# Masking through averages – intraprovincial heterogeneity in HIV prevalence within the Western Cape

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*Objective*. To measure HIV prevalence at health-district level in the Western Cape (WC) and to compare these findings with those of the National HIV Antenatal Surveys (NHASs). This investigation aimed to estimate the degree of heterogeneity of HIV prevalence within the province in order to inform the design of appropriate and targeted HIV interventions.

*Method*. Annual cross-sectional, unlinked district HIV antenatal surveys were implemented in all 25 health districts of the WC for the years 2001 - 2004, concurrently with the NHAS. A stratified proportional sample was drawn for each district, involving all 344 antenatal clinics in the province, and the anonymous screening method as described by the World Health Organization (WHO) was applied.

*Results*. The NHAS revealed a significant increase in HIV prevalence in the WC from 8.6% (95% confidence interval (CI): 5.6 - 11.6) in 2001 to 15.4% (95% CI: 12.5 - 18.2) in 2004. The district-level HIV surveys showed wide variation in HIV prevalence across the health districts, which increased progressively during this period (a range of 0.6 - 22% for the year 2001 increased to 1 - 33% in 2004). Spatial analysis of HIV prevalence by health district for this period also revealed progressive spatial growth of the sub-epidemics, with the highest prevalence observed in districts located in the Cape metropole region.

*Conclusions*. These concurrent surveys highlight the fact that examining a provincial estimate of HIV prevalence alone has the potential to mask epicentres within the province. This underscores the importance of expanding the surveillance systems to detect heterogeneity sub-provincially, in order to link with local-level planning and resource allocation.

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It is well established that the HIV/AIDS pandemic is most concentrated in sub-Saharan Africa (SSA). However, within the region, temporal trend data show that the epidemic in SSA is far from being a single epidemic.[1,2] There is a wide variation in HIV prevalence at the subregional level, with southern Africa (25.7%) reporting a significantly higher HIV prevalence than eastern (11.4%) or western Africa (4.3%) in 2001.[1] Within southern Africa, although South Africa ranks as having a relatively lower HIV prevalence than neighbouring countries such as Botswana (37.3%), Lesotho (28.9%) and Swaziland (38.8%), the absolute size of South Africa's population makes the scale of the epidemic significantly larger.[1] Out of a population of 43 million, it is estimated that 5.6 million people in South Africa are HIV-infected, ranking South Africa as one of the countries with the highest number of people living with HIV and AIDS in the world.[1,2] The HIV epidemic in South Africa is characterised as being a generalised, mature epidemic largely affecting young, sexually active, heterosexual adults.[3]

These estimates derive largely from the National HIV Antenatal Surveys (NHASs),[3,4] which have been conducted by the National Department of Health (DOH) over the last 15 years. The surveys involve select public-sector clinics, and remain the primary source of data to track the epidemic among young, sexually active adults. This method of surveillance was developed for countries experiencing a generalised epidemic and this form of surveillance is applied in many developed and developing countries.[5] Pregnant women are examined on the basis that they are considered to be healthy individuals accessing the health services, and blood tests are done routinely at their first antenatal visit. Trend data from these NHAS surveys show consistent interprovincial variation over the last decade. In 2004, the lowest HIV prevalence rate was reported in the Western Cape (WC) at 15.4%, with the highest rate in KwaZulu-Natal at 40.9%.[3] This interprovincial variation was also observed in the Nelson Mandela National Household HIV Survey[6] (the latter survey showed variation in HIV prevalence among adults aged 15 - 49 years, ranging from 9.6% in the Northern Cape to 21% in Mpumalanga) and in the report on the national death notification system.[7] Bradshaw *et al*.[7] showed provincial differences in the mortality profile derived from the death notification system, with age-standardised death rates due to HIV in the WC (72/100 000) ranking the lowest of all 9 provinces, and KwaZulu-Natal (574/100 000) the highest in rates for the year 2000. However, little is known about the

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degree of variation of HIV prevalence, levels of morbidity or mortality at district level.

Clearly, from an epidemiological and programmatic perspective it is no longer appropriate to view the HIV epidemic as a single epidemic.[1] This is particularly relevant for the planning and delivery of public health programmes and services in South Africa, given the state's commitment to delivering public health services through a district health system, as outlined in the national health plan (National Health Act (Act No. 61 of 2003)). The relatively low overall HIV prevalence for the WC reported in the NHAS reports, contradicted the number of AIDS-related morbidity and mortality cases that were being reported at health facilities and from the death notification system.[3,7] This raised the question of whether the provincial estimates were actually masking local-level variation or local epidemics.

Understanding the degree of variation and the magnitude of the HIV problem at district level in the WC became particularly critical to public health managers during the planning phase of the various HIV intervention programmes such as the prevention of mother-to-child transmission (PMTCT) programme, the highly active antiretroviral treatment (HAART) programme and the voluntary counselling and testing (VCT) programme as these programmes are essentially managed at district level. Therefore, a health district-level investigation was undertaken within the WC in the year 2000 in the form of a pilot study of 5 health districts; this was scaled up to include all 25 health districts from the year 2001. This article presents the findings of the health district-level surveys, highlighting the variation in magnitude and spread of the HIV epidemic at district level for the years 2001 and 2004 and the importance of district-level surveillance.

## Methods

### Study setting

The WC has a population of 4 187 035, occupies an area of 129 527 km$^2$ and is the second wealthiest province in the country.[8] It is highly urbanised with more than two-thirds of the population living in the Cape metropole region. In terms of health provision, 344 service points provide antenatal care through the public sector, and the annual number of births reported at these facilities in the year 2001 was estimated at 98 512. Despite its relative wealth, income, poverty and inequality varies significantly within the province. This is no different with regard to various measures of health status. Specific health challenges such as tuberculosis co-exist with chronic diseases of lifestyle, namely hypertension and diabetes.[8] Overriding this mixed spectrum of diseases, the province is also experiencing a rapidly growing HIV epidemic.[9]

### Survey design and sampling for the national/provincial survey (NPS)

A cross-sectional sentinel HIV antenatal survey has been conducted in the WC since 1990 as part of the national HIV survey (NPS).[3] The protocol for this NPS is based on the World Health Organization (WHO) guidelines[5] for unlinked anonymous seroprevalence surveys. The sampling design is a two-stage systematic random cluster sampling, using the probabilities proportion to size (PPS) method for weighting,[3] with a fixed sample size set at 2 040.

### Survey design for district-level surveys (DLSs)

In 2000, a pilot study was conducted in 5 of the 25 health districts in the WC.[9] As from 2001, district-level HIV surveys were scaled up to involve all the 25 health districts within the WC. The DLSs entailed 25 separate cross-sectional studies, which included all 344 antenatal public health facilities within the province. These surveys were carried out over the period October - November from 2001 to date. The sampling process for each health district was determined by drawing a proportional stratified sample for each health district. The sample size was determined by specifying a 3 - 4% error margin (the use of an acceptable error margin was weighed against the technical and logistical resources available to implement the survey), a 95% confidence interval (CI), an estimated HIV prevalence (in the absence of baseline HIV information, estimates were drawn from the PMTCT data, the pilot district HIV surveys and national HIV survey data for 2000) and the reported annual first-time antenatal clinic attenders in the district. The sample size was proportionally allocated to reflect the distribution of the annual first antenatal visits by facility within a specified health district, which produced a self-weighting sample for each district.

### Inclusion criteria and data collection

The surveys examined pregnant women who attended public-sector clinics for their first booking visit. For the purposes of the HIV surveys, an extra tube of blood was drawn after the woman had consented to participate. The surveys were anonymous, with blood specimens and test results identified by barcode number. Fieldwork for the NPS and DLSs was conducted simultaneously. Training workshops were held at regional and district levels. Standard operational guidelines, posters, and algorithms were developed to guide the clinical and laboratory staff when conducting the survey.

### Laboratory testing

HIV antibody testing was performed on the serum using the AxSYM HIV1/2gO assay (Abbott Diagnostics, Delkenheim, Germany). During the period of low prevalence (< 10%) in the WC, a second assay, the Vironostika HIV Uni-Form II plus O

Microelisa system (Organon Tecknika, Boxtel, Netherlands) was used to confirm reactive results. Panels of specimens for quality control purposes were supplied by the National Institute of Virology for HIV (20 specimens) and the results of the quality control specimens were validated by this institution before commencement of the survey.

### Data processing and analysis

The provincial HIV prevalence was determined from the NPS dataset after adjusting for the cluster sampling technique, with the sentinel sites representing a primary sampling unit. Weighting of the HIV prevalence at district level was not required as the sampling design ensured self-weighting. The HIV prevalence for the WC was also determined from the district-level surveys, after adjusting for the proportional distribution of first-time antenatal clinic attenders across districts, the non-response rate and the specimen return rate.

## Results

The specimen return rates for the NPS for the years 2001 and 2004 were 99% and 93%, respectively.[4] The return rates and sample sizes for individual district surveys for the years 2001 and 2004 are presented in Table I. The sample size per district increased over time, given that the sample size calculation was based on a binomial distribution, adjusting for changes in HIV prevalence based on the previous year's district survey results.

**Table I. Sample size and realised samples by district, Western Cape 2001 - 2004 (*N* (%))**

| District | 2001 *N* = 3 803 (realised sample) | 2004 *N* = 8 336 (realised sample) |
|---|---|---|
| Blaauwberg | 84 (93) | 170 (99) |
| Cape Town Central | 117 (91) | 285 (100) |
| Greater Athlone | 156 (76) | 355 (99) |
| Helderberg | 154 (81) | 538 (99) |
| Khayelitsha | 294 (84) | 729 (93) |
| Mitchells Plain | 159 (93) | 230 (97) |
| Gugulethu/Nyanga | 170 (73) | 615 (100) |
| Oostenberg | 195 (98) | 424 (110) |
| South Peninsula | 119 (100) | 332 (100) |
| Tygerberg Eastern | 182 (100) | 299 (100) |
| Tygerberg Western | 189 (100) | 333 (99) |
| Bredasdorp/Swellendam | 76 (95) | 155 (90) |
| Caledon/Hermanus | 135 (94) | 441 (94) |
| Ceres/Tulbagh | 116 (70) | 258 (100) |
| Worcester/Robertson | 159 (91) | 190 (100) |
| Malmesbury | 118 (96) | 315 (51) |
| Paarl | 251 (92) | 349 (100) |
| Stellenbosch | 188 (97) | 273 (70) |
| Vredenburg | 116 (87) | 303 (86) |
| Vredendal | 116 (80) | 150 (91) |
| Knysna/Plettenberg Bay | 147 (61) | 434 (89) |
| Klein Karoo | 150 (87) | 196 (63) |
| Mossel Bay/Langeberg | 149 (77) | 382 (73) |
| George | 152 (65) | 373 (83) |
| Central Karoo | 111 (82) | 207 (75) |
| | Non-response *f* = 86 | Non-response *f* = 118 |

### HIV prevalence

Fig. 1 shows HIV prevalence trends according to the NHAS for the WC and the country as a whole for the period 1990 - 2004. There is a clear depiction of a linear increase in the prevalence over this 14-year period for both the WC and South Africa as a whole. The data show a consistently lower prevalence within the WC relative to the national estimates, over the entire 14-year period. In 2001, the national HIV prevalence stood at 24.8% (95% CI: 23.6 - 26.1), and for the WC 8.6% (95% CI: 5.6 -11.6) (Table II). The most recent data for the year 2004 indicate a national prevalence of 29.5% (95% CI: 25.5 - 27.6) and a figure of 15.4% for the WC (95% CI: 12.5 - 18.2).[4] The 2001 district-level surveys revealed wide variation in HIV prevalence for the districts, ranging from 0.6% to 22.4%, with an overall provincial weighted mean of 9.1% (95% CI:8.1 - 10.1). The lowest prevalence within the province for 2001 was in the Blaauwberg district at 0.6%, and the highest was 22.4% recorded for the Khayelitsha health district. In 2004, this intraprovincial variance widened considerably. The HIV prevalence across health districts ranged from 1% to 33%, with an overall provincial weighted mean of 14.9% (95% CI: 14.0 - 15.6). The largest percentage point increase over the 2001 - 2004 period was recorded for the Gugulethu/Nyanga district, where the prevalence rose from 16.1% to 29.1%, a 13.0% point increase.

In contrast, the prevalence for the province as a whole increased by 5.8% points. Notably, the gap between the lowest and highest HIV prevalence rates widened significantly between 2001 and 2004, from 21.4% to 31.8% points. In addition to the variation in magnitude of HIV infection, trend data show variation in the growth of the epidemic at district level. There was significant percentage point change in HIV prevalence in 14 of the 25 health districts for the period 2001 - 2004. Figs 2 and 3 show the spatial representation of HIV prevalence by district. In the earlier phase of the epidemic in 2001, districts

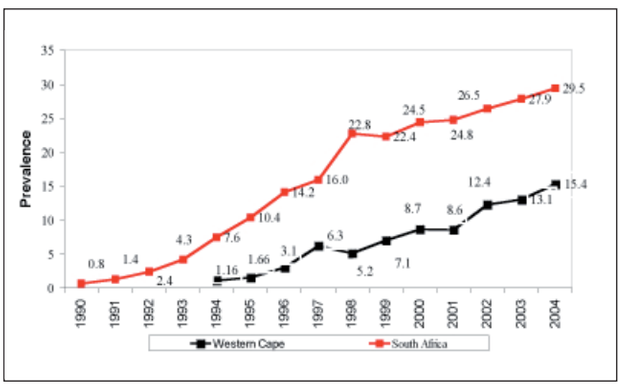


*Fig. 1. HIV prevalence among antenatal clinic attenders – trends for the Western Cape versus South Africa, 1990 - 2004.*

**Table II. Western Cape HIV prevalence by health district, 2001 and 2004**

| Health district | 2001 prevalence (%) | 2004 prevalence (%) | Change in prevalence (%) | 95% confidence interval (low - upper) |
|---|---|---|---|---|
| Caledon/Hermanus | 13.0 | 12.5 | -0.5 | -7.8 - 6.1 |
| Helderberg | 19.0 | 18.8 | -0.2 | -7.8 - 7.7 |
| Blaauwberg | 0.6 | 1.2 | 0.6 | -2.8 - 2.9 |
| Paarl | 8.3 | 8.9 | 0.6 | -4.2 - 5.3 |
| < 1 percentage point change | | | | |
| Worcester/Robertson | 5.7 | 8.4 | 2.7 | -2.8 - 8.3 |
| George | 10.0 | 13.3 | 3.0 | 1.3 - 12.3 |
| Central Karoo | 5.5 | 8.9 | 3.0 | -2.6 - 9.2 |
| Malmesbury | 2.7 | 6.2 | 3.5 | -0.2 - 7.8 |
| Vredenburg | 8.9 | 13.0 | 4.1 | -2.4 - 10.9 |
| Knysna/Plettenberg Bay | 13.3 | 17.4 | 4.1 | -3.2 - 11.1 |
| Ceres/Tulbagh | 6.2 | 10.5 | 4.3 | -1.5 - 10.4 |
| Vredendal | 1.3 | 5.8 | 4.5 | -0.3 - 8.9 |
| 1 - 4.9 percentage point change | | | | |
| Mossel Bay/Langeberg | 7.0 | 12.5 | 5.0 | 0.4 - 11.3† |
| Klein Karoo | 0.8 | 6.5 | 5.7 | 2.1 - 9.8† |
| South Peninsula | 5.9 | 12.1 | 6.2 | 0.4 - 11.9† |
| Tygerberg Western | 7.9 | 15.1 | 7.2 | 1.3 - 12.9† |
| Bredasdorp/Swellendam | 1.4 | 10.0 | 8.6 | 3.3 - 14.7† |
| Tygerberg Eastern | 6.1 | 15.1 | 8.9 | 3.3 - 14.7† |
| Greater Athlone | 6.8 | 16.4 | 9.6 | 3.4 - 15.2† |
| Oostenberg | 5.7 | 15.3 | 9.6 | 4.7 - 14.7† |
| 5 - 9.9 percentage point change | | | | |
| Cape Town Central | 3.7 | 13.7 | 10.0 | 4.8 - 15.7† |
| Stellenbosch | 7.1 | 17.8 | 10.7 | 4.8 - 17.3† |
| Khayelitsha | 22.0 | 33.0 | 11.0 | 4.1 - 17.8† |
| Mitchells Plain | 0.7 | 12.9 | 12.2 | 7.6 - 17.2† |
| Gugulethu/Nyanga | 16.1 | 29.1 | 13.0 | 5.9 - 20.6† |
| ≥ 10 percentage point change | | | | |
| Western Cape | 9.1 * (SE = 1.0) | 14.9 * (SE = 1.2) | 5.8 | 4.5 - 7.1† |

* Weighted HIV prevalence.
† Significant change in prevalence for districts whose confidence interval does not include zero.
SE = standard error

that reported a prevalence of 15% or higher were clustered in the metropole region such as the Khayelitsha (22%), Gugulethu (16.1%) and Helderberg (19%) districts. In 2004, however, we observe a diffusion of the epidemic into other metropolitan and peri-urban districts involving Khayelitsha (33.0%), Helderberg (18.8%), Gugulethu/Nyanga (29.1%), Greater Athlone (16.4%), Oostenberg (15.3%), Tygerberg Eastern (15.1%) and Tygerberg Western (15.1%) as well as the districts outside the metropole, namely Stellenbosch (17.8%) and the Knysna/Plettenberg Bay district (17.4%). This clearly has implications for the scale of the HIV problem in terms of absolute numbers, as approximately 94% of the WC population reside in these districts.

The overall HIV point prevalence for the WC derived from the NHAS in 2001 (8.6%; 95% CI: 5.6 - 11.6) and 2004 (15.4%; 95% CI: 12.5 - 18.2) was remarkably similar to the weighted provincial HIV prevalence estimated from the district-level surveys for the same years (9.1%; 95% Cl: 8.1 - 10.1) in 2001 and 14.9%; 95% CI: 14.0 - 15.6 in 2004) (Table II).

## Discussion

This study shows that despite a relatively low overall HIV prevalence for the WC, there was a wide variation across the health districts within the province. The HIV prevalence in the Khayelitsha and Gugulethu health districts in 2004, at 33% and 29.1% respectively, was almost double the provincial figure of 15.4%, and marginally higher than the national prevalence of 29.5%.[4] This illustrates that examining an aggregate provincial figure alone runs the risk of masking the heterogeneity in prevalence across the health districts. Trend data, based on the health-district HIV surveys, show a consistent and progressive widening of the range of HIV prevalence by health district.

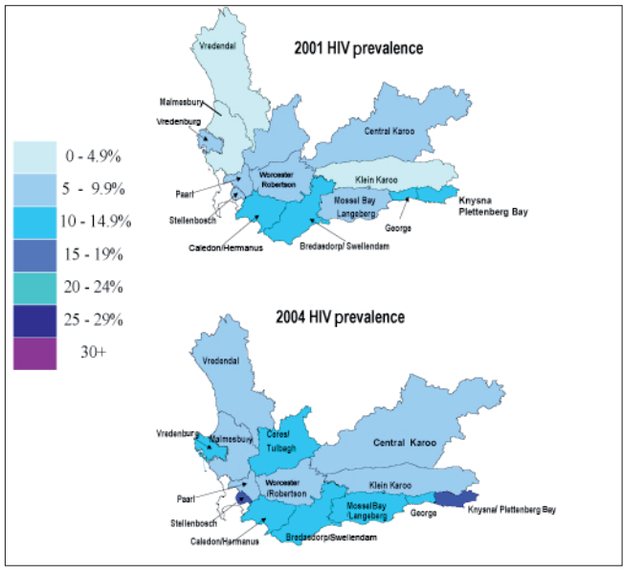


*Fig. 2. Non-metropole districts.*

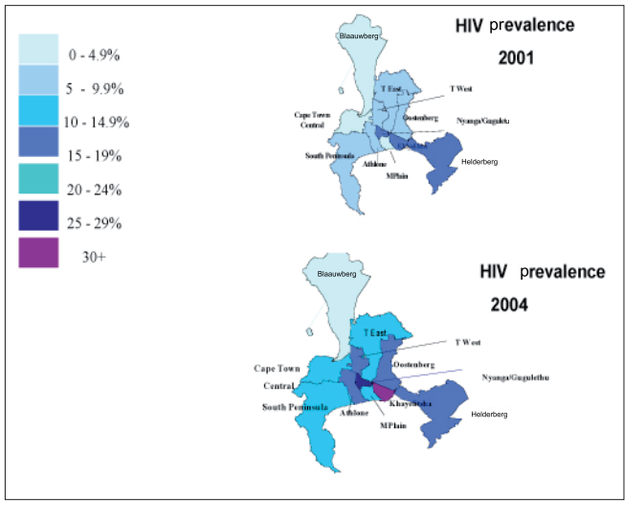


*Fig. 3. Cape metropole districts.*

Hence, a range of 0.6 - 28% observed in 2001 expanded to 1 - 33% in 2004, suggesting that the magnitude, spread and pace of the epidemic differs across health districts. Unevenness and heterogeneity in HIV prevalence is therefore manifest both in absolute terms at any given point in time, and in the rate of growth over time. This suggests that there are sub-epidemics within the province, at various stages of development. For example, while HIV prevalence in the Khayelitsha and Gugulethu health district results is consistently high in absolute and growth terms, Mitchells Plain and Athlone have lower absolute rates, but very high growth rates over the 2001 - 2004 period – the latter suggestive of emerging sub-epidemics. On the other hand, Blaauwberg remains low in absolute terms and yielded a very low growth rate over the period. These findings are consistent with trends of HIV prevalence among pregnant women in SSA, whereby wide variations in HIV prevalence are described at subregional and at country levels.[1,4]

The spatial analysis of HIV prevalence by health district shows progressive changes in the magnitude and growth of the epidemic in the province. The data also highlight that apart from variation in the magnitude of the HIV epidemic across districts, the sub-epidemics within the health districts are also at different stages of growth, manifesting as young, emerging and mature epidemics. It also demonstrates the early stages of the epidemic in the WC, as concentrated sub-epidemics within select districts, having spread over time to the surrounding districts in a non-homogeneous manner. The reasons for the heterogeneity of HIV prevalence by health district within the province were not explored in this study. However, empirical evidence suggests that a combination of individual factors and socio-economic and demographic factors are attributed to the variation.[6,10-12] Some of these include age of sexual debut, practise of unprotected sex, presence of sexually transmitted infections (STIs), rapid urbanisation, migration, high population density, unemployment, sexual networks and proximity to national roads.[6,10-13] The variation in these influencing factors across districts may explain the heterogeneity in HIV prevalence across the health districts.

The HIV antenatal survey method of surveillance has limitations. Factors such as contraceptive use, proportion of women using public-sector clinics, women choosing not to have children, fertility changes with age and HIV status may lead to the underestimation or overestimation of HIV prevalence.[1,14,15] Another potential bias with the antenatal HIV sentinel surveys includes the underrepresentation of rural areas, since sentinel sites selected are often located in urban settings. In the case of the DLS, all the public health facilities that offered antenatal services (including mobile services) participated in the survey. Notwithstanding the biases, this method of surveillance is designed to estimate HIV prevalence trends among young, sexually active heterosexual adults and is regarded as a robust and cost-effective method of monitoring HIV trends in countries experiencing generalised epidemics.[5,14-17]

Second-generation surveys such as the Nelson Mandela HSRC National Household survey[6] and the Youth and Risk Behaviour surveys[18] capture greater detail on the behavioural elements and risk factors associated with HIV and are an excellent complement to the NHAS.[16] The estimates derived from population surveys are expected to differ from the antenatal sentinel surveys as the sample includes men and women as well as children. However, as with HIV sentinel surveys of pregnant women, the population survey method also suffers from limitations, such as high costs, logistics, ethical challenges and the risk of incomplete response rates from certain households.[6,16]

In the case of this investigation, the provincial estimates derived from two separate surveys, namely the health district-level HIV surveys and the provincial survey, yielded a very similar HIV seroprevalence for the province. Hence, the annual district survey acted as a validation tool for the provincial survey while at the same time it provided district-level information, essential for planning and implementing programmes and monitoring the epidemic at a local level. The NHASs were essentially designed to provide country- and provincial-level estimates and do not allow for a sub-provincial analysis.[9] These findings demonstrate that examining a geographically large and diverse province such as the WC has the potential to mask high HIV prevalence at sub-provincial levels.

In a trend analysis of HIV prevalence among pregnant women in SSA, it was highlighted that due to the heterogeneity of HIV prevalence subregionally, the current surveillance systems will have to expand in order to guide the scaling-up of interventions.[1] The DLS can be a valuable tool for planning and implementing district-level services and programmes. This information can contribute importantly to the allocation of resources, to the planning, monitoring and evaluation of targeted interventions at local level (e.g. PMTCT, VCT, HAART programmes and condom distribution). For example, in the WC the results of these surveys have guided programme planners with the roll-out of the PMTCT, VCT and HAART programmes in terms of prioritising districts for service delivery as well as with resource allocation and the procurement of supplies for the specific programmes. The information derived from these surveys allows for better planning of AIDS-related services such as HAART, hospice step-down care, foster care programmes, children's homes and social security grants. In South Africa, districts or sub-districts correspond to formal local municipal boundaries. A survey of this nature allows municipalities to appreciate the extent of HIV spread in their geographical jurisdiction. The availability of local-level HIV prevalence data allows for planning of innumerable functions across sectors such as education, housing and economic development. Hence, in settings where high HIV variation is suspected and there are sufficient resources and capacity to implement the district-level survey, it is recommended that both these surveys be conducted simultaneously.

## Conclusion

The district-level surveys demonstrated the heterogeneous spread and distribution of HIV infection at a sub-provincial level. The district surveys showed that the WC does not have a single epidemic, but that sub-epidemics within the province are spreading and maturing at various rates. Higher levels of HIV infection and a more rapid growth rate were observed in districts located in the metropole region. This evidence suggests that the HIV epidemic has not stabilised. This investigation has shown that district-level surveys can provide critical information for allocating resources, and for planning, monitoring and evaluating HIV interventions at local level.

In the absence of a cure for HIV/AIDS, prevention remains the key strategy that can turn the tide of the epidemic in this province. Given that the epidemic is relatively less mature than epidemics in the other provinces of South Africa, the WC has an opportunity to halt the epidemic through intensive preventive strategies that have been proven to be effective. Some of these strategies include improving STI screening and management, promoting VCT uptake, and promoting the practice of safe sex. The study also highlighted that it is possible to assess the scale, pace and magnitude of HIV infection at district level, while at the same time use it as a validation tool for the provincial survey. This novel implementation of HIV surveillance at district level provides valuable management information for planning interventions in developing countries.

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