



# HIV epidemic in South Africa: A comparison of HIV epidemic patterns of two extreme provinces in South Africa

**Authors:**

Khangelani Zuma<sup>1,2</sup>  
Khanyisile Manzini<sup>3</sup>  
Neo Mohlabane<sup>3</sup>

**Affiliations:**

<sup>1</sup>Human Sciences Research Council, Research Methodology Centre, South Africa

<sup>2</sup>Department of Statistics, University of South Africa, Pretoria, South Africa

<sup>3</sup>Human Sciences Research Council, HAST Research Program, South Africa

**Correspondence to:**

Khangelani Zuma

**Email:**

kzuma@hsrc.ac.za

**Postal address:**

Private Bag X41, Pretoria 0001, South Africa

**Dates:**

Received: 15 Nov. 2012

Accepted: 07 Apr. 2014

Published: 26 Aug. 2014

**How to cite this article:**

Zuma, K., Manzini, K. & Mohlabane, N., 2014, 'HIV epidemic in South Africa: A comparison of HIV epidemic patterns of two extreme provinces in South Africa', *Health SA Gesondheid* 19(1), Art. #716, 5 pages. <http://dx.doi.org/10.4102/hsag.v19i1.716>

**Copyright:**

© 2014. The Authors.  
Licensee: AOSIS  
OpenJournals. This work is licensed under the Creative Commons Attribution License.

**Read online:**

Scan this QR code with your smart phone or mobile device to read online.

**Background:** South Africa is experiencing one of the worst HIV epidemics, which varies by province and by districts within each province.

**Objective:** To explore and compare HIV trends and patterns between two provinces in South Africa.

**Method:** 'Know your epidemic' synthesis suggests that HIV prevalence is rising in older age groups and falling in younger people. Using secondary data analyses of population-based and antenatal care surveillance (ANC) surveys, we explored trends and patterns in HIV prevalence in KwaZulu-Natal and Western Cape.

**Results:** Even though KwaZulu-Natal has the highest HIV prevalence in the country (15.5% compared with 3.8% in the Western Cape), there is considerable recent decline (6%) in HIV prevalence in KwaZulu-Natal, compared with a 2% increase in the Western Cape, based on ANC data, in youth aged 15 to 24 years. These results are consistent with those from a population-based survey where a decline of 0.3% in HIV prevalence in KwaZulu-Natal was observed as compared with an increase of 0.7% in Western Cape youth. Both ANC results and population-based surveys conducted in different years show a decline in HIV prevalence amongst youth in KwaZulu-Natal compared with an increase in the same age group in the Western Cape. HIV infection in this age group is associated with recent infection, thus indicating an increasing epidemic in the Western Cape compared with KwaZulu-Natal.

**Conclusion:** Interventions aimed at curbing infections such as sexual abstinence and condom promotion in this age group need to be implemented extensively in the Western Cape. These should include HIV counseling and testing campaigns.

**Agtergrond:** Suid-Afrika ondervind een van die ergste MIV-epedemies, wat verskil ten opsigte van elke provinsie en distrik en binne elke provinise.

**Doelstelling:** Om MIV-voorkoms en -patrone tussen twee provinises in Suid-Afrika te ondersoek en vergelyk.

**Metode:** 'Ken jou epidemie' sintese dui daarop dat die voorkomssyfer van MIV in ouer ouderdomsgroepe styg en daal by jonger mense. Ons het sekondêre data analises van bevolkingsgebaseerde en swangerskapsorg waarnemingsopnames (ANC) gebruik om neigings en patrone in MIV-voorkoms in Kwa-Zulu Natal en die Wes-Kaap, vas te stel.

**Resultate:** Ofskoon Kwa-Zulu Natal die hoogste voorkoms in Suid-Afrika (15.5% vergelyk met 3.8% in die Wes-Kaap) het, is daar 'n aansienlike onlangse afname (6%) in die voorkoms van MIV in Kwa-Zulu Natal waargeneem, vergelyk met die 2% verhoging in die Wes-Kaap, gebaseer op ANC data, in jongmense in die ouderdomsgroep 15–24 jaar. Hierdie resultate is konsekwent met dié van die bevolkingsgebaseerde opname, waar 'n afname van 0.3% in MIV-voorkoms in Kwa-Zulu Natal waargeneem is, vergelyk met 'n toename van 0.7% in die jeug van die Wes-Kaap. Altwee die ANC-resultate en die bevolkings-gebaseerde opnames wat in verskillende jare uitgevoer is, wys 'n afname in MIV-voorkoms onder die jeug in Kwa-Zulu Natal vergelyk met 'n toename onder dieselfde ouderdomsgroep in die Wes-Kaap. MIV-infeksie onder hierdie ouderdomsgroep word verbind met 'n onlangse infeksie, wat 'n toename van die epidemie in die Wes-Kaap, vergelyk met Kwa-Zulu Natal aandui.

**Gevolgtrekkings:** Ingryping, wat daarop gemik is om infeksies soos seksuele onthouding en die reklame van kondome vir hierdie ouderdomsgroep, behoort wyd in die Wes-Kaap geïmplementeer te word. Hierdie behoort voorligtings- en toetsveldtogte in te sluit.



## Introduction

South Africa remains heavily affected by HIV, with more than 15% of South Africa's population aged 15–49 years living with HIV (UNAIDS 2008). After 1990, the epidemic crossed the 15% prevalence level in less than eight years amongst pregnant women (Department of Health 2011). Data from population-based sero-surveys and sentinel surveillance of pregnant women suggest that the HIV epidemic has reached a plateau in South Africa. The pattern of plateaued epidemic is also seen in the antenatal surveillance survey results (Department of Health 2011). Three Human Sciences Research Council (HSRC) surveys estimated that 15.6% (2002), 16.2% (2005) and 16.9% (2008) of males and females aged 15–49 years were infected with HIV (Shisana *et al.* 2009).

There is considerable experience regarding the use of various methods of estimating HIV incidence (new HIV infections) in South Africa (Hargrove, van Schalkwyk & Eastwood 2012; Rehle *et al.* 2007; 2010; Williams *et al.* 2001). Various incidence-estimation techniques used since early 2000 to date all show a continuing declining trend in national HIV incidence (Fraser-Hurt *et al.* 2011). Based on the model of synthetic cohort methods of estimating HIV incidence, a decline in HIV incidence was reported, showing a decrease from 2.0 per 100 person-years between 2002 and 2005 to 1.3 per 100 person-years between 2005 and 2008 (Rehle *et al.* 2010). These estimates, however, provide a national picture of the incidence of HIV at a specific point of time and did not report on the contributing factors and dynamics of the HIV epidemic.

The assessment of the HIV epidemic through the 'know your epidemic and know your response' synthesis conducted by the World Bank, the South African National AIDS Council (SANAC) and the HSRC in 2010 has assisted in contributing to the ongoing efforts toward understanding the differentials of the HIV epidemic by describing the levels of heterogeneity, as well as identifying the populations at greatest risk of HIV infection and the critical modes of HIV transmission (Fraser-Hurt *et al.* 2011). In this 'know your epidemic' report, extensive comparative analyses and the highlighting of high risk areas have been covered (Fraser-Hurt *et al.* 2011). However, it is important to understand the comparative likely scenario and trends of HIV differentials between provinces or districts. Such understanding is needed in order to inform tailored interventions and policies targeted at curbing the scourge of HIV.

With the expansion of anti-retroviral treatment (ART), the interpretation of HIV prevalence trends is becoming increasingly complex. The complexity comes with the expectation that increased access to ART will increase survival of HIV-infected people, with the effect that HIV prevalence is expected to increase in the age groups that are predominantly receiving ART, as people with HIV now live longer. On the other hand, prevention programmes are expected to yield a reduction in new HIV infections (HIV incidence), which would result in a decline of HIV prevalence in a scenario without ART. It is thus becoming more complex to explain changes in HIV prevalence in terms of whether they are a

result of recent infections or because of increased survival resulting from access to ART. It is becoming increasingly important when presenting HIV estimates to dissect the contribution to HIV prevalence resulting from HIV incidence compared with the contribution resulting from people living longer because of expanded access to ART.

This article explores HIV prevalence estimates from KwaZulu-Natal (the province with highest HIV prevalence in South Africa) and the Western Cape (the province with lowest HIV prevalence in South Africa) using two different sources of data at two different time points in different age groups in order to understand the trends of HIV prevalence. The article aims to highlight the need to address the slowly-increasing HIV epidemic in the Western Cape in order to prevent the epidemic from increasing to the catastrophic levels experienced in KwaZulu-Natal.

## Research method and design

This article explores HIV prevalence data in five-year age groupings between 10 and 49 years using antenatal survey data sets from 2009 and 2010 (Department of Health 2011) and population-based surveys conducted by the HSRC (Shisana *et al.* 2005; 2009) in two provinces (KwaZulu-Natal and the Western Cape) in order to understand the dynamics of HIV infection in South Africa. The article is based on secondary data analyses of the 2008 South African national HIV prevalence, incidence, behaviour and communication survey (Shisana *et al.* 2009) and the 2010 South African national antenatal care (ANC) sentinel HIV and syphilis prevalence survey (Department of Health 2011). The two data sources chosen are used for the purposes of validation and generalisability. In the population-based survey, 23 369 individuals from 13 440 households, of whom 15 031 (64.3%) were tested for HIV, were interviewed by professional retired nurses trained as data collectors. Shisana *et al.* (2009) present in detail the design and implementation of the survey. In the ANC survey conducted by the Department of Health in 2010 (Department of Health 2011), 32 225 pregnant women who attended antenatal services in 1424 sentinel clinics were interviewed and tested. In the 2008 survey report (Shisana *et al.* 2009), results such as HIV prevalence data from the 2005 wave of the survey were also reported. Similarly, the ANC report of 2010 also reported on the HIV estimates of the previous year for trend purposes (Department of Health 2011).

In the population-based survey, data collected in 2005 and 2008 on individuals agreeing to participate in the survey were compared. In the annual ANC survey, the results on women going for the first time during their current pregnancy to a public health facility in both 2009 and 2010 were reported on. The statistical analyses approach that was adopted enabled the researcher to compare the differences in percentage points of the prevalence between two consecutive ANC surveys of the Department of Health and the population-based surveys of the HSRC. A positive percentage difference implies a year-to-year increase in HIV prevalence whilst a negative percentage difference implies a decline in HIV prevalence. Furthermore, a percentage difference between different years



was computed as year two minus year one divided by year one. Confidence intervals were adjusted for the data obtained through the complex survey design. Statistical significance was based on a 5% level of significance.

## Results

In South Africa, it was found that there was a statistically-significant difference ( $p$ -value < 0.001) between the HIV prevalence levels in the Western Cape and KwaZulu-Natal provinces. These HIV prevalence levels were 3.8% [95% CI: 2.7% – 5.3%] in the Western Cape to 15.8% [95% CI: 13.4% – 18.6%] in KwaZulu-Natal in 2008 for the age group two years and older (Shisana *et al.* 2009). Comparisons between the prevalence of men in the Western Cape and KwaZulu-Natal showed that men in KwaZulu-Natal were significantly more likely (11.8% vs 2.6%) to be HIV positive than men in the Western Cape ( $p$ -value < 0.001). Women in KwaZulu-Natal were also significantly more likely (18.0% vs 4.9%) to be HIV positive compared with women in the Western Cape ( $p$ -value < 0.001). The ANC sentinel survey showed that there is an even larger difference in HIV prevalence between the different health district levels. In terms of districts, HIV prevalence ranges from a low of 10% in the West Coast district of the Western Cape to a high of 42.2% in the uMgungundlovu and iLembe districts of KwaZulu-Natal (Department of Health 2011). There is also a considerable level of clustering in HIV prevalence in particular districts (Fraser-Hurt *et al.* 2011), with HIV prevalence concentrated in fewer districts in KwaZulu-Natal.

The results from the ANC survey (Department of Health 2011) show a considerable decline in HIV prevalence in KwaZulu-Natal between ages 10 and 24 years, ranging

from a -0.8% difference to a -2% difference between 2009 and 2010 surveys compared with the Western Cape, where a considerable increase in HIV prevalence in the same age groups was observed (Table 1), with the highest year-on-year increase of 5.6% amongst persons aged 10 to 14 years being seen between the 2005 and 2008 surveys. Between 2009 and 2010, the percentage change in HIV prevalence dropped by 6% in pregnant youth aged 15–24 years in KwaZulu-Natal compared to a percentage increase of 2% in pregnant youth aged 15–24 years in the Western Cape. Overall, there was no change in HIV prevalence in KwaZulu-Natal between 2009 and 2010 in pregnant women aged 15–49 years, whilst in the Western Cape, there was a 1.6% increase in HIV prevalence.

In KwaZulu-Natal, a gradual increase from 0.5% to 13.5% in HIV prevalence is observed from ages 25–49 years. In the same province, the percentage difference (ranging from -2% to -0.8%) in HIV prevalence for age groups 10–24 years shows a decrease in HIV prevalence from 2009 to 2010 (refer to Table 1). All age groups in Western Cape show a positive percentage difference, with the highest prevalence amongst those aged 35–39 years. Amongst those aged 15–24 years, KwaZulu-Natal shows a decrease in HIV prevalence whilst the prevalence in the Western Cape increased by 0.3% in the same age group. A consistent increase in HIV prevalence in Western Cape has been observed since 2006 (Fraser-Hurt *et al.* 2011).

Using the HSRC population-based survey (Shisana *et al.* 2005; 2009), a decline in prevalence was observed only in age groups 35–39 and 45–49 years in the Western Cape. In KwaZulu-Natal, however, a decline was shown in the 10–19 and 25–29 years age groups (Table 2). Those aged

**TABLE 1:** HIV prevalence and percentage differences between KwaZulu-Natal and Western Cape: Antenatal care data by age.

Age in years	KwaZulu-Natal			Western Cape		
	HIV + % [95% CI] 2009	HIV + % [95% CI] 2010	Percentage difference	HIV + % [95% CI] 2009	HIV + % [95% CI] 2010	Percentage difference
10–14	20.0 [2.8–33.6]	19.2 [6.6–39.4]	-0.8	0 [0–23.1*]	5.6 [0.1–27.3]	5.6
15–19	22.0 [17.4–21.2]	20.5 [18.5–22.6]	-1.5	6.4 [3.9–7.7]	7.7 [5.7–10.1]	1.3
20–24	37.2 [34.1–38.1]	35.2 [33.2–37.2]	-2	14.9 [11.8–15.7]	15.2 [13.2–17.5]	0.3
25–29	50.4 [49.5–54.5]	50.9 [48.4–53.4]	0.5	21.0 [19.7–24.9]	21.9 [19.5–24.5]	0.9
30–34	56.1 [50.5–57.3]	57.8 [54.4–61.1]	1.7	24.5 [20.5–27.6]	27.4 [24.1–30.9]	2.9
35–39	46.2 [45.4–54.6]	52.7 [47.8–57.4]	6.5	17.2 [8.9–17.0]	22.1 [17.8–26.8]	4.9
40–44	37.9 [26.6–44.9]	46.5 [37.1–56.1]	8.6	17.8 [5.6–23.2]	17.6 [9.7–28.2]	-0.2
45–49	25.0 [2.2–51.8]	38.5 [13.9–68.4]	13.5	0 [0–70.8*]	0 [0–0.975*]	0
15–24	31.0 [27.6–30.5]	29.2 [27.8–30.7]	-1.8	12.2 [9.6–12.5]	12.5 [11.0–14.2]	0.3
15–49	39.5 [37.6–39.9]	39.5 [38.3–40.7]	0	16.9 [14.9–17.3]	18.5 [17.3–19.7]	1.6

Notes: \*one-sided, 97.5% confidence interval.

**TABLE 2:** HIV prevalence and percentage difference for KwaZulu-Natal and Western Cape: Population-based survey by age.

Age in years	KwaZulu-Natal			Western Cape		
	HIV+ % 2005	HIV+ % 2008	Percentage difference	HIV+ % 2005	HIV+ % 2008	Percentage difference
10–14	3.4	0.9	-2.5	0	0.5	0.5
15–19	9.6	5.9	-3.7	0.4	1.3	0.9
20–24	22.1	23.8	1.7	4.7	5	0.3
25–29	39	37.9	-1.1	4.2	7.9	3.7
30–34	29.6	45.1	15.5	4.5	12	7.5
35–39	25	32.1	7.1	4.2	3.3	-0.9
40–44	22.6	26.6	4	1.5	4.9	3.4
45–49	8.2	15.1	6.9	3.9	1.1	-2.8
15–24	16.1	15.8	-0.3	2.3	3	0.7
15–49	21.9	25.8	3.9	3.2	5.3	2.1



15–24 years showed a modest decline in HIV prevalence (0.3%) in KwaZulu-Natal whilst the Western Cape showed a modest increase (0.7%) in the same age group. The slight decline in the 15–24 age group in KwaZulu-Natal is a result of the considerable decline of 3.7% which was observed in the 15–19-year olds. The decline in this 15–19 year age group is consistent with a reported increase in condom use in this age group (Shisana *et al.* 2009).

## Discussion

HIV prevalence in the 15–24 year age group was used as one of the key indicators for the Millennium Development Goals (MDG) and the United Nations General Assembly Special Session (UNAIDS 2008) on HIV and AIDS. National estimates, however, tend to mask localised epidemic patterns. For example, in KwaZulu-Natal province, which has the highest HIV prevalence in South Africa, only four out of 11 districts have an HIV prevalence above 40%. This demonstrates the need to dissect HIV estimates to the smallest level of analysis possible in order to illuminate likely hidden epidemics. In understanding the epidemic of HIV, it is important to understand the dynamics and differentials of the HIV prevalence at a local level. Based on the HSRC 2005 and 2008 population-based HIV prevalence surveys (Shisana *et al.* 2005; 2009), the prevalence of HIV appeared to have dropped by 0.3% in KwaZulu-Natal whilst there was an increase of 0.7% in the Western Cape amongst 15–24 year olds. Based on the ANC surveys of 2009 and 2010 (Department of Health 2011), the prevalence has dropped by 1.8% in KwaZulu-Natal and increased by 0.3% in Western Cape in the same age group. The latest HIV population-based survey (Shisana *et al.* 2014) shows that even though in most provinces the number of people living with HIV in the 15–24 year age group has declined, the trend in the Western Cape follows a reverse pattern compared with other provinces, with the number of people living with HIV increasing. Based on the HSRC surveys (Shisana *et al.* 2005; 2009), the 15–19 year age group showed the biggest HIV prevalence decline (3.7%) in KwaZulu-Natal, whilst the 45–49 year age group showed the biggest decline (2.8%) in the Western Cape. However, these results should be interpreted with caution because of the small samples surveyed in these age categories.

HIV prevalence within the 15–19 year age group is an indirect indicator of recent HIV infections (HIV incidence). A considerable decline in HIV incidence in South Africa has been shown amongst 15–24 year olds (Rehle *et al.* 2010). This decline in national HIV incidence was not reflected in the Western Cape based on year-to-year HIV prevalence. There is a need for a concerted effort to address behaviour that puts young people at risk of HIV infection.

An important factor in interpreting HIV prevalence in terms of ART strategies is that HIV prevalence can increase purely as a result of effective ART and the consequent prolonging of survival amongst HIV-infected individuals. This increase is expected to be more pronounced amongst those in age groups most likely to be receiving ART. Rehle *et al.* (2010) showed

that in South Africa, the impact of ART was predominant amongst women aged 25–49 years and amongst men aged 30 years and older. The consistent positive percentage difference observed amongst 25–49 year old pregnant women (Table 1) in KwaZulu-Natal is consistent in relation to the use of ART. When using the results from the HSRC population-based HIV prevalence surveys (Shisana *et al.* 2005; 2009), KwaZulu-Natal showed a positive percentage difference in all age groups between 30 and 49 years, whilst the Western Cape shows a positive increase amongst only those aged 30–34 and 40–44 years and a negative percentage difference among those aged 35–39 and 45–49 years. It is plausible that the increase in prevalence in the 30–49 year age group in KwaZulu-Natal could be attributed in part to expanded access to ART, which has resulted in people living longer otherwise who would have died without access to ART. It has been shown that approximately 2% of the increase in South African HIV prevalence is a result of access to ART (Rehle *et al.* 2010).

The HIV epidemic in South Africa is heterogeneous in nature and varies considerably by province, district, population group and locality type (Fraser-Hurt *et al.* 2011). The latest population-based survey further confirms this, with the Western Cape showing the highest percentage increase in HIV prevalence which has more than doubled between 2005 (1.9%) and 2012 (5%) (Shisana *et al.* 2014). It is important to disaggregate the results and explore HIV trends at the lowest operational level in order to unmask the hidden trends in the HIV epidemic. Whilst the epidemic trend in KwaZulu-Natal seems to have begun reversing amongst young people aged 10–24 years, there is a need to address the increasing trend of HIV in the Western Cape, especially amongst young people, in order to curb the emerging increases in HIV infection levels in the province that are likely to trigger an explosive dual epidemic of HIV and tuberculosis (Abdool Karim *et al.* 2009).

## Limitations of the study

The analysis was based on a triangulation of secondary data that is limited by small numbers in some of the younger age groups, implying that these results should be interpreted with caution.

## Recommendations

This article has brought to the fore the fact that whilst prevalence is increasing in one province, it seems to be decreasing in another, which highlights the need to explore this trend further in order to understand the possible reasons for the different patterns, especially with the advent of ART programmes and other interventions. An accelerated implementation of targeted interventions that have been shown to work, such as promotion of voluntary medical male circumcision and promotion of condom use (especially amongst high-risk groups such as the youth), as well as promotion of HIV testing and counseling, are recommended for the Western Cape.



## Conclusion

In conclusion, the article has used publically-available datasets in order to highlight the emerging trends in the HIV epidemic in South Africa. The focus in epidemic monitoring has been largely on the magnitude of the burden of HIV by province, neglecting emerging trends that have the potential to lead to the worst epidemic of HIV in Western Cape given the high TB burden in that province. Both population-based surveys and ANC data should endeavour to collect robust and representative local data, for example, at the district level, in order to enable efficient monitoring of HIV epidemic.

## Acknowledgements

I thank Professor Thomas M. Rehle for his helpful suggestions and critical comments during the development of the article.

## Competing interests

The authors declare that they have no financial or personal relationship(s) which may have inappropriately influenced them in writing this article.

## Authors' contributions

K.Z. (Research Methodology Centre, HSRC; Department of Statistics, University of South Africa) conceptualised the article and conducted the analyses and drafting of the

article. K.M. (HAST Research Program, HSRC) collated the information and drafted tables with some interpretation. N.M. (HAST Research Program, HSRC) conducted the literature review and edited the article.

## References

- Abdool Karim, S.S., Churchyard, G.J., Abdool Karim, Q. & Lawn, S.D., 2009, 'HIV infection and tuberculosis in South Africa: An urgent need to escalate the public health response', *Lancet* 374(9693), 921–933.
- Department of Health, 2011, *The 2010 national antenatal sentinel HIV & syphilis prevalence survey in South Africa*, Department of Health, Pretoria.
- Fraser-Hurt, N., Zuma, K., Njuho, P., Chikwava, F., Slaymaker, E., Hosegood, V. et al., 2011, *The HIV epidemic in South Africa: what do we know and how has it changed?*, South African National AIDS Council, Pretoria.
- Hargrove, J., Van Schalkwyk, C. & Eastwood, H., 2012, 'BED estimates of HIV incidence: Resolving the differences, making things simpler', *PLoS One* 7(1), e29736. <http://dx.doi.org/10.1371/journal.pone.0029736>
- Rehle, T., Shisana, O., Pillay, V., Zuma, K., Puren, A. & Parker, W., 2007, 'National HIV incidence measures – new insights into the South African epidemic', *South African Medical Journal* 97(3), 194–199.
- Rehle, T.M., Hallett, T.B., Shisana, O., Pillay-van Wyk, V., Zuma, K., Carrara, H. et al., 2010, 'A decline in new HIV infections in South Africa: estimating HIV incidence from three national HIV surveys in 2002, 2005 and 2008', *PLoS One* 5(6), e11094. <http://dx.doi.org/10.1371/journal.pone.0011094>
- Shisana, O., Rehle, T., Simbayi, L.C., Parker, W., Zuma, K., Bhana, A. et al., 2005, *South African national HIV prevalence, HIV incidence, behaviour and communication survey, 2005*, HSRC Press, Cape Town.
- Shisana, O., Rehle, T., Simbayi, L.C., Zuma, K., Jooste, S., Mbelle, N. et al., 2009, *South African HIV prevalence, incidence, behaviour, & communication survey, 2008: a turning tide among teenagers?*, HSRC Press, Cape Town.
- Shisana, O., Rehle, T., Simbayi L.C., Zuma, K., Jooste, S., Zungu N. et al., 2014, *South African National HIV Prevalence, Incidence and Behaviour Survey, 2012*, HSRC Press, Cape Town.
- UNAIDS, 2008, *Report on the global AIDS epidemic*, UNAIDS, Geneva.
- Williams, B., Gouws, E., Wilkinson, D. & Abdool Karim, S., 2001, 'Estimating HIV incidence rates from age prevalence data in epidemic situations', *Statistics in Medicine* 20(13), 2003–2016.