV seroprevalence in the population of persons aged 2 years and older was estimated to be 11.4% (CI: 10.0 - 12.7). Women had a significantly higher HIV prevalence rate than men (RR: 1.3, CI: 1.1 - 1.6, $p = 0.005$), as shown in Table II.

Blacks were more likely to be HIV-positive than whites (RR 2.0, CI: 1.3 - 3.3), coloureds (RR 2.0, CI: 1.4 - 3.3) or Indians (RR: 10, CI: 2.5 - 25). Indians had significantly lower HIV prevalence than any other racial group (Table II).

Within racial groups, black females were at greater risk than black males (RR: 1.3, CI: 1.1 - 1.7). While females of other racial groups had higher prevalence rates than males of the same race, the difference did not reach statistical significance (RR: 1.2, CI: 0.7 - 2.1). As shown in Fig. 1, HIV prevalence peaked in women aged 20 - 29 years (24.1%), and in men at age 30 - 39 (21.3%). Of the 244 women who had been pregnant in the last 12 months, 24% were HIV-positive (CI: 16.5 - 33.6). The age distribution of the pregnant women was similar to that of women in the 2002 antenatal survey (DOH, 2003).

Informal settlements in urban areas showed the highest HIV prevalence rate when compared with urban formal areas (RR 1.8, CI: 1.7 - 3.5), rural informal areas (RR 2.5, CI: 1.7 - 3.5) or rural formal areas (RR 2.8, CI: 1.7 - 4.4), as shown in Table III. Women living in rural areas had a similar HIV prevalence rate to men (Table III) (RR: 1.2, CI: 0.8 - 1.6), whereas women in urban areas had significantly higher HIV levels than men (RR: 1.4, CI: 1.1 - 1.9). Informal areas are areas with limited infrastructure and shack-like housing.

HIV prevalence varied significantly by province, from 6.6% in the Eastern Cape to 14.9% in the Free State (Fig. 2). The CIs of the top four provinces overlap, suggesting that the differences are not statistically significant.

When age, sex, race and residence were entered in a multivariable logistical model, all factors remained statistically significant. However when the data were stratified by race (black versus other racial groups), the risk factors remained significant only in the black racial group (*p*-value for sex =

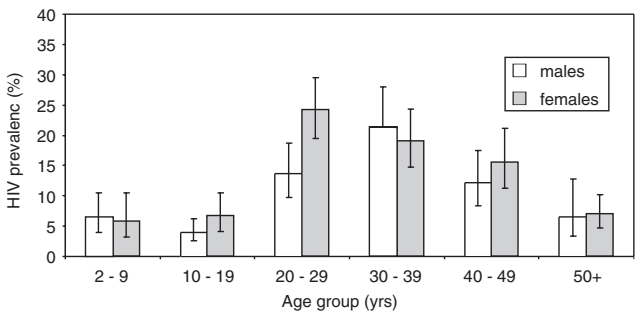

Fig. 1. Prevalence of HIV by sex and age, South Africa 2002.

Table II. HIV prevalence by race and sex, ages 2 - 99 years

	Male			Female			Total		
	N	%	95% CI	*N*	%	95% CI	*N*	%	95% CI
Black	2 229	10.8	9.0 - 12.8	2 827	14.5	12.4 - 16.8	5 056	12.9	11.3 - 14.6
White	334	5.2	2.6 - 9.8	367	7.0	3.6 - 13.3	701	6.2	3.7 - 10.0
Coloured	788	5.5	3.8 - 7.9	987	6.6	4.1 - 10.3	1 175	6.1	4.5 - 8.3
Indian	421	2.7	0.6 - 11.1	475	0.6	0.2 - 1.9	896	1.6	0.5 - 5.0
Total	3 772	9.5	8.1 - 11.2	4 656	12.8	11.0 - 14.7	8 428	11.4	10.1 - 12.7

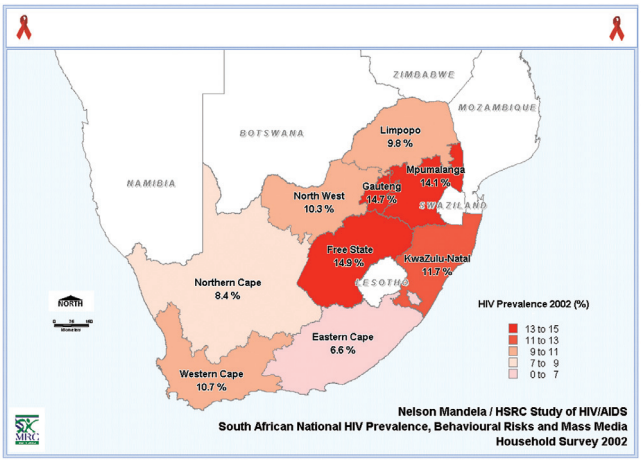

Fig. 2. HIV prevalence by province in South Africa — Nelson Mandela/HSRC Study of HIV/AIDS.

0.052). The main distinction was the lack of an age differential among other racial groups when compared with the strong association of age and HIV in blacks.

Discussion

A number of studies[1,8-10] have estimated HIV prevalence in various population groups within South Africa. Each has used a different methodology. The 2001 Department of Health[10] estimate of HIV prevalence in women aged 15 - 49 years attending government antenatal clinics was 24.8% (CI: 23.6 - 26.1). The DOH 2002[11] estimate was 26.5% (CI: 25.5 - 27.6). The Dorrington model,[9] which is based on the antenatal figures, estimated the prevalence in this group to be 25.9%. The prevalence among pregnant women in the Nelson Mandela/HSRC study is again very similar, at 24% (CI: 16.5 - 33.6).

However the population estimate for black and coloured women aged 15 - 49 years in the Nelson Mandela/HSRC surveys was much lower, at 19.2% (CI: 16.5 - 22.3). Since the age distribution of women attending antenatal clinics may be different from that in the community, the Nelson Mandela/ HSRC rate was standardised to the age distribution of the antenatal clinic attendees. The standardised rate was 21.4% (CI: 20.8 - 22.6) which, although still lower, is closer to the DOH rate.[11]

Rehle and Shisana[8] have estimated HIV prevalence in the adult population (males and females, all races, aged 15 - 49 years). The Nelson Mandela/HSRC survey[5] estimated the prevalence in this age group to be 15.6% (CI: 13.9 - 17.6). Using the Epi model and Spectrum, Rehle and Shisana estimated the prevalence to be 17.4% for 2001. The measured prevalence and the projected prevalence fall within the same confidence intervals.

Table IV compares the HIV prevalence estimates from the present study with those of the DOH 2001 antenatal study[10] and the modelled estimates of Dorrington *et al.*[9] by province. With the exception of the Western Cape, HIV prevalence estimates from the Nelson Mandela survey are lower than those of the DOH 2001 study. The estimates were significantly lower in KwaZulu-Natal, the Free State and the Eastern Cape, and higher in the Western Cape. Standardisation brings the rates slightly closer but the differences in these four provinces remain.

Table V shows the age-specific prevalence rates. In women aged less than 24 years the antenatal rate is higher than the Nelson Mandela/HSRC rate for black and coloured women and the antenatal rates for women aged 40 - 44, lower than the corresponding HSRC rates.

Based on a prevalence of 11.4%, the estimated number of cases in 2001 is 5.1 million. This is comparable to the UNAIDS[1] estimate of 5 million and that of Rehle and Shisana[8] of 4.69 million. Bearing in mind that the present survey included persons 2 years or older, the HIV prevalence as estimated is lower than estimates from other sources such as the projections based on the Dorrington model (14.2%).[9] However adult (15 - 49 years) estimates appear to be closer: Nelson Mandela/HSRC (15.6%),[5] DOH 2001 (19.3%),[10] Rehle and Shisana (17.4%)[8] and UNAIDS (20.1%).[1] For women aged 15 - 49, the estimates are slightly closer: Nelson Mandela HSRC (21.4% standardised; 24% pregnant women)[5] and DOH 2001 (24.8%).[10] This comparability of data from similar populations indicates that the Nelson Mandela/HSRC study of HIV/AIDS data is probably not significantly biased. This is an important issue because before the Nelson Mandela/HSRC study, all population-level estimates of the prevalence of HIV were modelled on antenatal data and extrapolated from pregnant women to the whole population based on many assumptions.

Table III. HIV prevalence by gender and locality type

	Males			Females			Total		
Locality type	*N*	% HIV	95% CI	*N*	% HIV	95% CI	*N*	%	95% CI
Rural formal	298	6.0	3.6 - 9.8	274	9.6	5.3 - 16.4	572	7.8	5.2 - 11.6
Rural informal	729	8.4	6.0 - 11.7	1 089	9.0	6.7 - 12.1	1 818	8.8	6.8 - 11.3
Urban formal	2 266	9.2	7.2 - 11.7	2 837	13.9	11.5 - 16.7	5 103	11.9	10.2 - 13.8
Urban informal	479	17.6	13.0 - 23.5	456	25.5	18.2 - 34.5	935	21.6	17.1 - 26.9
Total	3 772	9.5	8.1 - 11.2	4 656	12.8	11.0 - 14.7	8 428	11.4	10.1 - 12.7

Table IV. Comparison between Nelson Mandela/HSRC[5] provincial HIV prevalence estimates and data from the antenatal survey[11] and the modelled estimates of Dorrington *et al*.[9]

Province	Estimated (HIV+) 95% CI for year 2001	Nelson Mandela/HSRC 2001*	Standardised rate† (%)	Dorrington *et al*.‡ 2001 (%)
KwaZulu-Natal	33.5 (30.6 - 36.4)	22.1 (16.2 - 29.5)	22.7	34.5
Mpumalanga	29.2 (25.6 - 32.8)	23.4 (15.9 - 33.3)	24.8	30.2
Gauteng	29.8 (27.5 - 32.1)	27.7 (20.0 - 37.0)	29.3	25.0
Free State	30.1 (26.5 - 33.7)	14.6 (8.5 - 24.2)	17.7	28.9
North West	25.2 (21.9 - 28.6)	18.5 (11.3 - 28.9)	22.1	26.3
Eastern Cape	21.7 (19.0 - 24.4)	12.0 (8.1 - 17.0)	14.9	23.8
Limpopo	14.5 (12.2 - 16.9)	11.8 (7.5 - 18.1)	13.7	22.7
Northern Cape	15.9 (10.1 - 21.6)	11.8 (7.4 - 18.1)	19.4	14.8
Western Cape	8.6 (5.8 - 11.5)	20.7 (12.0 - 33.4)	23.9	8.4
National	24.8 (23.6 - 26.1)	19.2 (16.5 - 20.7)	21.4	25.9

Overall estimates of HIV prevalence, with 95% confidence intervals in brackets.
‡Child-bearing women (15 - 49 years).
*Black and coloured women (15 - 49 years).
†Nelson Mandela HSRC rates for black and coloured women standardised to the antenatal population.

Table V. Comparison by age band between antenatal data and Nelson Mandela/HSRC data[5]

Age group (yrs)	Antenatal data 2001	Nelson Mandela/HSRC data		
		Total sample	All women	Black and coloured women
15 - 19	15.4 (13.8 - 16.9)	5.9 (4.0 - 8.8)	7.3 (4.7 - 11.3)	8.1 (5.2 - 12.5)
20 - 24	28.4 (26.5 - 30.2)	13.2 (10.4 - 16.7)	17.1 (12.9 - 22.3)	17.5 (13.2 - 22.9)
25 - 29	31.4 (29.5 - 33.3)	28.4 (22.9 - 34.6)	32.0 (24.9 - 40.1)	35.3 (27.4 - 44.1)
30 - 34	25.6 (23.5 - 27.7)	24.1 (19.0 - 30.1)	24.1 (17.3 - 32.5)	27.0 (19.4 - 36.1)
35 - 39	19.3 (17.0 - 21.5)	15.6 (11.2 - 21.3)	13.8 (8.7 - 21.1)	15.5 (9.7 - 23.8)
40 - 44	9.1 (6.2 - 11.9)	16.4 (12.1 - 22.0)	19.0 (12.9 - 27.2)	20.9 (14.0 - 30.0)
45 - 49	17.8 (4.3 - 31.4)	11.5 (7.9 - 16.6)	11.2 (6.5 - 18.7)	11.0 (5.9 - 19.4)

Overall estimates of HIV prevalence, with 95% confidence intervals in brackets.

It is likely that the Nelson Mandela/HSRC data for non-pregnant women will be more reliable as these data are based on empirical measurement rather than modelling. Further work is needed to incorporate the age/race/sex estimates from this survey to recalibrate and refine existing models.

The higher HIV prevalence found among young women participating in the 2002 antenatal survey compared with that measured among young women in the community and the opposite finding among older women, may be due to inherent biases in antenatal data. Antenatal data are likely to overestimate HIV prevalence in women under 20 because such data are based only on data from sexually active women who recently engaged in unprotected sex resulting in pregnancy.[2,3] Antenatal data are likely to underestimate HIV prevalence in the over-30s because fertility is lower among people living with HIV[12] and because of possible voluntary reduction in fertility among those who know their HIV status.

When considering the association between demographic variables and HIV infection, race remains an important predictor variable, with black people being at substantial and significantly higher risk. However, there is no biological evidence that particular races are at higher or lower risk and so the challenge remains to determine the behavioural variables for which race is a proxy indicator. We hope to provide some answers in a forthcoming paper investigating the relationships between demographic, socio-economic and behavioural variables.

Apart from limited data from workplace-based studies, there have been no unbiased data sources on the prevalence of HIV among whites in South Africa. This has led to the myth that HIV is essentially an 'African' disease. Our study has shown that HIV occurs in all race groups and that the prevalence among whites is the highest documented population-level prevalence in the world, contrasting starkly with prevalence in North America, Europe and Australasia where the general population prevalence is below 1%.[1] A prevalence level of 1% or higher is also indicative of a generalised, heterosexual epidemic because epidemics confined to subgroups such as homosexuals or injecting drug users cannot account for a level of 6.2% obtained from community-based studies such as ours.

The finding that more women than men are living with HIV is compatible with findings from many other studies in sub-

Saharan Africa. It is believed that the sex differential in prevalence reflects a biological, social and behavioural higher HIV risk among women. The observation that HIV prevalence peaks earlier in women than men has also been reported previously and probably reflects the fact that men tend to have sexual partners younger than themselves.[13-15] Data from our study support this contention in that 11.5% of women had partners who were 10 years or more older than themselves and the HIV prevalence in this group was 31.8%

A previously unreported finding is the high prevalence of HIV in urban informal areas compared with urban formal areas and rural areas. This is not surprising given the transient nature of life and lack of social cohesion in such settlements. Clearly these areas need to be targeted by appropriate HIV prevention campaigns.

The response rate for the study was lower than we would have liked. Several operational processes contributed to this result such as the delay between sampling respondents and interviews, loss of specimens, and lack of accessibility because of inclement weather. These factors can be corrected in future studies. However, subgroups refusing HIV testing for personal or religious reasons remain a concern. Non-response in whites was 42.0% compared with 24% in blacks. A higher proportion of non-responding whites and Indians were 'not willing to participate in any survey/interview'. Fear or lack of interest could account for their reaction. A higher proportion of non-responding youth (15 - 24 years) than older people were 'not available' at the time of the study, probably reflecting the mobility of this subgroup. Special attention needs to be paid to improving levels of co-operation by increasing HIV awareness and testing to ensure that future large HIV prevalence surveys are not negatively affected.

HIV prevalence in two provinces was significantly different from previous estimates. The explanation for the lower rates found in KwaZulu-Natal in this survey compared with the antenatal survey,[11] even after standardisation, may be that in KwaZulu-Natal the 35 clinics used in the antenatal survey are all located along main roads which are known to be high transmission areas.[16] Therefore, the results from the KwaZulu-Natal antenatal survey may overestimate the prevalence.

The present study found a higher HIV prevalence in the Western Cape than that found in antenatal data. This may be because of sampling bias. The antenatal data may not have included sufficient numbers of people living in informal settlements and black townships. The high prevalence of HIV in the Western Cape found in this study corresponds with the behavioural indicators, which show that youth in that province have the highest rate of ever having had sex, and the fourth highest HIV prevalence among youth. Respondents were asked if they had changed behaviour in the last few years because of widespread HIV infection. Only 35.2% of residents in the Western Cape reported behaviour change, which was the second lowest rate of behaviour change among provinces.

Other limitations of the survey include the omission of under 2-year-olds and residents in institutions such as the uniformed forces and those in university hostels. These omissions did not significantly alter the findings as shown in the modelling of HIV/AIDS in South Africa.[8]

The Nelson Mandela/HSRC survey[5] sampled people from all walks of life, from different races, age groups, sex groups and locality type. The strength of the survey is that, for the first time, prevalence data are available on a sample representing the whole country.

In conclusion, we believe that the data presented here are the most reliable and valid source of information for understanding the extent and distribution of the HIV epidemic in South Africa. These data will enable researchers and policy makers from a variety of sectors and institutions to estimate the prevalence of HIV among their specific populations.

This study was funded by the Nelson Mandela Foundation, Nelson Mandela Children's Fund, Human Sciences Research Council and the Swiss Agency for Development and Co-operation.

References

1. UNAIDS/World Health Organization. Report on the global HIV/AIDS epidemic 2002. XIV International Conference on AIDS, Barcelona, 7 - 11 July 2002.
2. Kigadye R, Klokke A, Nicoll A, *et al*. Sentinel surveillance for HIV-1 among pregnant women in a developing country: 3 years' experience and comparison with a population serosurvey. *AIDS* 1993; **7:** 849-855.
3. Fylkesnes K, Ndhlovu Z, Kasumba K, Musonda RM, Sichone M. Studying the dynamic of the HIV epidemic: Population-based data compared with sentinel surveillance in Zambia. *AIDS* 1998; **12:** 1227-1234.
4. Statistics South Africa. *Census 2001, Census in Brief*. Pretoria: Stats SA, 2003.
5. Nelson Mandela/Human Sciences Research Council. *South African National HIV Prevalence, Behavioural Risks and Mass Media Household Survey 2002*. Cape Town: Human Sciences Research Council, 2002.
6. Shisana O, Stoker DJ, Simbayi L, *et al*. South African National Household Survey of HIV/AIDS Prevalence, Behavioural Risks and Mass Media Impact: Detailed methodology and response rate results. *S Afr Med J* 2004; **94:** 283-288.
7. Rao JNK, Scott AJ. On chi-squared tests for multiway contingency tables with cell proportions estimated from survey data. *Annals of Statistics* 1984: **12:** 46-60.
8. Rehle TM, Shisana O. Epidemiological and demographic HIV/AIDS projections: South Africa. *African Journal of AIDS Research* 2003; **2**(1): 1-8.
9. Dorrington RE, Bradshaw D, Budlender D. *HIV/AIDS Profile of the Provinces of South Africa: Indicators for 2002*. Cape Town: Centre for Actuarial Research, Medical Research Council and the Actuarial Society of South Africa, 2002.
10. Department of Health. *National HIV Sero-Prevalence Survey of Women Attending Public Antenatal Clinics in South Africa*. Pretoria: DOH, 2002.
11. Department of Health. *National HIV and Syphilis Antenatal Sero-Prevalence Survey in South Africa 2002*. Pretoria: DOH, 2002.
12. Gray RH, Wawer MJ, Serwadda D, *et al*. Population-based study of fertility in women with HIV-1 infection in Uganda. *Lancet* 1998; **351:** 98-103.
13. Abdool Karim Q. Barriers to preventing human immunodeficiency virus in women: Experiences from KwaZulu-Natal, South Africa. *J Am Med Womens Assoc* 2001; **56:** 193-196.
14. Gregson S, Nyamukapa CA, Garnett GP, *et al*. Sexual mixing patterns and sex-differentials in teenage exposure to HIV infection in rural Zimbabwe. *Lancet* 2002; **359:** 1896-1903.
15. MacPhail C, Williams, BG, Campbell C. Relative risk of HIV infection among young men and women in a South African township. *Int J STD AIDS* 2002; **13:** 331-342.
16. Barongo L, Borgdorff MW, Mosha FF, *et al*. The epidemiology of HIV-1 infection in urban areas, roadside settlements and rural villages in Mwanza Region, Tanzania. *AIDS* 1992; **6:** 1521-1528.

Accepted 31 May 2004.