HIV surveillance: *A 12 year analysis of HIV prevalence trends and comparing HIV prevalence from sentinel antenatal clinic surveys and Prevention of mother-to-child programmes.*

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Part 0: Preamble

DECLARATION

I, Vivien Essel hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Date: 13 June 2014

Dedication

I dedicate this to my family for their support, especially to my husband Dr. Kwabena Essel and my son Jonathan.

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- Professor Andrew Boulle and Dr David Pienaar for the supervision and support for my dissertation;
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Abstract

Background

Sentinel antenatal clinic (ANC) surveys remain a key source of data on HIV prevalence trends. Recently though, with an increase in the uptake of prevention of mother–to–child transmission (PMTCT) programmes, there have been debates on the prospects of using PMTCT data for reporting antenatal HIV prevalence and trends.

Aim

To describe the HIV prevalence trends for the Western Cape Province and to compare prevalence from ANC surveys to PMTCT programmes.

Methods

HIV prevalence and 95% confidence intervals were estimated from ANC surveys from 2001-2012 for the province as well as the 6 health districts and the 8 City of Cape Town Metropolitan sub-districts in the province. HIV prevalence from expanded provincial ANC survey sampling was compared to the nationally reported provincial and district estimates, before and after re-weighting to account for differences between the realized sample and updated sampling frame. A regression line was fitted with calendar year included as both a linear and quadratic term to create smoothed trend lines of the change in HIV prevalence over time by province, district, sub-district and age group. A multivariable logistic regression model was fitted to the multi-year ANC survey data to explore associations with HIV prevalence. ANC survey HIV prevalence estimates were compared to those from routinely reported HIV testing data from the PMTCT program for 2009-2012.

Results

Antenatal HIV prevalence in the province has increased from 8.5% (95% CI 7.8 – 9.3%) in 2001 to 17.5% (95% CI 16.7% – 18.3%) in 2012. Trends derived from national, provincial and re-weighted provincial data were broadly comparable, but with sufficient variation to justify use of the re-weighted estimates in subsequent analyses. Trend analysis shows that prevalence has stabilised in the province, districts and 6 of the 8 City of Cape Town sub-districts. HIV prevalence from ANC survey was comparable to PMTCT estimates for the province but there were some disparities mainly at a sub-district level.

Conclusion

HIV prevalence trends are leveling in the Western Cape Province but variations exist at a sub-district level. Using PMTCT HIV prevalence estimates as an alternative to sentinel annual surveys would not change the reported estimates for the province considerably, but the disparities seen between ANC and PMTCT estimates, especially at sub-provincial level, requires further exploration prior to accepting the routine PMTCT estimates as an alternative to continued annual ANC surveys.

Parts and Subheadings

Part A: Protocol

Part B: Literature review

Part C: Journal manuscript

This section concludes the dissertation in the format of a submission to the Public Library of Science (PLOS ONE).

Part D: Appendices

List of Acronyms

AfDB	African Development Bank
AIDS	Acquired immunodeficiency syndrome
ALS	Area-Level Survey
ANC	Antenatal Care
ART	Antiretroviral therapy
ARV	Antiretroviral
CDC	Centres for Disease Control and Prevention
DHIS	District Health Information System
DHS	Demographic Health Surveys
ELISA	Enzyme-linked Immunosorbent Assay
HAST	HIV/AIDS, STIs and TB

HIV	Human immunodeficiency Virus
HREC	Human Research Ethics Committee
HSRC	Human Science Research Council
IDUs	Intravenous Drug Users
MDGs	Millennium Development Goals
MRC	Medical Research Council
MSM	Men who have sex with men
NDoH	National Department of Health
NHLS	National Health Laboratory Service
PEPFAR	US President's Emergency Plan for AIDS Relief
PICT	Provider Initiated Counselling and Testing
PMTCT	Prevention of mother-to-child transmission
PPS	Probability Proportional to Size
RPR	Rapid Plasma Reagin
SADC	Southern African Development Community
SAHARA	Social Aspects of HIV/AIDS Research Alliance
SSA	sub-Saharan Africa
STIs	Sexually Transmitted Infections
UN	United Nations
UNAIDS	Joint United Nations Programme on HIV/AIDS
UAT	Unlinked Anonymous Testing
USA	United States of America
VCT	Voluntary Counselling and Testing
WHO	World Health Organization

Part A: Protocol

HIV surveillance: *A 12 year analysis of HIV prevalence trends and comparing HIV prevalence from sentinel antenatal clinic surveys and Prevention of mother-to-child programmes.*

Protocol, 25 April 2014

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Background

HIV / AIDS is still a global concern with an estimated 34 million people infected at the end of 2011.[1] Sub-Saharan Africa (SSA) is the worst affected. It is believed that in SSA, 1 in every 20 adults is infected with HIV whilst in South Africa; the HIV prevalence as reported by a household survey has increased from 10.6% in 2008 to 12.3% in 2012.[2] It is important to monitor trends so as to effectively allocate resources for HIV prevention and control.[3]

Surveillance for HIV remains the basis of our understanding of this disease.[4] Although there are several HIV surveillance systems in existence, including population based household surveys, sentinel antenatal clinic (ANC) surveys and prevention of mother–to–child transmission (PMTCT) programmes, sentinel ANC surveys are the most commonly used to monitor prevalence and trends.[5]

In South Africa, HIV sentinel ANC surveys have been done annually since 1990 in all nine provinces. 2012 was the 23rd round of the survey by the National Department of Health (NDoH). This stand-alone / unlinked survey samples pregnant women at selected public health facilities in the country.[6]

Using HIV prevalence estimates from ANC surveys to represent estimates in sexually active heterosexual adults allows the NDoH to describe the HIV epidemic in the country, province and districts; and to extrapolate ANC survey findings to the general population. To date, ANC survey remains an important source of information for determining HIV trends.[6,7]

In 2001, the national ANC survey was expanded by the Western Cape Provincial Department of Health by including additional sites. This Provincial/expanded survey was designed to give a more accurate HIV prevalence estimate at a provincial, district and sub-district level.[6]

Despite the long standing high burden of HIV infection in South Africa, PMTCT programmes were only implemented nationally in 2002 after the Health Department was instructed by the Constitutional Court to offer services to every pregnant woman.[8,9] Through offering antenatal HIV testing and providing antiretroviral treatment or prophylaxis for all HIV positive pregnant women, the purpose of this programme is to reduce HIV transmission from mothers to their infants.[10] PMTCT programmes are integrated with basic antenatal care services being provided at health facilities[10] and data from this is routinely collected.

The Western Cape Province was the first to introduce PMTCT programmes at its public sector facilities. In 1998 – 1999, prior to there being a national policy, a programme was initiated at two obstetric facilities in the Western Cape's Khayelitsha township in Cape Town.[8] By 2007/8, PMTCT coverage in this province was 95.7%[9] and uptake was almost 100% in 2010.[11] This high coverage and uptake in PMTCT programmes reduces concerns around selection bias.

By increasing the number of sites in the provincial ANC survey, both PMTCT and ANC surveillance have been conducted at similar facilities in the Western Cape Province since 2001. This puts it in the best position to monitor trends and compare HIV prevalence estimates from both surveillance systems.

Justification

There is now over a decade of information from the expanded sentinel ANC surveys in the Western Cape Province. In 2005-7 there were boundary changes in the province and this has led to difficulties in describing the HIV prevalence trend throughout the expanded survey period. Also the probability proportional to size (PPS) sampling used in the ANC survey may not be sufficient to account for service utilisation changes from when sampling is done to the time of the survey; and older analyses (pre 2007) were not reweighted. There is value in reweighting old surveys to represent new districts and sub-districts as well as re-analysing the entire period using a common methodology. This will enable a better description of the HIV prevalence trend in the Western Cape Province.

By testing sexually active women, both ANC surveys and PMTCT programmes give an estimate of the HIV prevalence of the province and the country. Although sentinel ANC surveys are useful, they are expensive to conduct and do not form part of routine healthcare services. On the other hand, PMTCT programmes are done routinely and do not create additional costs to the healthcare system.

It is therefore important to assess whether HIV prevalence estimates from PMTCT programme are comparable to estimates from ANC surveys. This will inform the Western Cape Provincial Health Department as well as the National Health Department with an evidence-based recommendation for transition from antenatal surveys to PMTCT programmes in monitoring HIV prevalence and trends in the future.

Aim

To describe for the Western Cape Province down to sub-district level, the HIV prevalence and prevalence trends from both sentinel ANC surveys and routine PMTCT programmes, and to compare these estimates and trends to each other.

Objectives

a. To compare the national, provincial and provincial re-weighted HIV prevalence estimates for the Western Cape Province from 2001 to 2012 according to the annual ANC survey;

b. To describe the provincial, district and sub-district HIV prevalence trends from 2001 to 2012 according to the annual ANC survey;

c. To describe the provincial HIV prevalence age trends from 2001 to 2012 according to the annual ANC survey;

d. To identify risk factors associated with HIV infection;

e. To describe the provincial, district and sub-district HIV prevalence trends from 2009 to 2012 according to routine data obtained from the PMTCT programme;

f. To compare HIV prevalence estimates from the ANC surveys and routine PMTCT programmes;

g. To make recommendations on the utility of routine PMTCT data in monitoring HIV prevalence trends.

Methods

Study Design

Both the ANC survey and PMTCT programmes are cross sectional studies. A retrospective descriptive review will be done to analyse the antenatal HIV survey data from 2001 – 2012 and routine PMTCT data from 2009 – 2012 for the Western Cape Province.

Population and Sampling

The sentinel ANC surveys involve all pregnant women attending a health facility for their first antenatal booking in the month of October of each year. No exclusion is made to any pregnant woman based on their known HIV status.

For the PMTCT programme, the population is all pregnant women attending a health facility for their first antenatal booking at any given time.

In this review, there will be no further sampling since available data on all pregnant women who consented to participate in the ANC survey from 2001 – 2012 and PMTCT data on all women who agreed to be tested or were already known to be HIV-infected from 2009 – 2012 will be reviewed.

Measurements

Variables

The main outcome variable will be prevalence of HIV.

Data collection

Based on the information included in the standardised collection tool used in all the surveys (Appendix A), ANC survey data over the years are double-entered into an Excel spreadsheet and checked for any inconsistencies. Information entered includes demographic details of the pregnant women as well as their HIV test results. After data cleaning, the information is exported into a Microsoft Access database which allows comparison of data to previous years and linkage of each laboratory result to the antenatal booking data from the same year to facilitating re-weighting estimates when combining sub-district data into district and provincial estimates.

For this review, data for the ANC survey from 2001 – 2012 will be obtained from the provincial antenatal survey database.

PMTCT data from facilities is collated at sub-district and then district level. District level data is then entered into a District Health Information System (DHIS) on a monthly basis. This includes several elements of which the ones that will be extracted for review from 2009 to 2012 are:

- The number of women refusing PMTCT initial tests

- The number of women accepting PMTCT initial tests
- The number of PMTCT initial tests testing positive
- The number of known PMTCT clients on treatment
- The number of known PMTCT clients not on treatment
- The number of known PMTCT clients referred for care

The extracted information will be entered into Excel for data checking.

Sample size

For the ANC surveys, a PPS sampling method is taken based on the previous year's antenatal booking data. The sample size is stratified by sub-district to achieve a precision around the HIV prevalence point estimate of 3.5% above and below the estimate. For logistical reasons, sampling is capped at 1.5 months of booking data for smaller sub-districts.[6]

Based on the available sample and data, it will be possible to do a trend analysis. With an anticipated HIV prevalence of 17%, 90% power and a 5% level of significance, over the 12 years of the study period, a sample size of 25 700 (12 850 per group) will be sufficient to detect a difference of 1.5% when comparing groups in the risk factor analysis. For each year, a sample size of 4 700 (2 350 per group) will be needed to detect a difference of 3% at 80% power with the same level of significance.

Data analysis

Data from both systems will be analysed using Stata version 12.1, StataCorp, College Station, Texas.

In the Western Cape Province, there are six health districts and each health district is further sub-divided into sub-districts. The six health districts are the City of Cape Town Metropolitan district which has the highest population per square meter and the five rural districts namely; Cape Winelands, Central Karoo, Eden, Overberg and West Coast.

For the ANC survey data, sub-districts will be weighted according to annual booking data. Data will be combined to estimate sub-district, district and provincial prevalence. HIV prevalence will be estimated from PMTCT data without any re-weighting to reflect differential coverage, as coverage of testing is uniformly high and the intention of the analysis is to compare dedicated surveillance to routine program data estimates.

Prevalence estimates will be calculated with 95% confidence intervals. A comparison will be made between the national reported estimates for the Western Cape Province and the estimates calculated from the expanded provincial survey without re-weighting and with re-weighting (referred to as provincial and provincial re-weighted estimates respectively).

For trend analysis, a regression line will be fitted with calendar year included as both a linear and quadratic term to create smoothed trend lines to determine the change in HIV prevalence over time. Age from 15 years onwards will be categorised in a 5 year interval and HIV prevalence trends from 2001 – 2012 in each age category will be analysed.

To determine risk factors for HIV infection, logistic regression models will be fitted. The first model will include year as a variable and the second model will be fitted looking at several variables for each year from 2001 – 2012.

ANC survey estimates will be compared to PMTCT estimates using descriptive statistics.

Logistics

Submission of protocol for ethics approval: 25 April 2014

Data analysis: 23 May 2014

Resources

No budget will be required for this review.

Ethics and Communication

Ethics approval for the National sentinel antenatal HIV and syphilis survey was granted by the Medical Research Council's (MRC) ethics committee. Since this review will use data with no personal identifiers, individual patient consent will not be required. Both the antenatal survey and routine HIV testing are consented.

The anticipated benefit from this review is for the Western Cape Health Department to be informed on the utility of a less costly form of HIV surveillance through PMTCT programmes. There are minimal risks in doing this review. Risks in identifying problems with the quality of ANC survey or PMTCT data may be encountered. Once areas of data quality weaknesses are identified, recommendations for improvement will be made.

A report of the findings from the review will be written for the Western Cape Provincial Department of Health. Verbal communication to senior management will be done as per the guidelines of the department's communication directorate.

Permission to use the ANC survey and PMTCT data will be obtained from the Director of the HAST directorate of the Western Cape Department of Health through the Provincial Health Research sub-directorate.

Ethics approval will be sought from the University of Cape Town's Human Research Ethics Committee (HREC).

Limitations

This will be a retrospective review of ANC survey and PMTCT data for the past decade. Certain facility names and geographic information (district and sub-district alignment) may have changed over the years. Furthermore, some facilities may no longer have antenatal services. This may lead to difficulties in directly comparing HIV prevalence estimates for districts and sub-districts. In order to have comparable data for all the districts and sub-districts across the years, data will cleaned and current information regarding participating facilities and geographic demarcations will be verified.

There may be issues regarding the availability and quality of routine PMTCT data from the DHIS.

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Part B: Literature Review

Contents

Objectives of the Literature review

1. To review current knowledge regarding HIV epidemiology;

2. To describe trends in HIV prevalence;

3. To describe the various surveillance methods for determining HIV prevalence;

4. To compare sentinel antenatal clinic surveys to PMTCT programmes;

5. To describe HIV prevalence surveillance systems in the South African and Western Cape context.

Search strategy

A literature search was done between December 2013 and April 2014 using the following databases: Pubmed; EBSCO; Google Scholar; WHO website; University of Cape Town (UCT) Library; UCT Health Sciences Librarian and the national and local department of health reports. Search terms used were 'HIV epidemiology, 'risk factors for HIV', 'HIV trends' 'HIV surveillance methods', 'sentinel antenatal surveys', 'prevention of mother-to-child transmission', 'antennal surveys in South Africa', 'Africa', 'PMTCT in South Africa', 'comparison of PMTCT and antenatal surveillance'. Articles / research done outside South Africa as well as those done in South Africa were included. Only articles written in English were selected. 50 articles considered appropriate for the study were used.

Summary of the literature

Since HIV/AIDS was first described amongst five individuals in the United States of America (USA) in 1981, it has become a global pandemic.[1] In the past 30 years, the number of people who have been infected is estimated to be about 70 million whilst 35 million have died from AIDS related diseases. This burden however varies between countries and regions.[2]

The region with the worst HIV/AIDS burden in the world is sub-Saharan Africa (SSA). With about 22.9 million people infected in 2011, SSA accounts for 69% of all people infected with HIV globally.[2,3] Even within SSA, HIV prevalence is not uniform with Southern Africa being defined as the core HIV/AIDS epidemic area in the world. Nine Southern African countries, including South Africa, Botswana and Swaziland represent one third of all HIV infections worldwide.[3]

Over the years, efforts have been made to control this epidemic. Although HIV/AIDS cannot be cured, prevention through health education and the use of antiretroviral drugs have decreased the spread and reduced HIV/AIDS related morbidity and mortality. With biomedical advances, new classes of drugs have become available[4] and with ongoing research, the possibility of a vaccine is being explored.[5]

Despite these advances, HIV/AIDS still remains a challenge globally. At its Millennium Summit in 2000, the United Nations established 8 Millennium Development Goals (MDGs). Included in these goals are to reduce extreme poverty, promote gender equality, education and a sustainable environment. MDG 6 (to combat HIV/AIDS, malaria and other diseases) has two specific targets, one being to 'have halted and begun to reverse the spread of HIV/AIDS by 2015'.[6]

HIV epidemiology and trends

The zoonotic origin of HIV, including the two main types (HIV-1 and HIV-2) has been well documented. HIV-1 is the main cause of the epidemic and it is thought that human infection was due to cross-species transmission from chimpanzees. It is also believed that this transmission pattern occurred in western equatorial Africa in the early twentieth century[7] with rare groups of HIV-1 being discovered in the Democratic Republic of the Congo in the early 1980s.[8] HIV-2, predominantly found in West Africa was first reported in 1986. It originated through cross-species transmission from the sooty mangebeys, a species of monkeys found in the forests of West Africa.[9] The exact period when HIV-1 was transmitted outside Africa is

unknown but it is estimated that in the mid-1960s, it reached Haiti and subsequently to USA years later.[10]

Transmission of HIV between humans is mainly through unprotected sexual intercourse, vertical transmission from infected mothers to their infants, contact with contaminated blood, blood products or hypodermic needles.[3] Three main types of the HIV epidemic has been described, namely low, concentrated and generalised.[11] In low epidemics, HIV prevalence is less than 5% in any sub-population (persons with high risk behaviours such as intravenous drug users, sex workers and men who have sex with men) whilst prevalence in concentrated epidemics is greater than 5% in at least one sub-population but less than 1% in the general adult population. For generalised epidemics where HIV in the general population is strongly established, prevalence is persistently more than 1% in pregnant women.[11] Low and concentrated epidemics are mainly found in USA and Europe whilst generalised epidemic is seen in SSA primarily due to spread from heterosexual sexual intercourse.[3]

Several biological, socio-economic, demographic and behavioural factors are known to increase the risk of HIV infection.[4] In SSA, women are more affected when compared to men. This region also has the highest number of all paediatric HIV.[12] Vertical transmission from mothers to their infants is the most common route of infection in children. Poverty, gender inequality, sexual violence, food insecurity, poor economic conditions, fear, discrimination and stigma are all known to increase the prevalence of HIV in Africa.[12]

The association of sexually transmitted infections (STIs) has played a significant role in the spread of HIV.[13] A systematic review has shown that STIs, especially the genital ulcer diseases such as syphilis, increases the transmission of HIV. In this review, individuals without STIs were less susceptible to HIV infection compared to individuals with STIs.[14] STIs has also being shown to increase the rate of disease progression from HIV to AIDS.[14] With the same route of transmission, HIV and syphilis co-infection is high. In Uganda, 14.3% of pregnant women who are syphilis-positive are also HIV co-infected. The rate is 24.2% for Zambia.[15]

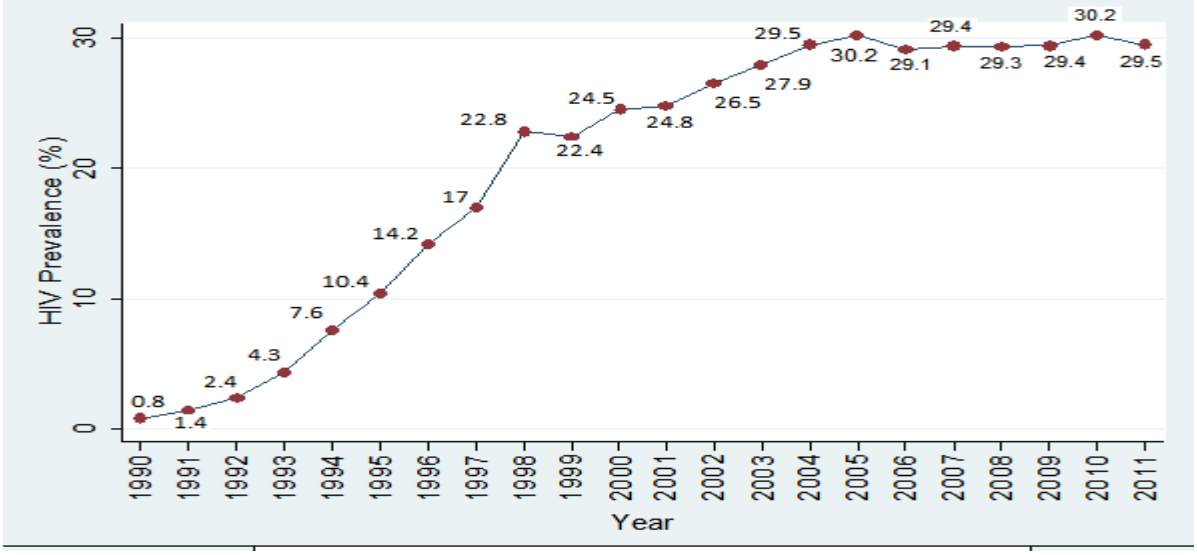
Globally the prevalence of HIV continues to show a downward trend despite there being variations between regions.[16] In SSA, between 2001 and 2012, HIV prevalence decreased by 42% in young people between the ages of 15-24 years. This decline however was not seen in all SSA countries with some countries such as Lesotho showing a higher prevalence trend.[16,17] Other regions reporting a decline in prevalence are the Caribbean, South and

South-East Asia.[16,18] However for the Middle East and North Africa, there has not been a noticeable downward trend. Eastern Europe and Central Asia show an increase in HIV prevalence since 2001.[19]

Decline in HIV prevalence have been attributed to a combination of behavioural changes, the natural course of the HIV epidemic, prevention strategies and increase access to antiretroviral therapy (ART).[18]

In South Africa (SA), HIV prevalence in adults 15–49 years has stabilised since 2005. Estimates as reported in the 2011 National ANC survey has stabilised around 29% in the past six years.[20] From this survey, HIV prevalence increased rapidly from 1990 to 1998. There was then a gradual increase from 1998 till it peaked in 2005. It has since plateaued (Figure 1).[20] Trends for the Western Cape Province are similar.[21]

Figure 1: HIV prevalence among antenatal women, South Africa, 1990 to 2011.[20]



Prevalence estimates from ANC surveys are said to overestimate the HIV prevalence in the general population. For this reason, population based HIV prevalence surveys have been done in SA in 2002, 2005, 2008 and 2012.[22,23] Despite the differences in prevalence estimates, data from the population based HIV prevalence survey and the Joint United Nations Programme on HIV/AIDS (UNAIDS) also show similar trends in HIV prevalence to that from the National ANC survey (Table 1).[22,24] From the population based HIV prevalence survey, there has been minimal changes in HIV prevalence estimates since 2002.[22] This survey in 2012 however showed an increase in HIV prevalence compared to previous years. The reported

increase to 18.8% likely reflects the increase in access to ART which prolongs life and therefore the duration of HIV infection.[23] HIV prevalence estimates from UNAIDS has stabilised around 18% since 2008.[24]

Table 1: HIV Prevalence in 15-49 year age group[20,23,24]

	2002	2005	2008	2009	2010	2012
Data Source	**%**	**%**	**%**	**%**	**%**	**%**
National ANC Survey	26.5	30.2	29.3	29.4	30.2	-
Population Based Survey	15.6	16.2	16.9	-	-	18.8
UNAIDS	-	-	17.9	17.8	17.9	-

Data from the population based HIV prevalence survey shows that in children 2–14 years, the prevalence has decreased from 5.6% in 2002 to 2.4% in 2012.[23] Also, prevalence has decreased in infants less than 12 months (2.0% to 1.3% in 2008 and 2012 respectively) due to a successful PMTCT programme.[23] Evidence from the 2011 National ANC survey shows that prevalence in the 15 – 24 year group has declined since 2005.[20] Similar trends were also reported in the population based HIV prevalence survey; the prevalence has declined from 10.3% in 2005 to 8.7% in 2008 to 7.1% in 2012.[22,23] HIV prevalence in 15–24 year olds is used to estimate HIV incidence.[25] In this group, decline in prevalence was probably due to safer sex practices; the use of condoms went up from 57% in 2002 to 87% in 2008 amongst male participants and 46% to 73% amongst female participants in the same period.[22] However, despite a decline in HIV prevalence in 2012, there was also a reported decline in condom use for this year.[23] Table 2 summarises the prevalence in HIV in three age groups as reported by the population based HIV prevalence surveys from 2002 - 2012.

Table 2: HIV prevalence by age[23]

	2002	2005	2008	2012
Age group (years)	**% (95% CI)**	**% (95% CI)**	**% (95% CI)**	**% (95% CI)**
2 – 14	5.6 (3.7–7.4)	3.3 (2.3–4.8)	2.5 (1.9–3.5)	2.4 (2.0–3.0)
15 – 24	9.3 (7.3–11.2)	10.3 (8.7–12.0)	8.7 (7.2–10.4)	7.1 (6.2–8.1)
15 – 49	15.6 (13.9–17.6)	16.2 (14.9–17.7)	16.9 (15.5–18.4)	18.8 (17.5–20.3)

Although HIV prevalence has been high amongst those 25+ years, the 30 – 34 year age group has persistently been the group with the highest HIV prevalence over time. ANC survey estimates in this group has increased from 2009 (41.5%) to 2011 (42.2%).[20] In the older age groups, the persistence of high prevalence rates is probably due to the use of ART.[21]

Several risk factors have been described to be associated with HIV infection. These include education, race as well as the age of the partner.[26,27] In studies done in SSA and in South Africa, women with a higher educational achievement were found to have a lower risk of HIV infection.[26,27] Having an older male partner and being of the African population group increased the risk of infection.[27] A combination of factors including intergenerational sex involving older men,[28] the social effects of past forced removals in South Africa, deterioration in cultural and traditional values leading to unstable communities and the migrant labour system[29,30] have been mentioned as some of the reasons for the increased risk.

Surveillance Methods

In view of the fact that the exact number of people living with HIV/AIDS is not known, surveillance systems are used to obtain estimates. This allows for effective response to the epidemic and has major implications on government policy planning, prevention, allocation of resources and monitoring of programmes.[31,32]

With the lack of reliable data, monitoring of HIV prevalence and its trends over time has been done mainly through reports from sentinel ANC surveillance in pregnant women.[25,33] To obtain national estimates for countries, HIV prevalence in this group as a whole is used to approximate the estimate in the overall adult population based on a model with underlying assumptions on the differences in HIV prevalence between pregnant women and the general population.[31] Sentinel ANC surveillance is mainly used to estimate HIV prevalence in countries with generalised epidemics.[25,32]

Other available methods for describing the HIV epidemic include data from PMTCT programmes and voluntary counseling and testing (VCT) programmes as well as population based Demographic and Health Surveys (DHS).[25] Data from PMTCT and VCT programmes (specifically for VCT) may be influenced by participation bias. Although population based surveys have the advantage of being more representative of the country's population by including both men and women as well as providing a link between HIV and household characteristics, they are expensive to conduct and hence are done less frequently.[25,32] Case

notifications and information obtained from mortality reports have also provided data on HIV trends.[34]

HIV prevalence has also been described in groups considered to be at high risk for HIV infection. These include female sex workers and their clients, attendees at STI clinics, truck drivers, military and police workers, intravenous drug users (IDUs) and men who have sex with men (MSM).[25,34] In these groups however, data is not commonly available and HIV trends from them cannot be generalised to the overall population.[25] This method of surveillance is best suited for countries with low and concentrated epidemics.[34]

Earlier surveillance systems monitored prevalence in blood donors. Due to current restrictions on blood donation, this group is considered to be at low risk of infection and hence HIV prevalence amongst them is likely to be biased.[25]

The World Health Organisation (WHO) and UNAIDS came up with guidelines for a second-generation surveillance in 2000. By using data from a number of sources, these guidelines urged nations to adapt surveillance systems based on the stage and type of their HIV epidemic. The aim of this is for nations to have a more complete report of HIV trends.[35] A summary of the recommended second generation surveillance methods is shown in box 1.

Box 1. WHO / UNAIDS data collection methods for HIV surveillance.[35]

1. Biological surveillance
    - Sentinel sero-surveillance in defined sub-populations
    - Regular HIV screening of donated blood
    - Regular HIV screening of occupational cohorts or other sub-populations
    - HIV screening of specimens taken in general population surveys
    - HIV screening of specimens taken in special population surveys
2. Behavioural surveillance
    - Repeat cross-sectional surveys in the general population
    - Repeat cross-sectional surveys in defined sub-populations
3. Other sources of information
    - HIV and AIDS case surveillance
    - Death registration
    - STI surveillance, TB surveillance

Surveillance systems for HIV continue to change based on new knowledge. Recently though, with an increase in the uptake of PMTCT programmes and provision of ART, there have been debates amongst public health practitioners worldwide on the prospects of using PMTCT data for reporting antenatal HIV prevalence and trends.[31,35]

Sentinel ANC Surveys and PMTCT programmes

Sentinel ANC surveys have been done since the late 1980s.[32] These surveys are conducted in selected clinics at regular intervals. During routine antenatal care, extra blood is drawn from participating pregnant women and tested for HIV. The test is done anonymously and it is unlinked so the specimen collected cannot be traced to the participant.[36] Unlike ANC surveys, PMTCT is provided throughout the year in all facilities providing antenatal care. Also, HIV tests done in PMTCT programmes are linked to the pregnant woman. This is done to provide antiretroviral therapy to pregnant women so as to prevent HIV being transmitted from them to their infants.[36]

Both surveillance systems provide valuable information on HIV prevalence in pregnant women. However, ethical concerns have been raised regarding the unlinked anonymous testing (UAT) approach used in ANC surveys. This includes the apparent lack of direct individual benefit to the pregnant women since they will not know of their HIV test results.[36,37] Also ANC surveys are done at a specific time in a year in selected facilities. There is often uncertainty as to whether or not the selected facilities in ANC surveys represent whole populations in a country.[37]

Several studies including those done in SSA have evaluated the estimated prevalence of HIV from ANC surveys and from PMTCT programmes. In Ethiopia, HIV prevalence estimates from ANC survey was 6.1% and 5.5% in 2008 and 2009 respectively; and that from PMTCT was 6.2% and 4.5% for the same period. Due to the consistency in prevalence from both surveillance systems, this study concluded that routine PMTCT data can be used in monitoring HIV trends.[37] Similar outcomes were also seen in Cameroon, Botswana and Thailand.[38]

Even though these studies recognised the potential of PMTCT data to be used in HIV surveillance, certain issues need to be considered. These include PMTCT data quality and uptake.

Firstly regarding uptake, higher HIV prevalence has been reported from PMTCT programmes with low uptake.[36,38] Low uptake leads to data that does not fully represent all antenatal care attendees.[36] This is particularly so where the opt-out approach to testing is used. It is believed that women who refuse to be tested maybe significantly different to those who agree to be tested. This can lead to bias in HIV prevalence estimates for PMTCT programmes.[36] A Ugandan study found that where the uptake of PMTCT was less than 70%, HIV prevalence from PMTCT programmes was greater than in ANC surveys. However, there was no difference in HIV prevalence between the two surveillance methods when uptake was greater than 70%.[39] Similarly in Ethiopia, when the uptake of PMTCT was at its lowest in 2005 (33%), HIV prevalence was 8.8% and 12.5% in PMTCT and ANC surveys respectively. Once uptake improved in 2008 and 2009, prevalence of HIV was comparable between the two.[37] In Thailand, after reaching a PMTCT uptake of 96.7% in 2001, PMTCT prevalence differed by 0.1% from ANC survey prevalence. Thailand now uses only PMTCT data to report on HIV prevalence.[38]

Secondly, the main issues regarding the quality of PMTCT data are the absence of standardised testing algorithms, stocking of test kits, inconsistent staff training, the use of different registers for recording and reporting; missing data and the absence of quality control systems.[37,38,40]

In countries such as Kenya, Mozambique, Uganda and Zimbabwe, the use of PMTCT data to estimate HIV prevalence has not yet being recommended since studies found considerable discrepancies in HIV prevalence between ANC surveys and PMTCT programmes.[36,38-40] This was mainly due to low uptake and problems with data quality. In Kenya for instance, PMTCT data showed an HIV prevalence of 14.4% in 2003 compared to the 12.8% found from ANC survey.[36]

Despite these concerns, the use of PMTCT data for HIV surveillance still remains topical due to its cost effectiveness. Additional resources are needed to conduct ANC surveys since it is not part of routine antenatal care.[36,37] PMTCT on the other hand, being part of routine healthcare, have been found to be cost saving.[37]

WHO recommends the use of UAT ANC surveillance to report HIV trends only if data from other sources such as PMTCT programmes, does not give the essential information needed for surveillance.[41] For PMTCT data to be used for HIV surveillance, uptake must be high and data collection and reporting should be standardised, accurate and unbiased.[36]

Currently though, due to the substantial variability found in the quality of surveillance systems in SSA,[11] no country in this region has yet replaced UAT ANC surveys with PMTCT programmes.[41]

The South African and the Western Cape Context

The country with the most number of people living with HIV/AIDS in the world is South Africa.[42] With prevalence exceeding 15% and the rate of new infections being more than 5% per year, UNAIDS has defined the generalised epidemic found in SA as being hyperendemic.[42,43] The 2011 national ANC HIV and syphilis prevalence survey estimated the prevalence in pregnant women to be 29.5% with one of the lowest prevalence (18.2%) being reported in its Western Cape province.[20,44]

Similar to most sub-Saharan countries, statistics on HIV prevalence in SA is primarily based on sentinel ANC surveys. However data is also available from PMTCT programmes and DHS.

Sentinel ANC surveys have been done annually in SA for over 20 years. For each year, all pregnant women attending a health facility for their first antenatal booking in the month of October of each year are invited to participate in the survey. No exclusion is made to any pregnant woman based on their known HIV status. If the woman gives consent to be part of the survey, as routine antenatal blood tests are being taken, an extra blood specimen is taken to test for HIV and syphilis. The survey is anonymous and a barcode is used to identify specimens. The National Health Laboratory Service (NHLS) analyses all specimens and an Enzyme-linked Immunosorbent Assay (ELISA) test for the HIV antigen as well as a Rapid Plasma Reagin (RPR) test for syphilis is done.[20,21] The national antenatal HIV and syphilis prevalence survey is conducted in selected clinics (sentinel sites) representative of the provincial population (urban, rural and informal settlements) in all provinces and is designed to provide provincial and district level estimates. The sampling for the national survey is based on the Probability Proportional to Size (PPS) method.[21] In 2011, a total of 33 446 women were tested in 1 445 antenatal facilities in all nine provinces in the country. The goal was to test 36 000 pregnant women using antenatal services.[20]

The Western Cape HIV antenatal survey has two components. It includes the national component already described above as well as a sub-district component. The sub-district survey expands the national survey by including additional sites. This Provincial/expanded

survey was designed to give a more accurate HIV prevalence estimate at a provincial, district and sub-district level for the purpose of programme management.[21] In 2006, a review of HIV prevalence estimates for the Western Cape Province was done comparing estimates reported from the national component to the sub-district component.[45] It was found that using the national estimates alone may mask HIV prevalence at the sub-provincial level.[45]

Steps to implement PMTCT nationally in SA were started in 2001 when the programme was piloted at 18 sites. In 2002, after a scale up of interventions, it was rolled out to antenatal and maternity facilities in the country. As of 2010, over 95% of all facilities providing antenatal and maternity care offered PMTCT services. Amendment to the programme was done in 2008 and in 2010 due to advances in medical care.[46]

In the PMTCT programme, all pregnant women presenting at any healthcare facility for their first antenatal visit in their current pregnancy are offered routine HIV counselling and voluntary testing. This is offered with an "opt-out" option where the woman can refuse to be tested. If she consents, as blood is drawn for routine antenatal care, a rapid test for HIV is done. Should this be positive, a second confirmatory test is performed. Diagnosis of HIV is made when the second confirmatory test is also positive. An ELISA is only done when there are discordant results between the first and second rapid tests.[47]

If diagnosis is confirmed, the pregnant woman is then enrolled into the PMTCT programme which involves taking blood for CD4 count and WHO staging. Based on this, ARV prophylaxis or treatment is given in the antenatal period, during labour and delivery; and in the postnatal period for both mother and infant.[47]

Although PMTCT is offered in over 95% of all public sector antenatal care facilities in the country,[46] coverage between provinces and districts ranges from 48% - 100%.[48] In 2002/3 after the policy was rolled-out nationally, the percentage of women booked at public sector antenatal facilities who had HIV tests in the country was 15.6% (Table 3).[49] This increased to 81% in 2007/8 and to 98% in 2011/12.[49,50] The Western Cape Province, having started services earlier, has persistently reported the highest coverage compared to the other provinces. The percentage of booked women who were tested for HIV at public sector antenatal facilities in the Western Cape Province was 43.9% in 2002/3 and 95.7% in 2007/8.[49]

Table 3: Proportion of booked women receiving HIV tests at public antenatal facilities, per province and year[49]

Province	2001/2	2002/3	2003	2004	2005/6	2006/7	2007/8
Eastern Cape	1.7%	6.7%				75.3%	88.3%
Free State	4.6%	15.8%	31.1%	33.7%	40.4%	66.9%	80.1%
Gauteng		20.0%	17.6%	39.0%	47.4%	60.6%	73.3%
KwaZulu-Natal	7.2%	13.6%			43.8%	58.5%	70.7%
Limpopo	1.0%	8.4%	26.0%	37.6%	46.5%	77.5%	90.1%
Mpumalanga	0.6%	0.0%	10.9%	12.9%	31.4%	58.2%	74.6%
Northern Cape	5.0%	4.6%	18.2%	16.4%	59.1%	81.5%	88.5%
North West	2.2%	30.7%		34.7%	47.9%	74.3%	85.6%
Western Cape		43.9%				93.7%	95.7%
South Africa	**6.9%**	**15.6%**	**25.3%**	**37.3%**	**49.1%**	**69.2%**	**81.0%**

The number of women who are tested for HIV is influenced by coverage, being offered HIV testing at facilities and uptake.[49] The high coverage seen in the country indicates an almost universal coverage of PMTCT services.[50] With the introduction of provider initiated counselling and testing (PICT), more women are being offered tests at PMTCT facilities and a study done in 2010 to evaluate PMTCT effectiveness has found current uptake in the country to be 98.8% and that of the Western Cape Province nearing 100%.[46]

Despite the increase in coverage and uptake, there are quality challenges that need to be addressed. These include the lack of standardised data collection tools and training, insufficient human resources, poor counselling methods and problems with monitoring and evaluation systems.[48]

With renewed political will however,[48] it is believed that these quality challenges will be addressed.

Conclusion

Prevalence in HIV has stabilised globally despite existing variations between regions and countries. Similarly, in South Africa, data from population based HIV prevalence surveys, UNAIDS and ANC surveys showed that HIV prevalence in this country is stabilising. In reporting HIV prevalence trends, there is the added complexity of patients already on treatment. Some surveillance tools however are able to describe the full cascade. Ongoing

monitoring of HIV prevalence trends is necessary for health service planning. For this reason, efficient surveillance methods such as the use of data from PMTCT programmes are needed.

PMTCT coverage, uptake and data quality, specifically in SSA hinders progress in using PMTCT estimates for surveillance. In South Africa however, both coverage and uptake are high. It is encouraging to also note that coverage and uptake in other countries is increasing and in time, information will be known on more women in PMTCT programmes than in ANC surveys. With health systems strengthening, factors affecting data quality can be improved on locally, nationally and internationally. This should enable the use of data from PMTCT programmes for antenatal HIV surveillance. It will be of benefit especially in resource limited countries where additional costs are incurred in conducting ANC surveys.

Needs for further research

Compared to ANC surveys, using PMTCT data for HIV surveillance will be cost saving and it will provide direct benefits to pregnant women. Empirical studies are needed in the South African context to determine whether HIV prevalence estimates from ANC surveys are comparable to estimates from PMTCT programmes. This will inform the National Department of Health on the utility of PMTCT programmes for future HIV surveillance. Further research is also needed to determine the quality of data obtained from PMTCT programmes as well as PMTCT coverage, uptake and monitoring. Internationally, there is a further need to identify the accurateness that PMTCT HIV estimates needs to be in order for it to be used for surveillance.

Definition of Terms

Surveillance: The continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice.

Epidemic: A widespread occurrence of an infectious disease in a community at a particular time.

Hyper-endemic: A disease that is constantly present at a high incidence and / or prevalence rate and affects all age groups equally.

Prevalence: The number / proportion of cases of a disease that is present (existing) in a particular population at a given time.

Incidence: The number / proportion of new cases that develop in a given period of time.

Coverage (PMTCT): The proportion of antenatal facilities providing PMTCT services.

Uptake (PMTCT): The proportion of antenatal care attendees who consent to be tested for HIV out of all antenatal care attendees.

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Part C: Journal Manuscript

***Title**: HIV surveillance: A 12 year analysis of HIV prevalence trends and comparing HIV prevalence from sentinel antenatal clinic surveys and Prevention of mother-to-child programmes*

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Comment on race terminology: In this article, socially classified racial group is referred to as 'race'. Race, based on the South Africa apartheid concept is categorised as 'Black/African', 'White', 'Coloured' and 'Asian/Indian'. Antenatal risk of HIV infection varies considerably by population group in South Africa. Understanding the interplay between geography and population group in accounting for differential antenatal HIV prevalence is key to understanding the evolution of the epidemic. Race is used in this article in order to provide the opportunity to better understand the correlates of HIV prevalence and incidence given the data available in the antenatal survey.

Abstract

Background

Sentinel antenatal clinic (ANC) surveys remain a key source of data on HIV prevalence trends. Recently though, with an increase in the uptake of prevention of mother–to–child transmission (PMTCT) programmes, there have been debates on the prospects of using PMTCT data for reporting antenatal HIV prevalence and trends.

Aim

To describe the HIV prevalence trends for the Western Cape Province and to compare prevalence from ANC surveys to PMTCT programmes.

Methods

HIV prevalence and 95% confidence intervals were estimated from ANC surveys from 2001-2012 for the province as well as the 6 health districts and the 8 City of Cape Town Metropolitan sub-districts in the province. HIV prevalence from expanded provincial ANC survey sampling was compared to the nationally reported provincial and district estimates, before and after re-weighting to account for differences between the realized sample and updated sampling frame. A regression line was fitted with calendar year included as both a linear and quadratic term to create smoothed trend lines of the change in HIV prevalence over time by province, district, sub-district and age group. A multivariable logistic regression model was fitted to the multi-year ANC survey data to explore associations with HIV prevalence. ANC survey HIV prevalence estimates were compared to those from routinely reported HIV testing data from the PMTCT program for 2009-2012.

Results

Antenatal HIV prevalence in the province has increased from 8.5% (95% CI 7.8 – 9.3%) in 2001 to 17.5% (95% CI 16.7% – 18.3%) in 2012. Trends derived from national, provincial and re-weighted provincial data were broadly comparable, but with sufficient variation to justify use of the re-weighted estimates in subsequent analyses. Trend analysis shows that prevalence has stabilised in the province, districts and 6 of the 8 City of Cape Town sub-districts. HIV prevalence from ANC survey was comparable to PMTCT estimates for the province but there were some disparities mainly at a sub-district level.

Conclusion

HIV prevalence trends are leveling in the Western Cape Province but variations exist at a sub-district level. Using PMTCT HIV prevalence estimates as an alternative to sentinel annual surveys would not change the reported estimates for the province considerably, but the disparities seen between ANC and PMTCT estimates, especially at sub-provincial level, requires further exploration prior to accepting the routine PMTCT estimates as an alternative to continued annual ANC surveys.

Introduction

Since it was first described amongst five individuals in 1981, HIV/AIDS has become a global pandemic and to date, it is still a significant health concern worldwide with approximately 34 million people infected at the end of 2011(1,2). Over the years, efforts have been made to control this epidemic. Prevention strategies, health education and the use of antiretroviral drugs have decreased the spread and reduced HIV/AIDS related morbidity and mortality (3). It is important to monitor trends so as to effectively allocate resources for HIV prevention and control (4).

Surveillance for HIV remains the basis of our understanding of this disease (5). Although there are several HIV surveillance systems, including population based household surveys, sentinel antenatal clinic (ANC) surveys and prevention of mother–to–child transmission (PMTCT) programmes, sentinel ANC surveys in pregnant women remain an important source of information for determining HIV trends (6,7). Based on a model, HIV prevalence in this group is extrapolated to the general adult population to obtain national estimates for countries (8). Surveillance for HIV continues to change based on new knowledge. Recently though, with an increase in the uptake of PMTCT programmes, there have been debates amongst public health practitioners worldwide on the prospects of using PMTCT data for reporting antenatal HIV prevalence and trends (8,9).

In South Africa (SA), sentinel ANC surveys have been done annually in each of its nine provinces since 1990. This unlinked anonymous testing (UAT) survey samples pregnant women receiving care at selected public health facilities in the country (10). In 2001, South Africa's Western Cape Province expanded the national ANC survey by including additional sites. This Provincial/expanded survey was designed to give a more accurate HIV prevalence estimate at a provincial, district and sub-district level (10).

PMTCT programmes were first introduced in the Western Cape Province in 1998/99 before being introduced nationally in 2002 (11,12). The purpose of PMTCT programmes is to reduce the transmission of HIV from mothers to their infants through providing antiretroviral prophylaxis or treatment for all HIV positive pregnant women (13). PMTCT services are integrated with basic antenatal care provided at health facilities (13) and data from this is routinely collected. In South Africa, after ten years of programme introduction, over 95% of public sector antenatal care facilities now offer PMTCT services (14). PMTCT testing uptake in the country has increased from 90% in 2009 to 98% in 2011/12 (15). In the Western Cape

Province, a study done in 2010 to evaluate PMTCT effectiveness found uptake to be almost 100% (14).

By increasing the number of sites in the provincial ANC survey, both PMTCT and ANC surveillance have been conducted at similar facilities in the Western Cape Province since 2001. Although sentinel ANC surveys are useful, they are expensive to conduct and do not form part of routine healthcare services (6,16). It is therefore important to assess whether the PMTCT programme gives comparable HIV prevalence estimates to the ANC survey.

The aim of this study was to describe the HIV prevalence trends for the Western Cape Province using ANC survey data and to compare prevalence estimates from ANC surveys to PMTCT programmes. Additional objectives were to determine the risk factors associated with HIV infection and describe the trends by age at booking.

Methods

A retrospective descriptive review was done to analyse repeated cross sectional ANC HIV survey data from 2001 – 2012 and routine PMTCT data from 2009 – 2012 for the Western Cape Province.

In the Western Cape Province, there are six health districts and each health district is further sub-divided into sub-districts. The six health districts are the City of Cape Town Metropolitan district and the five rural districts namely; Cape Winelands, Central Karoo, Eden, Overberg and West Coast.

For the sentinel ANC surveys, all pregnant women attending a health facility for their first antenatal booking in the month of October of each year are invited to participate in the survey. No exclusion is made to any pregnant woman based on her known HIV status. If a woman gives consent to be part of the survey, as routine antenatal blood tests are being taken, an extra blood specimen is taken to test for HIV. The survey is anonymous and a barcode is used to identify specimens. The National Health Laboratory Service (NHLS) analyses all specimens and an Enzyme-linked Immunosorbent Assay (ELISA) test for the HIV antigen is done (10,17). For the ANC surveys, a probability proportional to size (PPS) sampling method is taken based on the previous year's antenatal booking data. The sample size is stratified by sub-district to achieve a precision around the HIV prevalence point estimate of 3.5% above and below the estimate. For logistical reasons, sampling is capped at 1.5 months of booking

data for smaller sub-districts (10). When combining data for district and provincial estimates, data have been re-weighted to reflect the antenatal booking data of the same year in which the sample was conducted. District boundaries changed in 2007 limiting backwards comparison of estimates at district and sub-district level with data prior to 2007.

For the PMTCT programme, the population is all pregnant women attending a health facility for their first antenatal booking at any given time. Routine HIV counseling and voluntary testing is offered with an "opt-out" option where the woman can refuse to be tested. If she consents, as blood is drawn for routine antenatal care, a rapid test for HIV is done. Should this be positive, a second confirmatory test is performed. Diagnosis of HIV is made when the second confirmatory test is also positive. An ELISA is only done when there are discordant results between the first and second rapid tests (13). Prior to 2009, routine data systems only recorded total tests done and the number of positive results, and did not account for women who already knew they were HIV-infected or were on treatment for HIV and therefore elected not to test again.

In this review, further sampling was not done since available data on all pregnant women who consented to participate in the sentinel ANC survey from 2001 – 2012 and PMTCT data on all women who agreed to be tested or were already known to be HIV-infected from 2009 – 2012 were reviewed.

Data Collection and Analysis

ANC survey data over the years are double-entered into an Excel spreadsheet and checked for any inconsistencies. Information entered includes demographic details of the pregnant women as well as their HIV test results. After data cleaning, the data are exported into a Microsoft Access database which allows comparison of data to previous years and linkage of each laboratory result to the antenatal booking data from the same year to facilitate re-weighting estimates when combining sub-district data into district and provincial estimates. For this review, data for the ANC survey from 2001 – 2012 was obtained from the provincial antenatal survey database. PMTCT data from facilities is collated at sub-district and then district level. District level data is then entered into a District Health Information System (DHIS) on a monthly basis. This includes several elements of which the ones that were extracted for review from 2009 to 2012 were the number of women refusing PMTCT initial tests, the number of women accepting PMTCT initial tests, the number of PMTCT initial

tests testing positive and the number of known PMTCT clients either on treatment for HIV or already known to be HIV-infected and referred for treatment initiation.

Data from both systems were analysed using Stata version 12.1, StataCorp, College Station, Texas. For the ANC survey data, sub-districts were re-weighted according to annual booking data. HIV prevalence was estimated from PMTCT data without any re-weighting to reflect differential coverage, as coverage of testing is uniformly high and the intention of the analysis was to compare dedicated surveillance to routine program data estimates. Prevalence estimates were calculated with 95% confidence intervals. For ANC survey data, a comparison was made between the national reported estimates for the Western Cape Province and the estimates calculated from the expanded provincial survey without re-weighting and with re-weighting (referred to as provincial and provincial re-weighted estimates respectively). For trend analysis, a regression line was fitted with calendar year included as both a linear and quadratic term to create smoothed trend lines to determine the change in HIV prevalence over time. Age from 15 years onwards was categorised in 5 year intervals and HIV prevalence trends from 2001 – 2012 in each age category was analysed. To determine risk factors for HIV infection, logistic regression models were fitted. The first models included year as a variable and the second set of models was fitted looking at several variables for each year. Finally ANC survey estimates were then compared to PMTCT estimates.

Ethical considerations

Since this review used existing data with no personal identifiers, individual patient consent was not required, although both the antenatal survey and routine HIV testing are consented. Permission to use the ANC survey and PMTCT data was obtained from the Director of the HIV/AIDS, STI and TB (HAST) directorate of the Western Cape Department of Health through the Provincial Health Research sub-directorate. Ethics approval was granted by the University of Cape Town's Human Research Ethics Committee (HREC Ref.: 284/2014).

Results

Antenatal survey coverage

The provincial realised sample size for each year is more than the national realised sample size for the Western Cape Province (Table 1), and ranged from 5 287 to 13 063. For the districts, the City of Cape Town district represents over 60% of the total antenatal care

bookings and over 50% of the realised sample size for each year except for 2007 and 2012 where it represented 48% and 46% of the realised sample size respectively. The Central Karoo district has the least number of bookings and sample size per year. For the City of Cape Town sub-districts, Western, Khayelitsha, Klipfontein and Tygerberg sub-districts together have the most bookings and sample size in each year. Mitchells Plain sub-district was under-represented in all years whilst Eastern sub-district was over-represented from 2002 – 2012 (Table 1).

Comparison of antenatal survey estimates

Antenatal HIV prevalence from the national, provincial and provincial re-weighted estimates is depicted in figure 1. The overall HIV prevalence trend from 2001 – 2012 in the national, provincial and provincial re-weighted estimates is similar and the national estimates fall within the confidence interval of the provincial and provincial re-weighted estimates (Figure 1A). The confidence intervals seen from the provincial and provincial re-weighted estimates are narrow compared to the wide confidence intervals seen in the national estimates.

At a district level, the highest HIV prevalence estimate for 2012 is seen in the City of Cape Town district and the lowest is in the West Coast district. The Overberg district has the highest prevalence estimates in all the rural districts for 2012 (Figure 1B). National, provincial and provincial re-weighted estimates are broadly comparable with some disparities seen in the City of Cape Town and Central Karoo districts. In all the districts, the national estimates fall within the confidence interval of the provincial and provincial re-weighted estimates. The provincial and provincial re-weighted estimates for the Central Karoo district and to a lesser extent the Overberg district have wider confidence intervals compared to the same estimates for the other districts as a result of the smaller sample sizes (Figure 1B). Although a similar overall trend could be inferred from each set of estimates, the point estimates do differ, as evidenced in 2012 where the under-representation of the City of Cape Town in the realised sample resulted in the weighted provincial estimate for HIV prevalence being higher than the un-weighted estimate.

All future comparisons use the re-weighted estimates to represent the ANC survey data.

Antenatal survey HIV prevalence trends

The provincial HIV prevalence has increased from 8.5% (95% CI 7.8 – 9.3%) in 2001 to 17.5% (95% CI 16.7% – 18.3%) in 2012. The highest recorded prevalence was 18.6% (95% CI 17.8% - 19.3%) in 2011 (Table 2). The overall Western Cape provincial estimate is being driven by the estimates in the City of Cape Town district which has had the highest prevalence in all the districts since 2002. In the 8 City of Cape Town sub-districts, the highest prevalence estimates from 2001 to 2012 can be seen in Khayelitsha (Table 2). The smoothed predicted lines show a plateauing of HIV prevalence estimates over time in the province, districts and the Metro sub-districts except for the Western and Mitchells Plain sub-districts. In these two sub-districts there is a continued upward trend in HIV prevalence estimates (Supplementary Figure 1).

The trend in HIV prevalence by age group demonstrates that HIV prevalence is lowest in the 15–19 year age group and highest in the 30–34 years group (Figure 2). In the younger groups (15–29 years), there is a downward trend in HIV prevalence. But in the older groups (30+ years) where prevalence estimates are high, there is an upward trend in HIV prevalence especially for the 35–39 and 40+ age groups.

The associations between calendar period and age group described above are reflected in the multivariable analysis (Table 3). Having a secondary or a tertiary education was found to be a protective factor for HIV infection compared to a primary education, only after adjustment for other variables [adjusted OR 0.83 (95% CI 0.77 – 0.90) and adjusted OR 0.50 (95% CI 0.42 – 0.60) for secondary and tertiary education respectively] (Table 3). This protective effect of education however was only seen in later years from 2006 (Supplementary Table 1). Compared to Coloured, being African was associated with a nearly 10 fold higher risk of antenatal HIV infection, adjusted OR 9.08 (95% CI 8.47 – 9.73) with women in the "Other" group (Asians and Whites) having a lower risk of HIV infection. Male partner age 5 or more years older increased the risk of HIV infection by 8% compared to a male partner who was less than 5 years older (Table 3).

Comparison of antenatal survey estimates and trends to routine PMTCT data

A comparison of ANC survey and PMTCT estimates shows that for the province, both estimates are similar with the PMTCT HIV prevalence falling within the confidence interval of the ANC survey prevalence for 2009 – 2012 (Figure 3 and Supplementary Table 2). At a

district level, this is true for most years except for 2009 & 2012 for the City of Cape Town and 2009 & 2011 for Eden districts. The district trend for both ANC survey and PMTCT estimates is comparable. For the City of Cape Town sub-districts, the main disparities between ANC survey and PMTCT estimates can be seen in Khayelitsha (2009), Klipfontein (2012), Mitchells Plain (2011) and Tygerberg (2011 and 2012). PMTCT uptake was high; 98 – 99% of all booked PMTCT antenatal care attendees from 2009 – 2012 were evaluated (Supplementary Table 2).

Discussion

Antenatal survey coverage

It is expected for the provincial sample size to be more than the national sample size due to the inclusion of additional facilities in the provincial antenatal survey since 2001. By doing so, antenatal survey coverage was increased in the Western Cape Province and a better representation of districts and sub-districts was achieved. The City of Cape Town district, being the district with the highest population per square meter in the province has the most bookings but was under-represented in the survey each year. Similarly, Mitchells Plain sub-district was consistently under-represented each year. Central Karoo district has the least sample size due to its small population size.

Comparison of antenatal survey estimates

Comparing prevalence from the national, provincial and provincial re-weighted estimates showed a similar pattern in prevalence trend in all 3. Although the national estimates had wide confidence intervals because it assumes a two stage design and it has a smaller sample size, the reported estimate from the national data largely fell within the confidence interval of the provincial and provincial re-weighted estimates. However, although this analysis of the three data points was done at a provincial level for 2001 – 2012, it was done at a district level for only 2012. As was found in a study done in the Western Cape Province in 2006 (18), using the national estimates alone will lead to under-representation of sub-provincial level facilities and hence may mask HIV prevalence at this level. The differences between the realised samples and the booking data in each year supports the use of re-weighted estimates. The weighting also enabled historical data pre-2007 to be used to estimate district and sub-district level antenatal prevalence according to current health jurisdiction boundaries which changed in 2007.

Antenatal survey HIV prevalence trends

There is a stabilisation in antenatal HIV prevalence trends in the province, districts and 6 of the 8 City of Cape Town sub-districts. This stabilisation in prevalence is similar to what is seen nationally (17). The reason for the persistently high prevalence in Khayelitsha may be due to a number of factors including the high proportion of people receiving antiretroviral treatment (ART) and as a result living longer (19). Unlike PMTCT data, information about ART is not collected in the antenatal survey. This makes it complex when interpreting HIV prevalence trends from the antenatal survey since it becomes impossible to differentiate HIV prevalence due to new infections (incidence) from that due to the impact of ART. Also, the population of Khayelitsha is mostly Black African. Race is an important risk factor for HIV infection with Africans having a 9 – 10 times higher risk of infection compared to Coloureds. There are strong correlations between risk behaviours (such as concurrent sexual partnerships, number of sexual partners, age of sexual debut) and the racial differences in HIV prevalence (20). It is not clear what could be driving an upward trend in the Western and Mitchells Plain sub-districts differently to what is seen in the other sub-districts. The reasons may be similar to those found in Khayelitsha. Nonetheless, this shows inter district / regional variations in HIV prevalence that needs to be explored further.

Regarding age, the downward trend in HIV prevalence in the younger age groups is encouraging. HIV prevalence estimates in 15 – 24 year olds are assumed to be new or recent and therefore estimates in this group are used as a proxy for HIV incidence (21). Based on these results, it can be inferred that the rate of new HIV infections are declining. However, there is still a persistently high prevalence seen in those older than 30 years. In the older age groups, the upward trend in HIV prevalence is likely to be due to the impact of ART which has been shown to prolong life and hence the duration of infection (10). These age trend findings of the Western Cape Province are similar to trends found in SSA (21) and that of the national antenatal survey (17). Estimates as reported in the 2011 national survey shows a decline in HIV prevalence in women 24 years and younger and an increase in older women (17).

The adjusted risk of being HIV infected has not changed significantly from 2006 – 2012 confirming a stabilisation in HIV prevalence in the last 6 years. Consistent with other studies done in SSA (22) and in South Africa (23), a higher educational achievement was found to be a protective factor for HIV infection. The fact that this protective effect was not seen in

earlier years suggests a changing pattern in the epidemiology of HIV with the least educated women being at higher risk of infection in recent times. Also, older age of 40 – 49 years was a protective factor for HIV infection earlier in the epidemic. Now, compared to teenage women 15 – 19 years, all age groups have a higher risk of infection. Regarding the age of male partners, the increased risk in HIV infection if a male partner is 5 or more years older has been attributed to intergenerational sex involving older men who also have a high risk of been infected (24). Contrary to this, current evidence has found no association between older male partners and risk of HIV infection in women younger than 30 years; and in women older than 30 years, the risk was lower with increasing male partner age (25).

Comparison of antenatal survey estimates and trends to routine PMTCT data

Overall, for the province, districts and City of Cape Town sub-districts, HIV prevalence from ANC survey was comparable to PMTCT estimates. There were however some disparities seen in some years and some districts and the City of Cape Town sub-districts. Where there have been disparities in the reported estimates from the two surveillance methods, PMTCT uptake and data quality have been cited as possible reasons for the observed differences (6,16,26,27). In this study, uptake was high and hence reduces concerns around selection bias. There were data challenges and this was mainly because of missing information for certain PMTCT elements such as the number of known PMTCT clients on treatment for HIV and those not on treatment; and the number already known to be HIV-infected and referred for treatment initiation. This may explain the disparities seen. It must be noted that PMTCT data does not include the age of the pregnant women and hence age trend analysis cannot be done using routine data.

Strengths

This analysis used a large data set of ANC survey data and PMTCT data for the Western Cape Province from 2001 – 2012 and 2009 – 2012 respectively. Based on the sample size, it was possible to do a non-linear trend analysis and to test for associations using the ANC survey data.

Limitations

As mentioned earlier, PMTCT data quality was a concern. Due to unrecorded PMTCT elements, it was not possible to analyse and directly compare ANC survey estimates to PMTCT estimates for earlier years, 2001 – 2008. The PMTCT data are aggregate, limiting

the ability to interrogate quality and internal consistency. This was a retrospective review of ANC survey data for the past 12 years. Certain geographic information (district and sub-district alignment) had changed over the years. Furthermore, some facilities no longer had antenatal services. This had led to difficulties in directly comparing HIV prevalence estimates for districts and the City of Cape Town sub-districts for each year between the periods before and after the changing of jurisdiction boundaries. In order to have comparable information, data was cleaned and current information regarding participating facilities and geographic demarcations were verified. The analysis in this study focused on only the sub-districts in the City of Cape Town district and did not look at the sub-districts from the rural districts due to sample size limitations in the sub-districts outside of Cape Town.

Standardisation of data collection forms, training of staff, auditing of PMTCT data at facility level, monthly data review and making booking data routinely available electronically are recommended ways for improving the quality of PMTCT data.

Conclusion

HIV prevalence trends are leveling in the Western Cape Province at a provincial, district and City of Cape Town sub-district level. Variations exist in some City of Cape Town sub-districts where there is a continued upward trend in prevalence. Reasons for these variations will need to be investigated at a local level and will require using data from different sources. Further studies are needed to describe HIV prevalence trends at a sub-district level in the rural districts. The declining but continued prevalence in young women 15 – 24 years implies that HIV preventive programmes for the youth need to be further strengthened.

Even though using PMTCT HIV prevalence estimates will not change the reported estimates for the province, district and City of Cape Town sub-districts considerably, PMTCT data quality concerns need to be addressed if these data are to be used as an alternative to annual antenatal surveys at sub-provincial level. Also, if ANC surveillance is replaced with routine PMTCT programmes, it would not be possible to describe HIV prevalence trends by age unless the PMTCT data were available at individual patient level. Therefore replacing ANC surveys with PMTCT programmes for HIV surveillance is not currently recommended, and we propose that the comparison be repeated once booking data are routinely available electronically.

In reporting HIV prevalence trends, there is the added complexity of patients already on treatment. It is recommended that the proportion of pregnant women already on ART be measured as part of future ANC surveys in South Africa. This can be done by altering the current ANC sentinel surveillance form to include a section on whether the survey participant is on ART or not.

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Tables and Figures

Table 1. Antenatal booking and sampled population distribution, Western Cape Province, 2001 – 2012.

	2001		2002		2003		2004		2005		2006	
District	Bookings (%)	Sampled (%)	Bookings (%)	Sampled (%)	Bookings (%)	Sampled (%)	Bookings (%)	Sampled (%)	Bookings (%)	Sampled (%)	Bookings (%)	Sampled (%)
Cape Winelands	10,319 (12)	876 (16)	11,104 (13)	815 (14)	12,623 (14)	669 (13)	11,373 (13)	1,266 (13)	12,220 (14)	1,520 (14)	13,944 (14)	1,847 (14)
Central Karoo	1,068 (1)	91 (2)	1,343 (2)	108 (2)	1,433 (2)	121 (2)	1,422 (2)	194 (2)	1,467 (2)	140 (1)	1,403 (1)	247 (2)
City of Cape Town	54,450 (65)	3,054 (56)	53,782 (64)	3,218 (56)	56,911 (64)	2,807 (53)	55,728 (64)	5,520 (58)	53,954 (62)	6,291 (58)	59,147 (61)	7,700 (59)
Eden	9,186 (11)	668 (12)	9,020 (11)	784 (14)	9,275 (10)	943 (18)	9,192 (10)	1,270 (13)	10,089 (12)	1,247 (12)	11,975 (12)	1,549 (12)
Overberg	3,488 (4)	313 (6)	3,633 (4)	370 (6)	3,912 (4)	290 (5)	4,010 (5)	632 (7)	4,008 (5)	720 (7)	4,131 (4)	605 (5)
West Coast	5,562 (7)	426 (8)	5,026 (6)	412 (7)	5,150 (6)	457 (9)	5,845 (7)	671 (7)	5,781 (7)	857 (8)	6,204 (6)	1,115 (9)
Provincial Total	84,073 (100)	5,428 (100)	83,908 (100)	5,707 (100)	89,304 (100)	5,287 (100)	87,570 (100)	9,553 (100)	87,519 (100)	10,775 (100)	96,804 (100)	13,063 (100)
National sample		2,035		1,897		1,991		1,952		1,960		3,866
City of Cape Town subdistricts												
Eastern	6,883 (13)	299 (10)	5,335 (10)	389 (12)	5,258 (9)	416 (15)	4,424 (8)	872 (16)	5,248 (10)	792 (13)	5,395 (9)	848 (11)
Northern	3,489 (6)	209 (7)	4,036 (8)	235 (7)	5,401 (9)	212 (8)	6,656 (12)	322 (6)	2,978 (6)	440 (7)	4,995 (8)	312 (4)
Southern	4,958 (9)	269 (9)	4,885 (9)	288 (9)	5,781 (10)	271 (10)	5,191 (9)	538 (10)	4,664 (9)	690 (11)	5,023 (8)	900 (12)
Western	6,302 (12)	447 (15)	8,850 (16)	345 (11)	8,766 (15)	365 (13)	5,478 (10)	756 (14)	6,286 (12)	860 (14)	6,347 (11)	948 (12)
Khayelitsha	7,980 (15)	426 (14)	8,057 (15)	585 (18)	7,491 (13)	424 (15)	8,342 (15)	838 (15)	8,950 (17)	970 (15)	9,180 (16)	1,188 (15)
Klipfontein	9,407 (17)	539 (18)	8,543 (16)	725 (23)	9,331 (16)	603 (21)	9,845 (18)	1,168 (21)	10,206 (19)	1,180 (19)	9,118 (15)	1,390 (18)
Mitchells Plain	5,249 (10)	208 (7)	5,016 (9)	134 (4)	5,431 (10)	142 (5)	5,706 (10)	344 (6)	5,464 (10)	553 (9)	6,289 (11)	734 (10)
Tygerberg	10,182 (19)	657 (22)	9,060 (17)	517 (16)	9,452 (17)	374 (13)	10,086 (18)	682 (12)	10,158 (19)	806 (13)	12,800 (22)	1,380 (18)
City of Cape Town Total	54,450 (100)	3,054 (100)	53,782 (100)	3,218 (100)	56,911 (100)	2,807 (100)	55,728 (100)	5,520 (100)	53,954 (100)	6,291 (100)	59,147 (100)	7,700 (100)

	2007		2008		2009		2010		2011		2012	
District	Bookings (%)	Sampled (%)	Bookings (%)	Sampled (%)	Bookings (%)	Sampled (%)	Bookings (%)	Sampled (%)	Bookings (%)	Sampled (%)	Bookings (%)	Sampled (%)
Cape Winelands	12,737 (13)	1,877 (16)	13,942 (13)	1,514 (16)	12,182 (12)	1,313 (15)	13,282 (13)	1,658 (18)	13,041 (13)	1,754 (18)	13,083 (13)	1,757 (20)
Central Karoo	1,235 (1)	380 (3)	1,378 (1)	230 (2)	1,316 (1)	148 (2)	1,303 (1)	112 (1)	1,148 (1)	169 (2)	1,089 (1)	182 (2)
City of Cape Town	61,329 (64)	5,570 (48)	67,143 (64)	5,258 (56)	70,286 (67)	4,356 (50)	66,387 (65)	4,673 (52)	62,548 (65)	5,187 (53)	63,636 (65)	4,049 (46)
Eden	10,781 (11)	1,444 (12)	10,805 (10)	1,225 (13)	10,444 (10)	1,440 (16)	10,181 (10)	1,271 (14)	9,678 (10)	1,292 (13)	9,423 (10)	1,324 (15)
Overberg	4,357 (5)	946 (8)	4,655 (4)	533 (6)	4,517 (4)	628 (7)	4,192 (4)	538 (6)	4,231 (4)	598 (6)	4,088 (4)	570 (7)
West Coast	5,894 (6)	1,465 (13)	6,307 (6)	705 (7)	6,241 (6)	850 (10)	7,165 (7)	725 (8)	6,236 (6)	812 (8)	6,201 (6)	829 (10)
Provincial Total	96,333 (100)	11,682 (100)	104,230 (100)	9,465 (100)	104,986 (100)	8,735 (100)	102,510 (100)	8,977 (100)	96,882 (100)	9,812 (100)	97,520 (100)	8,711 (100)
National sample		3,830		3,848		3,679		3,981		4,029		3,908
City of Cape Town subdistricts												
Eastern	5,784 (9)	753 (14)	5,919 (9)	829 (16)	6,347 (9)	505 (12)	5,950 (9)	669 (14)	6,202 (10)	658 (13)	6,422 (10)	566 (14)
Northern	3,728 (6)	573 (10)	4,727 (7)	392 (7)	3,868 (6)	350 (8)	3,947 (6)	417 (9)	4,123 (7)	489 (9)	4,329 (7)	416 (10)
Southern	6,345 (10)	598 (11)	7,353 (11)	394 (7)	8,608 (12)	362 (8)	6,611 (10)	419 (9)	5,595 (9)	429 (8)	7,277 (11)	380 (9)
Western	7,833 (13)	591 (11)	8,927 (13)	835 (16)	8,921 (13)	617 (14)	6,785 (10)	478 (10)	6,988 (11)	730 (14)	6,614 (10)	552 (14)
Khayelitsha	8,636 (14)	811 (15)	9,591 (14)	903 (17)	10,984 (16)	784 (18)	9,562 (14)	1,056 (23)	9,542 (15)	1,013 (20)	10,561 (17)	718 (18)
Klipfontein	9,671 (16)	1,140 (20)	8,860 (13)	719 (14)	10,604 (15)	757 (17)	11,182 (17)	762 (16)	9,938 (16)	806 (16)	8,846 (14)	574 (14)
Mitchells Plain	7,278 (12)	393 (7)	7,263 (11)	416 (8)	6,961 (10)	404 (9)	8,185 (12)	504 (11)	8,408 (13)	562 (11)	7,722 (12)	392 (10)
Tygerberg	12,054 (20)	711 (13)	14,503 (22)	770 (15)	13,993 (20)	577 (13)	14,165 (21)	368 (8)	11,752 (19)	500 (10)	11,865 (19)	451 (11)
City of Cape Town Total	61,329 (100)	5,570 (100)	67,143 (100)	5,258 (100)	70,286 (100)	4,356 (100)	66,387 (100)	4,673 (100)	62,548 (100)	5,187 (100)	63,636 (100)	4,049 (100)

Table 2. Antenatal Survey HIV Prevalence by district and City of Cape Town sub-districts, Western Cape Province, 2001 – 2012.

	2001		2002		2003		2004		2005		2006	
District	Prevalence	95% CI	Prevalence	95% CI	Prevalence	95% CI	Prevalence	95% CI	Prevalence	95% CI	Prevalence	95% CI
Cape Winelands	5.5	4.0 - 7.0	8.3	6.4 - 10.1	7.9	5.9 - 9.9	10.7	9.0 - 12.3	10.9	9.4 - 12.4	12.8	11.4 - 14.3
Central Karoo	5.1	1.0 - 9.2	7.3	2.6 - 12.0	6.3	2.3 - 10.3	9.6	5.4 - 13.8	8.3	3.6 - 12.9	6.7	3.8 - 9.6
City of Cape Town	9.3	8.3 - 10.3	14.4	13.3 - 15.5	13.9	12.7 - 15.1	18.3	17.2 - 19.3	17.4	16.5 - 18.3	18	17.2 - 18.9
Eden	8.1	6.1 - 10.1	10.2	8.1 - 12.2	10.5	8.7 - 12.4	12.6	10.8 - 14.3	14	12.2 - 15.7	13.5	11.7 - 15.2
Overberg	12.6	7.8 - 17.4	10.5	7.7 - 13.3	13.7	9.8 - 17.6	12.7	10.1 - 15.2	12.8	10.4 - 15.2	13.1	10.6 - 15.6
West Coast	5.3	3.4 - 7.2	8.4	5.6 - 11.3	8.1	5.7 - 10.6	9.2	7.1 - 11.3	9.2	7.4 - 11.1	8.2	6.7 - 9.7
Provincial Total	**8.5**	**7.8 - 9.3**	**12.5**	**11.7 - 13.3**	**12.2**	**11.4 - 13.1**	**15.7**	**14.9 - 16.4**	**15.2**	**14.6 - 15.8**	**15.7**	**15.1 - 16.3**
City of Cape Town subdistricts												
Eastern	12	8.5 - 15.5	15.7	12.3 - 19.1	14.9	11.7 - 18.2	16.3	14.0 - 18.6	10.7	8.7 - 12.8	14.9	12.6 - 17.1
Northern	12	7.8 - 16.1	16.2	11.7 - 20.6	15.1	10.5 - 19.7	18.3	14.3 - 22.3	21.8	18.2 - 25.5	22.1	17.7 - 26.5
Southern	5.2	2.7 - 7.7	7.6	4.7 - 10.5	9.2	6.0 - 12.5	13	10.3 - 15.7	12.2	9.9 - 14.5	12.6	10.5 - 14.6
Western	8.7	6.2 - 11.2	18	14.1 - 21.8	11.2	8.2 - 14.3	12.4	10.2 - 14.7	15	12.7 - 17.3	15.8	13.6 - 18.0
Khayelitsha	21.8	18.1 - 25.6	24.4	21.1 - 27.7	23.8	20.0 - 27.7	31.9	28.9 - 34.9	32.9	30.1 - 35.7	32.8	30.3 - 35.4
Klipfontein	10.6	8.1 - 13.0	19.9	17.1 - 22.6	21.9	18.8 - 25.0	24.3	22.0 - 26.6	24.3	22.0 - 26.6	21.3	19.3 - 23.3
Mitchells Plain	0.5	0 – 1.4	4.5	1.2 - 7.8	7	3.0 - 11.0	13.1	9.7 - 16.5	4.9	3.2 - 6.6	10.8	8.6 - 12.9
Tygerberg	2.4	1.3 - 3.6	4.4	2.8 - 6.1	6.1	3.8 - 8.5	10.7	8.5 - 12.9	9.7	7.7 - 11.6	11.7	10.1 - 13.3

	2007		2008		2009		2010		2011		2012	
District	Prevalence	95% CI	Prevalence	95% CI	Prevalence	95% CI	Prevalence	95% CI	Prevalence	95% CI	Prevalence	95% CI
Cape Winelands	13	11.5 - 14.5	12.3	10.6 - 13.9	13	11.2 - 14.8	13.4	11.8 - 15.0	14.2	12.6 - 15.6	14.1	12.5 - 15.6
Central Karoo	14.2	10.9 - 17.6	7.7	4.7 - 10.7	9.8	5.2 - 14.4	7.2	2.7 - 11.7	8.7	4.7 - 12.7	12.2	7.5 - 16.9
City of Cape Town	17.5	16.5 - 18.4	18.3	17.3 - 19.3	18.1	17.1 - 19.2	19.5	18.3 - 20.6	21.1	20.0 - 22.1	19.5	18.4 - 20.7
Eden	13	11.4 - 14.5	14.3	12.5 - 16.2	16.3	14.5 - 18.1	16	14.1 - 17.9	14.5	12.7 - 16.3	14.3	12.5 - 16.0
Overberg	19	16.5 - 21.5	16.3	13.3 - 19.3	17.9	15.1 - 20.7	17.7	14.7 - 20.7	16.9	14.0 - 19.9	16.6	13.8 - 19.5
West Coast	8.8	7.1 - 10.4	11.6	9.3 - 13.8	10.3	8.4 - 12.3	11.2	8.8 - 13.6	12	9.8 - 14.1	10.9	8.9 - 12.9
Provincial Total	**15.9**	**15.2 - 16.5**	**16.4**	**15.7 - 17.2**	**16.8**	**16.0 - 17.6**	**17.5**	**16.7 - 18.4**	**18.6**	**17.8 - 19.3**	**17.5**	**16.7 - 18.3**
City of Cape Town subdistricts												
Eastern	18.3	15.7 - 20.9	18.9	16.4 - 21.5	19.8	16.5 - 23.1	18.4	15.6 - 21.2	17.9	15.2 - 20.7	16.3	13.4 - 19.1
Northern	22.7	19.4 - 25.9	21.4	17.6 - 25.3	18	14.2 - 21.8	22.1	18.3 - 25.8	26.2	22.5 - 29.9	21.9	18.1 - 25.6
Southern	9.9	7.6 - 12.1	9.9	7.1 - 12.7	11.9	8.7 - 15.0	8.8	6.3 - 11.4	12.4	9.4 - 15.3	10.3	7.4 - 13.2
Western	15.9	13.1 - 18.7	16.6	14.2 - 19.0	17	14.2 - 19.8	23.4	19.8 - 27.0	20	17.2 - 22.8	20.5	17.3 - 23.7
Khayelitsha	31.4	28.4 - 34.5	33.4	30.5 - 36.4	30	27.1 - 33.1	33.1	30.5 - 35.8	37.1	34.3 - 39.9	34.3	31.0 - 37.6
Klipfontein	23.2	20.8 - 25.5	23.4	20.4 - 26.3	24	21.2 - 26.9	23.4	20.5 - 26.2	25.1	22.2 - 27.9	22.3	19.1 - 25.5
Mitchells Plain	11.7	8.7 - 14.7	13.9	10.8 - 17.1	13.9	10.7 - 17.1	13.3	10.5 - 16.1	20.8	17.6 - 24.0	18.4	14.7 - 22.0
Tygerberg	9.4	7.4 - 11.5	11.3	9.2 - 13.4	10.2	7.9 - 12.6	13.6	10.3 - 16.9	9.4	7.0 - 11.8	11.1	8.3 - 13.8

CI, confidence interval.

Table 3. HIV risk factors, univariable and multivariable analysis of antenatal survey (model 1).

	Univariable	Multivariable (2006 - 2012)	Multivariable (2001 - 2012)
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
Year			
2001	1	_[a]	1
2002	1.53 (1.36 - 1.73)	_[a]	1.42 (1.23 - 1.65)
2003	1.50 (1.32 - 1.69)	_[a]	1.42 (1.23 - 1.66)
2004	1.99 (1.79 - 2.22)	_[a]	1.74 (1.52 - 2.00)
2005	1.92 (1.73 - 2.14)	_[a]	1.68 (1.47 - 1.92)
2006	2 (1.80 - 2.22)	1	1.73 (1.51 - 1.97)
2007	2.02 (1.82 - 2.51)	1.03 (0.95 - 1.13)	1.72 (1.50 - 1.97)
2008	2.11 (1.89 - 2.35)	0.99 (0.91 - 1.08)	1.75 (1.53 - 2.00)
2009	2.16 (1.04 - 2.41)	0.99 (0.91 - 1.08)	1.75 (1.53 - 2.01)
2010	2.28 (2.04 - 2.54)	1.06 (0.97 - 1.16)	1.85 (1.62 - 2.12)
2011	2.44 (2.20 - 2.72)	1.07 (0.98 - 1.16)	1.92 (1.68 - 2.19)
2012	2.28 (2.04 - 2.54)	0.99 (0.90 - 1.08)	1.81 (1.58 - 2.07)
Age group			
15 - 19	1	1	1
20 -24	2.40 (2.24 - 2.57)	2.19 (1.99 - 2.40)	2.06 (1.91 - 2.22)
25 - 29	3.49 (3.26 - 3.74)	3.43 (3.13 - 3.77)	2.89 (2.68 - 3.11)
30 - 34	3.33 (3.10 - 3.58)	3.68 (3.33 - 4.07)	2.97 (2.75 - 3.21)
35 - 39	2.45 (2.25 - 2.68)	2.92 (2.57 - 3.31)	2.35 (2.13 - 2.59)
40 - 49	1.61 (1.37 - 1.88)	2.20 (1.74 - 2.78)	1.64 (1.38 - 1.94)
Education			
Primary	1	1	1
Secondary	1.20 (1.14 - 1.26)	0.83 (0.77 - 0.90)	0.91 (0.86 - 0.96)
Tertiary	0.95 (0.82 - 1.09)	0.50 (0.42 - 0.60)	0.58 (0.50 - 0.68)
Race			
Coloured	1	1	1
African	10.80 (10.27 - 11.36)	9.08 (8.47 - 9.73)	10.26 (9.75 - 10.80)
Other	0.76 (0.55 - 1.07)	0.41 (0.24 - 0.70)	0.74 (0.54 - 1.03)
Male Partner age			
<5 years older	1	1	_[a]
5 or more years older	1.16 (1.10 - 1.21)	1.08 (1.03 - 1.14)	_[a]

OR, odds ratio; CI, confidence interval.

[a]Age of partner information was not included in the regression because data was only available from 2006 – 2012.

Supplementary Table 1. HIV Risk factors, univariable and multivariable analysis of antenatal survey by year (model 2).

	2001 OR (95% CI)		2002 OR (95% CI)		2003 OR (95% CI)		2004 OR (95% CI)		2005 OR (95% CI)		2006 OR (95% CI)	
	Univariaale	Multivariaale	Univariaale	Multivariaale	Univariaale	Multivariaale	Univariaale	Multivariaale	Univariaale	Multivariaale	Univariaale	Multivariaale
Age group												
15 - 19	1	1	1	1	1	1	1	1	1	1	1	1
20 -24	2.80 (1.88 - 4.19)	2.31 (1.51 - 3.55)	2.25 (1.72 - 2.96)	1.91 (1.44 - 2.55)	2.01 (1.51 - 2.68)	1.65 (1.22 - 2.23)	2.23 (1.82 - 2.75)	1.96 (1.58 - 2.44)	2.44 (1.98 - 2.99)	2.18 (1.76 - 2.69)	3.61 (2.93 - 4.43)	2.89 (2.33 - 3.59)
25 - 29	3.41 (2.29 - 5.07)	2.64 (1.72 - 4.04)	2.74 (2.08 - 3.59)	2.05 (1.54 - 2.73)	2.11 (1.58 - 2.83)	1.63 (1.20 - 2.22)	2.69 (2.18 - 3.32)	2.25 (1.81 - 2.82)	3.30 (2.68 - 4.06)	2.75 (2.21 - 3.41)	5.04 (4.09 - 6.21)	3.98 (3.21 - 4.95)
30 - 34	2.08 (1.33 - 3.27)	1.85 (1.14 - 3.00)	1.56 (1.14 - 2.14)	1.49 (1.07 - 2.08)	1.74 (1.27 - 2.39)	1.57 (1.13 - 2.19)	1.70 (1.35 - 2.14)	1.57 (1.22 - 2.00)	2.89 (2.32 - 3.61)	2.64 (2.09 - 3.34)	4.73 (3.78 - 5.91)	3.52 (2.79 - 4.45)
35 - 39	1.47 (0.78 - 2.75)	1.38 (0.71 - 2.71)	1.19 (0.77 - 1.82)	1.02 (0.65 - 1.58)	1.43 (0.95 - 2.16)	1.20 (0.78 - 1.85)	1.06 (0.78 - 1.45)	1.00 (0.72 - 1.39)	1.99 (1.52 - 2.60)	1.85 (1.39 - 2.47)	2.84 (2.11 - 3.81)	2.44 (1.79 - 3.33)
40 - 49	a	a	0.89 (0.41 - 1.94)	0.89 (0.41 - 1.94)	0.70 (0.30 - 1.60)	0.63 (0.27 - 1.48)	0.84 (0.44 - 1.59)	0.75 (0.38 - 1.51)	1.20 (0.69 - 2.09)	1.21 (0.66 - 2.21)	1.70 (0.88 - 3.28)	1.52 (0.77 - 3.00)
Education												
Primary	1	1	1	1	1	1	1	1	1	1	1	1
Secondary	1.41 (1.03 - 1.92)	1.14 (0.81 - 1.59)	1.42 (1.16 - 1.74)	1.01 (0.81 - 1.26)	1.38 (1.15 - 1.67)	1.02 (0.83 - 1.25)	1.23 (1.03 - 1.47)	0.86 (0.70 - 1.05)	1.37 (1.15 - 1.62)	1.03 (0.85 - 1.25)	1.14 (0.96 - 1.37)	0.85 (0.69 - 1.04)
Tertiary	2.54 (1.05 - 6.13)	2.50 (0.77 - 8.09)	1.46 (0.69 - 3.09)	1.60 (0.65 - 3.91)	1.52 (0.75 - 3.08)	1.68 (0.72 - 3.90)	0.85 (0.40 - 1.81)	1.13 (0.44 - 2.95)	1.66 (0.86 - 3.18)	1.56 (0.71 - 3.41)	0.25 (0.06 - 0.97)	0.21 (0.05 - 0.83)
Race												
Coloured	1	1	1	1	1	1	1	1	1	1	1	1
African	17.64 (13.02 - 23.89)	16.85 (12.39 - 22.91)	10.17 (8.13 - 12.71)	9.71 (7.76 - 12.15)	10.46 (8.29 - 13.21)	10.19 (8.08 - 12.86)	9.83 (8.34 - 11.59)	9.57 (8.13 - 11.26)	11.83 (10.12 - 13.83)	11.42 (9.76 - 13.35)	11.35 (9.60 - 13.42)	10.49 (8.86 - 12.41)
Other	a	a	2.07 (0.90 - 4.78)	2.06 (0.89 - 4.76)	0.74 (0.18 - 2.99)	0.71 (0.18 - 2.90)	1.57 (0.86 - 2.87)	1.58 (0.97 - 2.88)	0.76 (0.29 - 2.04)	0.70 (0.26 - 1.87)	0.65 (0.21 - 2.00)	0.59 (0.19 - 1.80)
Male Partner age												
<5 years older	a	a	a	a	a	a	a	a	a	a	1	1
5 or more years older											1.32 (1.19 - 1.46)	1.17 (1.04 - 1.31)

	2007 OR (95% CI)		2008 OR (95% CI)		2009 OR (95% CI)		2010 OR (95% CI)		2011 OR (95% CI)		2012 OR (95% CI)	
	Univariaale	Multivariaale	Univariaale	Multivariaale	Univariaale	Multivariaale	Univariaale	Multivariaale	Univariaale	Multivariaale	Univariaale	Multivariaale
Age group												
15 - 19	1	1	1	1	1	1	1	1	1	1	1	1
20 -24	2.48 (1.97 - 3.12)	2.22 (1.75 - 2.82)	2.43 (1.92 - 3.08)	1.94 (1.51 - 2.49)	2.87 (2.21 - 3.73)	2.40 (1.83 - 3.14)	1.98 (1.57 - 2.49)	1.65 (1.29 - 2.11)	3.12 (2.42 - 4.01)	2.38 (1.83 - 3.10)	2.70 (2.04 - 3.56)	2.19 (1.64 - 2.93)
25 - 29	4.21 (3.35 - 5.30)	3.51 (2.76 - 4.46)	4.01 (3.17 - 5.09)	3.06 (2.38 - 3.93)	4.45 (3.43 - 5.77)	3.59 (2.74 - 4.69)	3.24 (2.57 - 4.07)	2.62 (2.06 - 3.34)	5.52 (4.31 - 7.07)	3.88 (3.00 - 5.02)	5.41 (4.13 - 7.08)	4.07 (3.07 - 5.39)
30 - 34	3.73 (2.89 - 4.80)	2.89 (2.22 - 3.76)	4.83 (3.75 - 6.22)	3.66 (2.81 - 4.78)	4.76 (3.60 - 6.30)	3.74 (2.80 - 4.99)	4.20 (3.28 - 5.38)	2.91 (2.24 - 3.78)	6.56 (5.06 - 8.52)	4.95 (3.77 - 6.50)	6.46 (4.87 - 8.59)	4.81 (3.58 - 6.47)
35 - 39	2.29 (1.65 - 3.17)	1.97 (1.41 - 2.76)	2.0 (1.41 - 2.83)	1.62 (1.12 - 2.36)	3.95 (2.84 - 5.49)	3.46 (2.44 - 4.89)	3.57 (2.64 - 4.84)	3.06 (2.21 - 4.26)	5.34 (3.93 - 7.25)	3.95 (2.86 - 5.45)	5.78 (4.15 - 8.06)	4.32 (3.04 - 6.14)
40 - 49	1.69 (0.91 - 3.13)	1.29 (0.67 - 2.47)	3.00 (1.68 - 5.36)	2.88 (1.57 - 5.30)	2.70 (1.51 - 4.84)	2.57 (1.39 - 4.73)	2.38 (1.28 - 4.40)	1.69 (0.87 - 3.30)	3.26 (1.94 - 5.45)	2.33 (1.38 - 3.92)	4.45 (2.56 - 7.72)	3.48 (1.91 - 6.33)
Education												
Primary	1	1	1	1	1	1	1	1	1	1	1	1
Secondary	1.15 (0.93 - 1.42)	0.85 (0.66 - 1.08)	0.95 (0.78 - 1.15)	0.79 (0.63 - 0.98)	1.06 (0.88 - 1.29)	0.88 (0.71 - 1.08)	1.00 (0.83 - 1.20)	0.80 (0.65 - 0.99)	1.11 (0.94 - 1.32)	0.79 (0.65 - 0.96)	0.94 (0.81 - 1.08)	0.83 (0.70 - 0.97)
Tertiary	0.85 (0.33 - 2.18)	0.91 (0.35 - 2.37)	0.58 (0.18 - 1.86)	0.61 (0.13 - 2.86)	1.11 (0.76 - 1.61)	0.68 (0.46 - 1.02)	0.47 (0.30 - 0.74)	0.31 (0.19 - 0.51)	0.90 (0.65 - 1.24)	0.55 (0.39 - 0.78)	0.70 (0.49 - 1.00)	0.52 (0.36 - 0.77)
Race												
Coloured	1	1	1	1	1	1	1	1	1	1	1	1
African	9.79 (8.22 - 11.66)	9.33 (7.83 - 11.11)	10.22 (8.39 - 12.44)	9.57 (7.85 - 11.67)	7.48 (6.24 - 8.96)	7.07 (5.89 - 8.48)	10.46 (8.59 - 12.74)	9.98 (8.19 - 12.17)	9.62 (8.07 - 11.46)	8.97 (7.50 - 10.71)	9.68 (8.02 - 11.68)	8.82 (7.30 - 10.67)
Other	1.38 (0.66 - 2.88)	1.21 (0.57 - 2.54)	a	a	0.38 (0.99 - 1.46)	0.40 (0.11 - 1.54)	a	a	a	a	0.32 (0.05 - 2.08)	0.28 (0.041 - 1.84)
Male Partner age												
<5 years older	1	1	1	1	1	1	1	1	1	1	1	1
5 or more years older	1.04 (0.92 - 1.18)	1.02 (0.89 - 1.16)	1.22 (1.08 - 1.38)	1.15 (1.00 - 1.31)	1.30 (1.14 - 1.48)	1.20 (1.05 - 1.38)	1.12 (0.98 - 1.27)	1.04 (0.90 - 1.19)	1.07 (0.95 - 1.20)	1.00 (0.88 - 1.14)	1.07 (0.94 - 1.21)	1.01 (0.88 - 1.16)

[a]Data not included in regression analysis because of missing information.

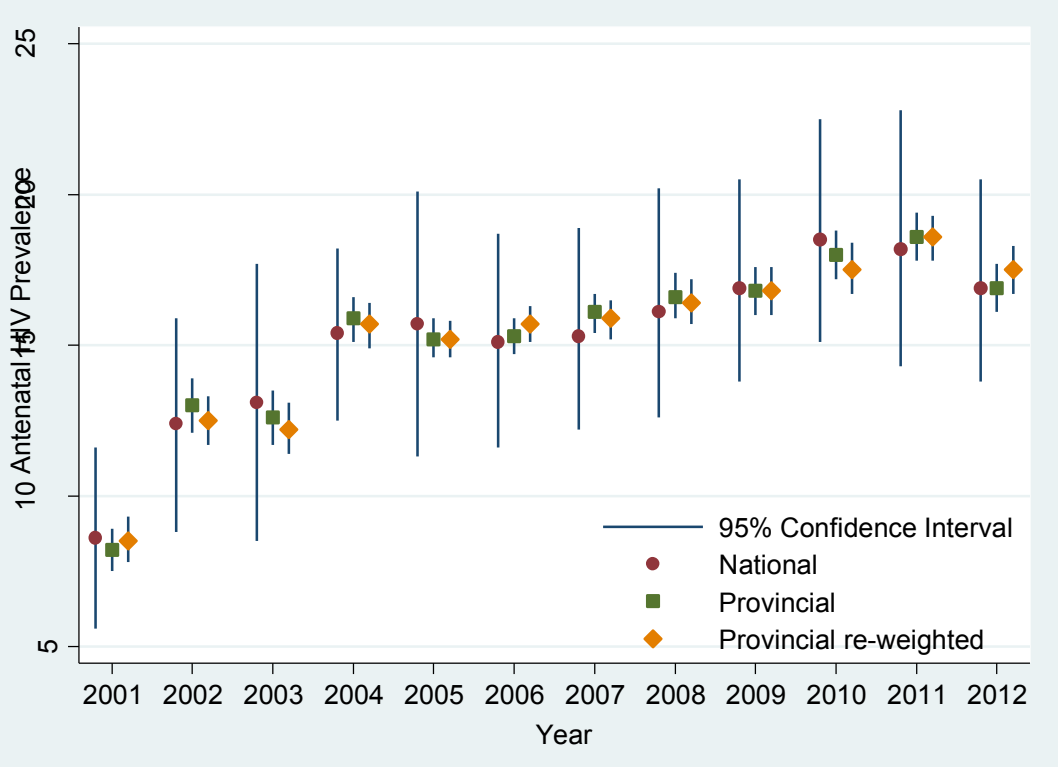
Supplementary Table 2. Comparing HIV prevalence estimates for antenatal survey and PMTCT, Western Cape Province, 2009 – 2012.

	2009							2010						
	ANC				PMTCT			ANC				PMTCT		
District	Bookings (%)	Sampled (%)	Prevalence	95% CI	Bookings (%)	Evaluated (%)	Prevalence	Bookings (%)	Sampled (%)	Prevalence	95% CI	Bookings (%)	Evaluated (%)	Prevalence
Cape Winelands	12,182 (12)	1,313 (15)	13	11.2 - 14.8	12,636 (13)	12,562 (13)	12.6	13,282 (13)	1,658 (18)	13.4	11.8 - 15.0	12,857 (13)	12,826 (13)	11.8
Central Karoo	1,316 (1)	148 (2)	9.8	5.2 - 14.4	1,149 (1)	1,139 (1)	9.7	1,303 (1)	112 (1)	7.2	2.7 - 11.7	1,150 (1)	1,124 (1)	8.9
City of Cape Town	70,286 (67)	4,356 (50)	18.1	17.1 - 19.2	65,414 (66)	63,360 (66)	20.5	66,387 (65)	4,673 (52)	19.5	18.3 - 20.6	66,483 (67)	65,576 (67)	20.5
Eden	10,444 (10)	1,440 (16)	16.3	14.5 - 18.1	9,524 (10)	9,502 (10)	13.4	10,181 (10)	1,271 (14)	16	14.1 - 17.9	8,556 (9)	8,547 (9)	13.8
Overberg	4,517 (4)	628 (7)	17.9	15.1 - 20.7	4,060 (4)	4,044 (4)	14.8	4,192 (4)	538 (6)	17.7	14.7 - 20.7	3,863 (4)	3,834 (4)	14.2
West Coast	6,241 (6)	850 (10)	10.3	8.4 - 12.3	5,732 (6)	5,647 (6)	8.9	7,165 (7)	725 (8)	11.2	8.8 - 13.6	5,624 (6)	5,558 (6)	9.2
Provincial Total	**104,986 (100)**	**8,735 (100)**	**16.8**	**16.0 - 17.6**	**98,515** (100)	**96,254** (100)	**17.7**	**102,510 (100)**	**8,977 (100)**	**17.5**	**16.7 - 18.4**	**98,533** (100)	**97,465** (100)	**17.7**
City of Cape Town subdistricts														
Eastern	6,347 (9)	505 (12)	19.8	16.5 - 23.1	5,722 (9)	5,602 (9)	19.0	5,950 (9)	669 (14)	18.4	15.6 - 21.2	6,036 (9)	5,923 (9)	17.6
Northern	3,868 (6)	350 (8)	18	14.2 - 21.8	3,609 (6)	3,608 (6)	22.1	3,947 (6)	417 (9)	22.1	18.3 - 25.8	4,032 (6)	4,030 (6)	24.3
Southern	8,608 (12)	362 (8)	11.9	8.7 - 15.0	7,430 (11)	7,356 (12)	13.6	6,611 (10)	419 (9)	8.8	6.3 - 11.4	8,254 (12)	8,149 (12)	12.8
Western	8,921 (13)	617 (14)	17	14.2 - 19.8	8,039 (12)	7,668 (12)	19.4	6,785 (10)	478 (10)	23.4	19.8 - 27.0	8,636 (13)	8,308 (13)	20.1
Khayelitsha	10,984 (16)	784 (18)	30	27.1 - 33.1	11,062 (17)	10,967 (17)	38.7	9,562 (14)	1,056 (23)	33.1	30.5 - 35.8	10,188 (15)	10,172 (16)	35.9
Klipfontein	10,604 (15)	757 (17)	24	21.2 - 26.9	9,634 (15)	8,894 (14)	25.6	11,182 (17)	762 (16)	23.4	20.5 - 26.2	9,838 (15)	9,521 (15)	26.9
Mitchells Plain	6,961 (10)	404 (9)	13.9	10.7 - 17.1	8,068 (12)	7,503 (12)	12.7	8,185 (12)	504 (11)	13.3	10.5 - 16.1	7,571 (11)	7,561 (12)	12.6
Tygerberg	13,993 (20)	577 (13)	10.2	7.9 - 12.6	11,850 (18)	11,762 (19)	10.1	14,165 (21)	368 (8)	13.6	10.3 - 16.9	11,928 (18)	11,912 (18)	12.9
City of Cape Town Total	**70,286 (100)**	**4,356 (100)**	**18.1**	**17.1 - 19.2**	**65,414** (100)	**63,360 (100)**	**20.5**	**66,387 (100)**	**4,673 (100)**	**19.5**	**18.3 - 20.6**	**66,483 (100)**	**65,576 (100)**	**20.5**

	2011							2012						
	ANC				PMTCT			ANC				PMTCT		
District	Bookings (%)	Sampled (%)	Prevalence	95% CI	Bookings (%)	Evaluated (%)	Prevalence	Bookings (%)	Sampled (%)	Prevalence	95% CI	Bookings (%)	Evaluated (%)	Prevalence
Cape Winelands	13,041 (13)	1,754 (18)	14.2	12.6 - 15.6	12,942 (13)	12,931 (14)	13.9	13,083 (13)	1,757 (20)	14.1	12.5 - 15.6	12,985 (13)	12,969 (13)	14.5
Central Karoo	1,148 (1)	169 (2)	8.7	4.7 - 12.7	1,168 (1)	1,158 (1)	10.2	1,089 (1)	182 (2)	12.2	7.5 - 16.9	1,146 (1)	1,137 (1)	8.4
City of Cape Town	62,548 (65)	5,187 (53)	21.1	20.0 - 22.1	63,763 (66)	63,036 (66)	21.2	63,636 (65)	4,049 (46)	19.5	18.4 - 20.7	67,877 (67)	66,982 (67)	21.5
Eden	9,678 (10)	1,292 (13)	14.5	12.7 - 16.3	8,399 (9)	8,384 (9)	11.7	9,423 (10)	1,324 (15)	14.3	12.5 - 16.0	9,209 (9)	9,183 (9)	12.7
Overberg	4,231 (4)	598 (6)	16.9	14.0 - 19.9	4,140 (4)	3,990 (4)	15.2	4,088 (4)	570 (7)	16.6	13.8 - 19.5	3,657 (4)	3,617 (4)	14.7
West Coast	6,236 (6)	812 (8)	12	9.8 - 14.1	5,728 (6)	5,719 (6)	10.5	6,201 (6)	829 (10)	10.9	8.9 - 12.9	5,958 (6)	5,916 (6)	9.9
Provincial Total	**96,882 (100)**	**9,812 (100)**	**18.6**	**17.8 - 19.3**	**96,140 (100)**	**95,218** (100)	**18.4**	**97,520 (100)**	**8,711 (100)**	**17.5**	**16.7 - 18.3**	**100,832** (100)	**99,804 (100)**	**18.7**
City of Cape Town subdistricts														
Eastern	6,202 (10)	658 (13)	17.9	15.2 - 20.7	6,190 (10)	6,110 (10)	18.2	6,422 (10)	566 (14)	16.3	13.4 - 19.1	6,285 (9)	6,219 (9)	16.1
Northern	4,123 (7)	489 (9)	26.2	22.5 - 29.9	4,249 (7)	4,247 (7)	24.0	4,329 (7)	416 (10)	21.9	18.1 - 25.6	4,484 (7)	4,476 (7)	24.6
Southern	5,595 (9)	429 (8)	12.4	9.4 - 15.3	7,526 (12)	7,439 (12)	15.4	7,277 (11)	380 (9)	10.3	7.4 - 13.2	7,747 (11)	7,719 (12)	13.1
Western	6,988 (11)	730 (14)	20	17.2 - 22.8	8,588 (13)	8,467 (13)	18.3	6,614 (10)	552 (14)	20.5	17.3 - 23.7	10,190 (15)	9,469 (14)	17.3
Khayelitsha	9,542 (15)	1,013 (20)	37.1	34.3 - 39.9	9,964 (16)	9,946 (16)	37.0	10,561 (17)	718 (18)	34.3	31.0 - 37.6	10,296 (15)	10,293 (15)	38.3
Klipfontein	9,938 (16)	806 (16)	25.1	22.2 - 27.9	8,316 (13)	8,238 (13)	27.9	8,846 (14)	574 (14)	22.3	19.1 - 25.5	8,957 (13)	8,937 (13)	28.4
Mitchells Plain	8,408 (13)	562 (11)	20.8	17.6 - 24.0	7,204 (11)	7,197 (11)	14.5	7,722 (12)	392 (10)	18.4	14.7 - 22.0	8,269 (12)	8,268 (12)	16.9
Tygerberg	11,752 (19)	500 (10)	9.4	7.0 - 11.8	11,726 (18)	11,392 (18)	13.3	11,865 (19)	451 (11)	11.1	8.3 - 13.8	11,649 (17)	11,601 (17)	15.1
City of Cape Town Total	**62,548 (100)**	**5,187 (100)**	**21.1**	**20.0 - 22.1**	**63,763 (100)**	**63,036 (100)**	**21.2**	**63,636 (100)**	**4,049 (100)**	**19.5**	**18.4 - 20.7**	**67,877 (100)**	**66,982 (100)**	**21.5**

Figure 1. Antenatal survey HIV prevalence estimates from sentinel and expanded surveys.

A. Trends for the Western Cape Province, 2001 – 2012.



B. Estimates of prevalence in 2012 for Western Cape health districts.

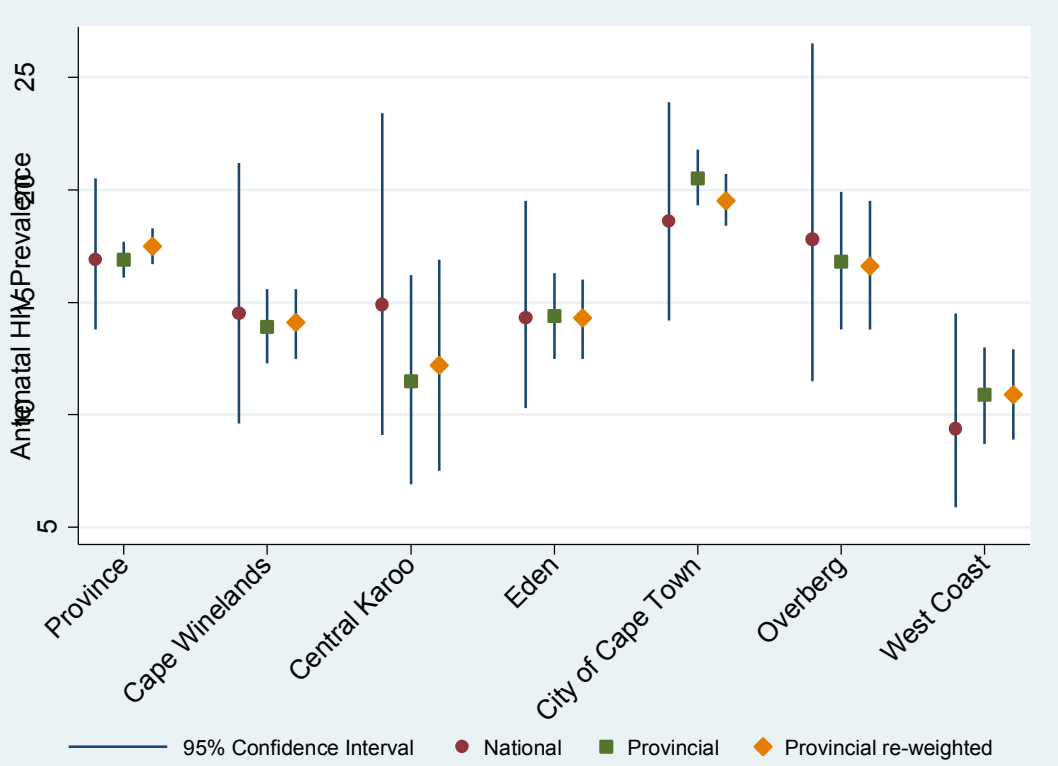


Figure 2. Antenatal HIV Prevalence trends by age groups, Western Cape Province, 2001 – 2012.

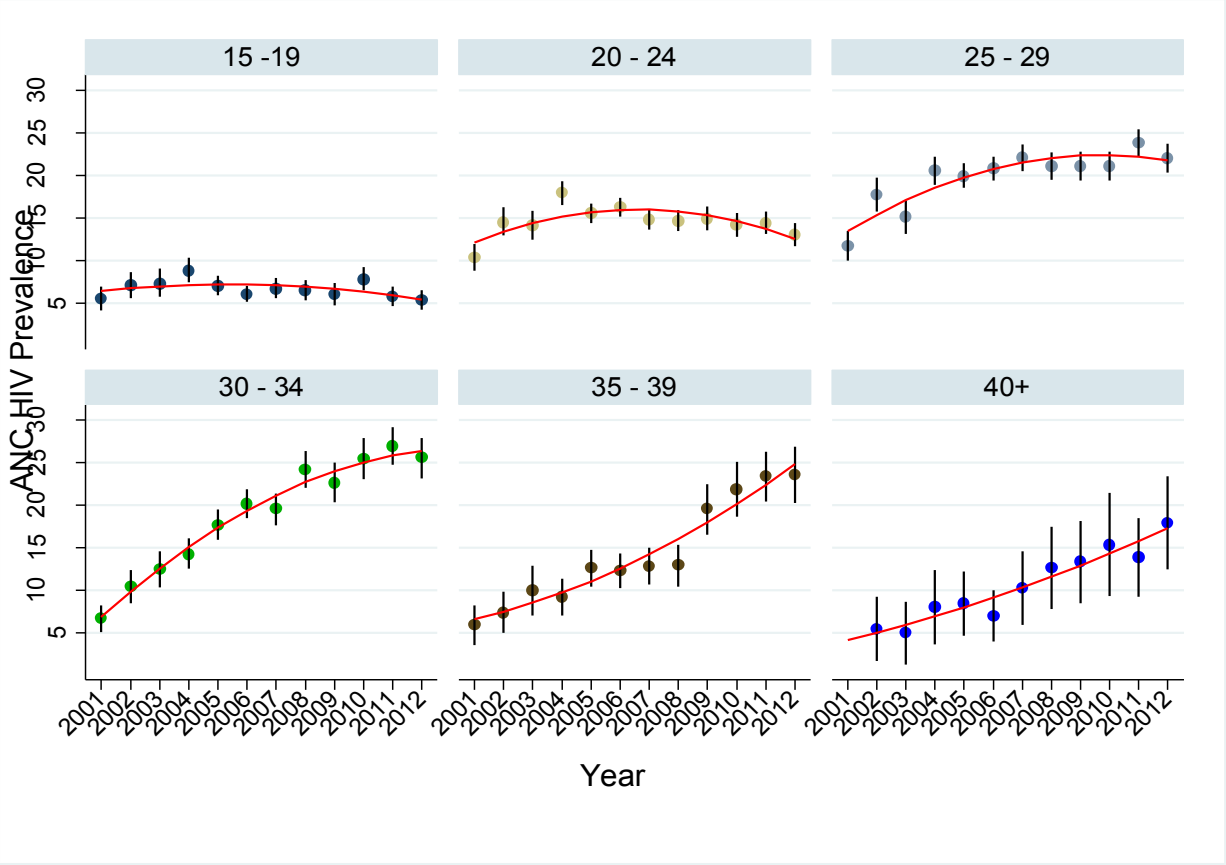
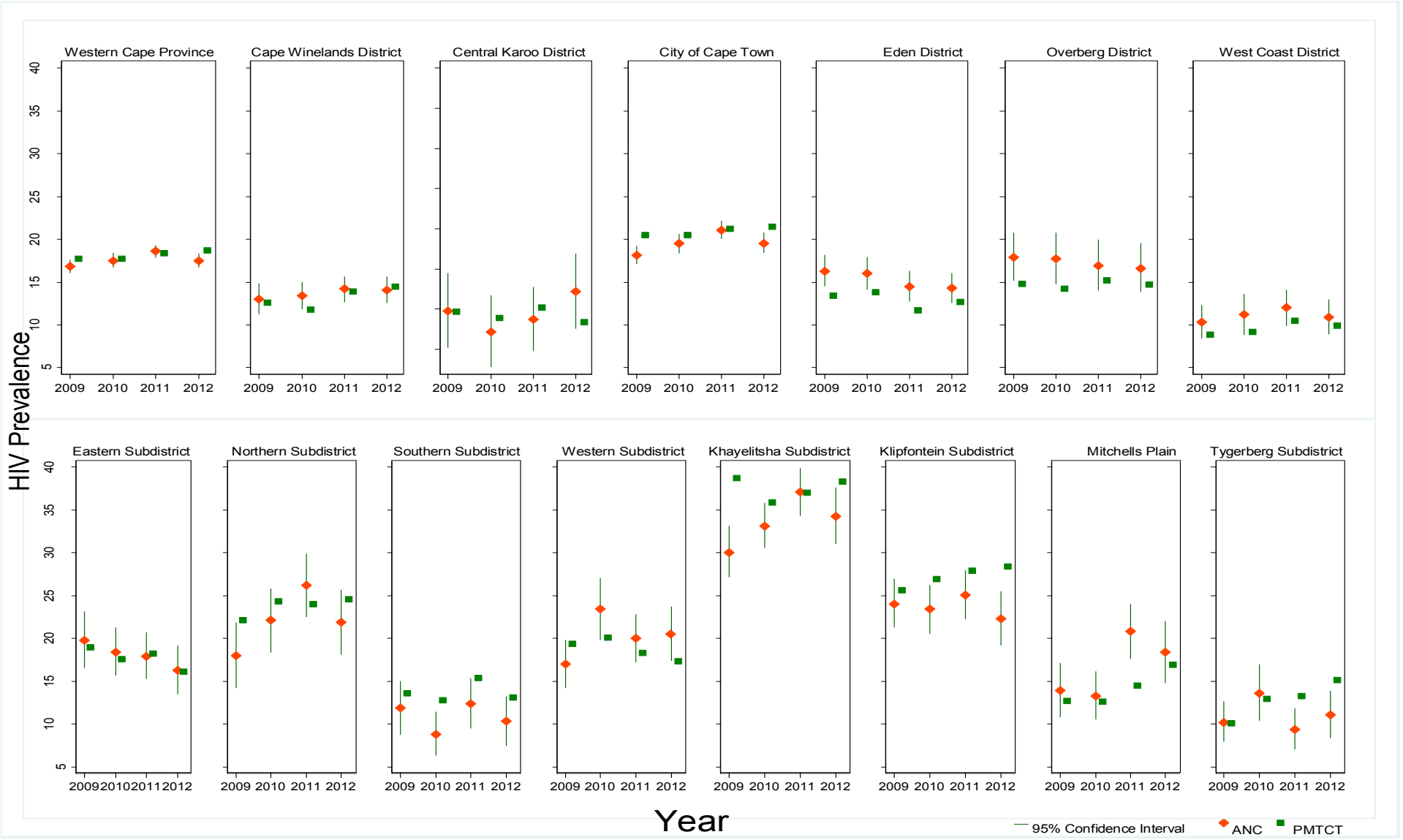
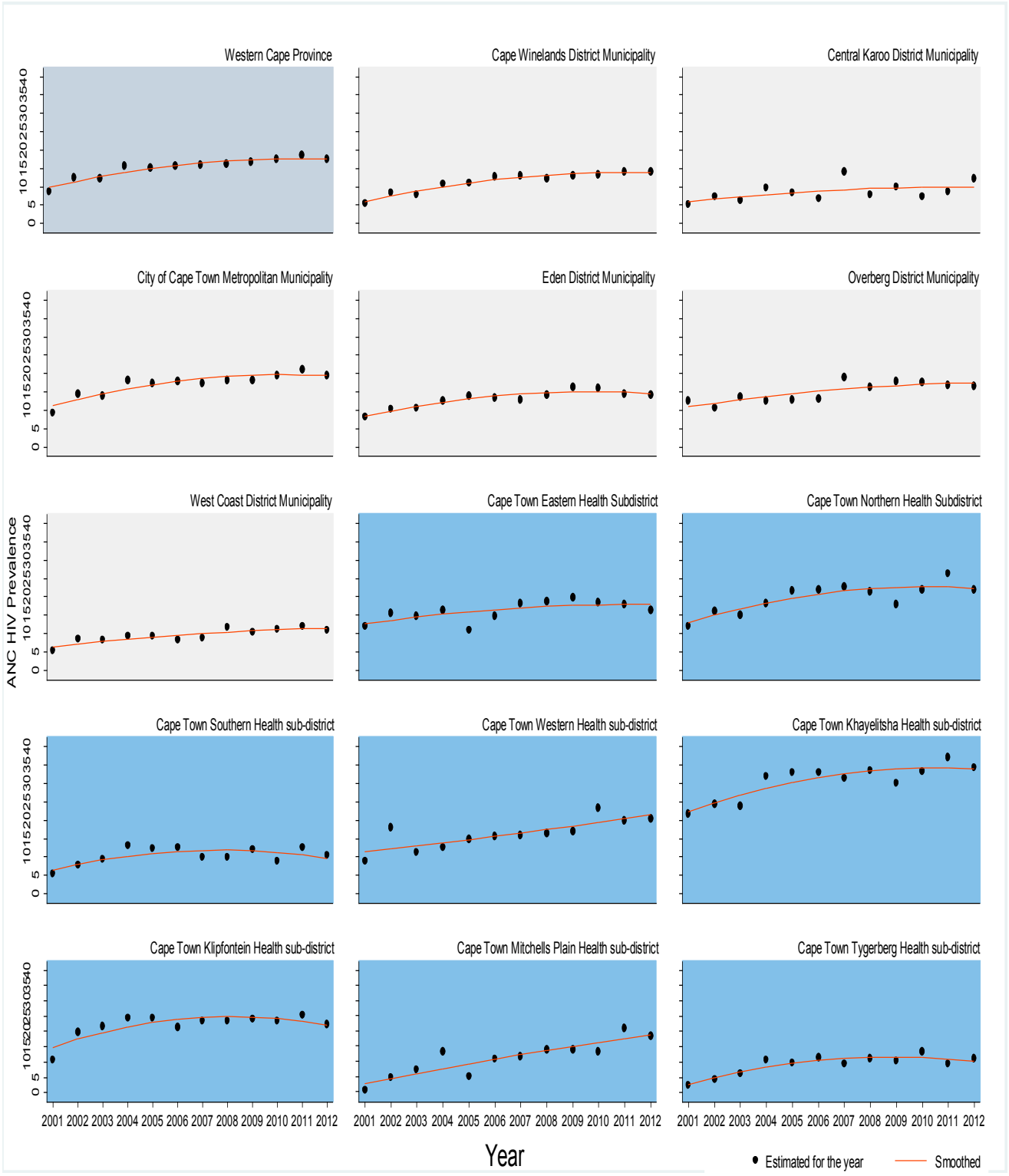


Figure 3. Comparing HIV Prevalence estimates for antenatal survey and PMTCT by district and City of Cape Town sub-district, Western Cape Province, 2009 – 2012.



Supplementary Figure 1. Antenatal survey HIV prevalence trends by district and City of Cape Town sub-district, Western Cape Province, 2001 – 2012.



V Essel, June 2014

Part D: Appendices

Contents

Appendix A: ANC Survey Data Collection Tool

TARGET:

health
Department:
Health
REPUBLIC OF SOUTH AFRICA

National Antenatal Sentinel HIV Prevalence Survey 2012

Data Collection Form

DISTRICT: _____ **SUBDISTRICT:**_____ **FACILITY (DHIS):** _____

COORDINATOR: _____ **CONTACT TELEPHONE:** _____

DATE SPECIMEN TAKEN:_____ **(DD/MM/2012)** **DATE SPECIMEN REACHED LABORATORY:**_____ **(DD/MM/2012)**

Bar code label	Age	Population Group AF=African AS=Asian CO=Coloured WH=White	Level of Education 0=None 1=Primary 2=Secondary 3=Tertiary	Marital Status 1=Single 2=Married 3=Widow 4=Divorce	Gravida (no of pregnancies including this one)	Parity (no of live born children)	Have you participated in this survey before Yes/No	Age of partner	Are you aware of your HIV status Yes/No	* For lab use		
										Lab. number	HIV result 0=Neg 1=Pos	RPR result 0=Neg 1=Pos

*** Last Column reserved for data entry at laboratory only: HIV and RPR RESULT**

Appendix B. Ethics Approval Letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492 • Facsimile [021] 406 6411
Email: Sumayah.ariefdien@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

06 June 2014

HREC/REF: 284/2014

Prof A Boulle
School of Public Health & Family Medicine
Entrance 5, CIDER Level 5
Falmouth Building
FHS

Dear Prof Boulle

Project Title: HIV SURVEILLANCE: A 12 YEAR ANALYSIS OF HIV PREVALENCE TRENDS AND COMPARING HIV PREVALENCE FROM SENTINEL ANTENATAL CLINIC (ANC) SURVEYS AND PREVENTION OF MOTHER TO CHILD (PMTCT) PROGRAMME- (MMed candidate-V Essel)

Thank you for your letter dated 02 June 2014, addressing the issues raised by the Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above mentioned study.

Approval is granted for one year until the 30 June 2015.

Please submit a progress form, using the standardised Annual Report Form, if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

We acknowledge that the following student:- Vivien Essel Is also involved in this project.

Please note that the on-going ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC REF in all your correspondence.

Yours sincerely

PP signature removed
PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

Hrec/ref:284/2014

Federal Wide Assurance Number: FWA00001637.

Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Hrec/ref:284/2014

Appendix C. Provincial Health Research sub-directorate Access Letter

Western Cape Government
Health

STRATEGY & HEALTH SUPPORT
Health.Research@westerncape.gov.za
tel: +27 21 483 6857; fax: +27 21 483 9895
5th Floor, Norton Rose House,, 8 Riebeek Street, Cape Town, 8001
www.capegateway.gov.za

REFERENCE: RP 076/2014
ENQUIRIES: Ms Charlene Roderick

Dr V Essel
5th Floor Norton Rose House
8 Riebeek Street
Cape Town

For attention: **Dr Essel**

Re: HIV surveillance: A 12 year analysis of HIV prevalence trends and comparing HIV prevalence from sentinel antenatal clinic (ANC) surveys and Prevention of mother to child (PMTCT) programmes.

Thank you for submitting your proposal to undertake the above-mentioned study. We are pleased to inform you that the department has granted you approval for your research.
Please contact the following people to assist you with any further enquiries in accessing the following:

WC Provincial HAST Datasets **J Arendse** **Contact No. 021 483 5751**

Kindly ensure that the following are adhered to:

1. Arrangements can be made with managers, providing that normal activities at requested facilities are not interrupted.
2. Researchers, in accessing provincial health facilities, are expressing consent to provide the department with an electronic copy of the final report within six months of completion of research. This can be submitted to the provincial Research Co-ordinator (Health.Research@westerncape.gov.za).
3. The reference number above should be quoted in all future correspondence.

Yours sincerely

DR J EVANS signature removed
ACTING DIRECTOR: HEALTH IMPACT ASSESSMENT
DATE: 11/06/14
CC **T NALEDI** **CHIEF DIRECTOR: HEALTH PROGRAMMES**

Appendix D. PLOS ONE Author Guidelines

http://www.plosone.org/static/guidelines.action

Accessed 6 June 2014

1. Format Requirements

PLOS ONE does **not** consider presubmission inquiries. All submissions should be prepared with the following files:

- Cover letter
- Manuscript, including tables and figure legends
- Figures (guidelines for preparing figures can be found at the Figure and Table Guidelines)

Manuscript Organization

PLOS ONE considers manuscripts of any length. There are no explicit restrictions for the number of words, figures, or the length of the supporting information, although we encourage a concise and accessible writing style. We will **not** consider monographs.

All manuscripts should be double-spaced and include line numbers and page numbers.

Manuscripts should begin with the ordered sections:

- Title
- Authors
- Affiliations
- Abstract
- Introduction

and end with the sections of:

- Acknowledgments
- References
- Figure Legends
- Tables

The title, authors, and affiliations should all be included on a title page as the first page of the manuscript file.

There are no explicit requirements for section organization between these beginning and ending sections. Articles may be organized in different ways and with different section titles, according to the authors' preference. In most cases, internal sections include:

- Materials and Methods
- Results
- Discussion
- Conclusions (optional)

PLOS ONE has no specific requirements for the order of these sections, and in some cases it may be appropriate to combine sections. Guidelines for individual sections can be found below.

Abbreviations should be kept to a minimum and defined upon first use in the text. Non-standard abbreviations should not be used unless they appear at least three times in the text.

2. Guidelines for Standard Sections

Title

Manuscripts must be submitted with both a full title and a short title, which will appear at the top of the PDF upon publication if accepted. Only the full title should be included in the manuscript file; the short title will be entered during the online submission process.

The full title must be 250 characters or fewer. It should be specific, descriptive, concise, and comprehensible to readers outside the subject field. Avoid abbreviations if possible.

The short title must be 50 characters or fewer and should state the topic of the paper.

Authors and Affiliations

All author names should be listed in the following order:

- First names (or initials, if used),
- Middle names (or initials, if used), and
- Last names (surname, family name)

Each author should list an associated department, university, or organizational affiliation and its location, including city, state/province (if applicable), and country. If the article has been submitted on behalf of a consortium, all author names and affiliations should be listed at the end of the article.

To qualify for authorship, a researcher should contribute to **all** of the following:

1. Conception and design of the work, acquisition of data, or analysis and interpretation of data
2. Drafting the article or revising it critically for important intellectual content
3. Final approval of the version to be published

All persons designated as authors should qualify for authorship, and all those who qualify should be listed. Each author must have participated sufficiently in the work to take public responsibility for appropriate portions of the content. Those who contributed to the work but do not qualify for authorship should be listed in the acknowledgments.

One author should be designated as the corresponding author, and his or her email address or other contact information should be included on the manuscript cover page. This information will be published with the article if accepted.

Abstract

The abstract should:

- Describe the main objective(s) of the study
- Explain how the study was done, including any model organisms used, without methodological detail
- Summarize the most important results and their significance
- Not exceed 300 words

Introduction

The introduction should:

- Provide background that puts the manuscript into context and allows readers outside the field to understand the purpose and significance of the study
- Define the problem addressed and why it is important
- Include a brief review of the key literature
- Note any relevant controversies or disagreements in the field
- Conclude with a brief statement of the overall aim of the work and a comment about whether that aim was achieved

Materials and Methods

This section should provide enough detail to allow suitably skilled investigators to fully

replicate your study. Specific information and/or protocols for new methods should be included in detail. If materials, methods, and protocols are well established, authors may cite articles where those protocols are described in detail, but the submission should include sufficient information to be understood independent of these references.

We encourage authors to submit detailed protocols for newer or less well-established methods as supporting information. Further information about formatting Supporting Information files, can be found here.

Methods sections of papers on research using **human or animal subjects and/or tissue or field sampling** must include required ethics statements.

Results, Discussion, and Conclusions

These sections may all be separate, or may be combined to create a mixed Results/Discussion section (commonly labeled "Results and Discussion") or a mixed Discussion/Conclusions section (commonly labeled "Discussion"). These sections may be further divided into subsections, each with a concise subheading, as appropriate. These sections have no word limit, but the language should be clear and concise.

Together, these sections should describe the results of the experiments, the interpretation of these results, and the conclusions that can be drawn. Authors should explain how the results relate to the hypothesis presented as the basis of the study and provide a succinct explanation of the implications of the findings, particularly in relation to previous related studies and potential future directions for research.

Acknowledgments

People who contributed to the work but do not fit the *PLOS ONE* authorship criteria should be listed in the acknowledgments, along with their contributions. You must ensure that anyone named in the acknowledgments agrees to being so named.

Funding sources should **not** be included in the acknowledgments, or anywhere in the manuscript file. You will provide this information during the manuscript submission process.

References

General guidelines

- Authors may cite any and all available works in the reference list.
- Authors may not cite unavailable and unpublished work, including manuscripts that have been submitted but not yet accepted (e.g., “unpublished work,” “data not shown”).
- If an article is submitted to a journal and also publicly available as a pre-print, the pre-print may be cited.
- If related work has been submitted to PLOS ONE or elsewhere, authors should include a copy with the submitted article as confidential supplementary information, for review purposes only.
- Authors should not state 'unpublished work' or 'data not shown,' but instead include those data as supplementary material or deposit the data in a publicly available database.

Reference formatting

References must be listed at the end of the manuscript and numbered in the order that they appear in the text. In the text, citations should be indicated by the reference number in brackets.

References should be formatted as follows:

- **Published papers**. Hou WR, Hou YL, Wu GF, Song Y, Su XL, et al. (2011) cDNA, genomic sequence cloning and overexpression of ribosomal protein gene L9 (rpL9) of the giant panda (*Ailuropoda melanoleuca*). Genet Mol Res 10: 1576-1588. Note: Use of a DOI number for the full-text article is acceptable as an alternative to or in addition to traditional volume and page numbers.

- **Electronic journal articles**. Huynen MMTE, Martens P, Hilderlink HBM (2005) The health impacts of globalisation: a conceptual framework. Global Health 1: 14. Available: http://www.globalizationandhealth.com/content/1/1/14. Accessed 25 January 2012.

- **Books**. Bates B (1992) Bargaining for life: A social history of tuberculosis. Philadelphia: University of Pennsylvania Press. 435 p.

- **Published media, not peer-reviewed. Examples: print or online newspapers and magazine articles.** Fountain H (29 Jan 2014). For Already Vulnerable Penguins, Study Finds Climate Change Is Another Danger. The New York Times. Available: http://www.nytimes.com/2014/01/30/science/earth/climate-change-taking-toll-on-

penguins-study-finds.html. Accessed 17 March 2014.

Tables

Tables should be included at the end of the manuscript. All tables should have a concise title. Footnotes can be used to explain abbreviations. Citations should be indicated using the same style as outlined above. Tables occupying more than one printed page should be avoided, if possible. Larger tables can be published as Supporting Information.

Figure legends should describe the key messages of a figure. Legends should have a short title of 15 words or less. The full legend should have a description of the figure and allow readers to understand the figure without referring to the text. The legend itself should be succinct, avoid lengthy descriptions of methods, and define all non-standard symbols and abbreviations.

3. Specific Reporting Guidelines

Human Subject Research

Methods sections of papers on research using human subject or samples must include ethics statements that specify:

- The name of the approving institutional review board or equivalent committee(s). If approval was not obtained, the authors must provide a detailed statement explaining why it was not needed
- Whether informed consent was written or oral. If informed consent was oral, it must be stated in the manuscript:
  - Why written consent could not be obtained
  - That the Institutional Review Board (IRB) approved use of oral consent
  - How oral consent was documented

For studies involving humans categorized by race/ethnicity, age, disease/disabilities, religion, sex/gender, sexual orientation, or other socially constructed groupings, authors should:

- Explicitly describe their methods of categorizing human populations
- Define categories in as much detail as the study protocol allows
- Justify their choices of definitions and categories, including for example whether any rules of human categorization were required by their funding agency
- Explain whether (and if so, how) they controlled for confounding variables such as

socioeconomic status, nutrition, environmental exposures, or similar factors in their analysis

In addition, outmoded terms and potentially stigmatizing labels should be changed to more current, acceptable terminology. Examples: "Caucasian" should be changed to "white" or "of [Western] European descent" (as appropriate); "cancer victims" should be changed to "patients with cancer."