Public Disclosure Authorized

Public Disclosure Authorized

WPS7042

Policy Research Working Paper 7042

A Comprehensive Review of Empirical and Modeled HIV Incidence Trends (1990–2012)

Jessica Taaffe
Nicole Fraser-Hurt
Marelize Gorgens
Pandu Harimurti

WORLD BANK GROUP
Health Nutrition and Population Global Practice Group
September 2014

Abstract

An accurate measurement of HIV incidence is a key for policy makers and HIV program managers directing national HIV response. However, there is no perfect method to measure or estimate the rate at which new HIV infections occur in a population. This review compiles and triangulates longitudinal HIV incidence and prevalence data from published studies and trials, national reports and surveys, and the Joint United Nations Programme on HIV/AIDS estimates from the Spectrum model, focusing on 20 countries in Sub-Saharan Africa with generalized HIV epidemics. Three main points can be taken from this analysis of HIV incidence trends. First, modeled HIV incidence and nationally reported HIV prevalence levels in young females suggest that national HIV incidence has declined since 2000 in all except three countries analyzed (stable estimated HIV trends in Burkina Faso, Burundi, and Uganda), but trial and survey data suggest that in some demographics, HIV incidence remains critically high. Second, all modeled national HIV incidence curves and most empirically observed trends commenced a downward trajectory prior to the introduction of anti-retroviral therapy programs around 2004, suggesting the contribution of other factors, such as HIV prevention programs and natural epidemic dynamics, to this decline. Third, modeled HIV incidence estimates, including the incidence peaks in the past, exhibit much variation between Spectrum model versions and when new data are added, emphasizing the uncertainty of model outputs and the need to use incidence estimates with caution.

This paper is a product of the Health Nutrition and Population Global Practice Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at mgorgens@worldbank.org.

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.

Produced by the Research Support Team

A Comprehensive Review of Empirical and Modeled HIV Incidence Trends (1990–2012)

Jessica Taaffe
Nicole Fraser-Hurt
Marelize Gorgens[1]
Pandu Harimurti

Keywords: HIV/AIDS, incidence prevalence estimates, epidemic model
JEL code: Other

[1] The authors are staff or consultants with the Global HIV and AIDS Program, HNP, Human Development Network. The authors wish to thank and acknowledge Jeff Eaton, Dan Hogan, Kim Powers, Mary Mahy, and Laith Jamal Abu Raddad for reviewing and providing useful comments and insights on this document. The authors would also like to acknowledge the support of David Wilson, Director of the Global HIV/AIDS Program of the World Bank.

Table of Contents

SUMMARY

Understanding and monitoring longitudinal HIV incidence trends is imperative for tracking progress towards HIV prevention goals, including how incidence trends have changed through increasing antiretroviral therapy (ART) coverage. There are several ways that HIV incidence can be assessed, empirical and modeled, and each method has its limitations. Incidence can be directly measured from prospective cohort studies, but logistical and financial restraints make this difficult to carry out at a scale that provides sufficient precision of the incidence estimate. Sampling of specimen within a population and using laboratory assays and testing algorithms that identify recent HIV infection can infer HIV incidence, though this method requires local validation against HIV incidence estimates obtained by other methods. Proxies of HIV incidence, such as HIV prevalence trends in young females, can also be used to infer incidence trends, as most HIV infections within this demographic are recent. However, this method requires repeat cross-sectional measurements over several years in order to infer any incidence trend. Finally, HIV incidence can be obtained through back-calculation models that use various HIV epidemiological data, including HIV prevalence and mortality rates, to estimate incidence within the adult population. Here, estimated incidence chiefly relies on prevalence estimates and factors that affect survival, including the effect of age and co-factors of transmission as well as the model's accurate representation of sexual behavior and transmission dynamics.

Modeled incidence estimates provided by UNAIDS are key information that policy makers and HIV program managers use to monitor the dynamics of the HIV epidemics in various countries. Therefore, it is important to evaluate how these HIV incidence and proxies of it (HIV prevalence trends in young females) correspond to modeled incidence data. To date, no report has comprehensively triangulated and compared modelled HIV incidence against several forms and sources of directly and indirectly measured incidence across multiple countries.

We therefore compared UNAIDS incidence estimates from the Spectrum model to directly measured incidence from published studies and trials. We also compared UNAIDS modeled estimates to HIV prevalence trends in young females, as a proxy of incidence, using cross-sectional data from published studies and trials and national surveys, such as from antenatal sentinel surveillance and population-based surveys (Demographic and Health Survey/AIDS Indicator Survey data). This report represents a comprehensive source of both modeled and empirical incidence trends in several countries.

A select group of countries were chosen for this analysis due to their known generalized HIV epidemics (epidemics in which HIV is highly disseminated within the general population): Botswana, Burundi, Burkina Faso, Congo, Central African Republic, Ethiopia, Ghana, Kenya, Lesotho, Namibia, Nigeria, Malawi, Mozambique, Rwanda, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe. Within each country, multiple forms and sources of incidence data, modeled and empirical, were graphed alongside ART coverage data, and longitudinal trends are described. Specifically, incidence trends

were evaluated for 1) rising or falling curves and rates of change between 1990 and 2012, 2) how well empirical and modeled UNAIDS data match each other, and 3) dynamics before and during the ART scale-up period (2004 –2012).

Briefly, it was found that the countries analyzed experienced overall decreases in UNAIDS modeled incidence since 2000, with the exception of Burkina Faso, Burundi, and Uganda. Modeled incidence in these three countries has shown very little change, and in some cases, a slight upward trend through some years. There is great variation in the slope of downward trends across countries since 2004, with some having small and moderate declines (slope -0.01 to -0.06), and others with steeper and more dramatic declines (slope -0.08 to -0.14). Available antenatal sentinel surveillance and population-based survey data in young females support these HIV trends, though the dynamics may slightly differ by rates of change and/or timing. In Nigeria, the Spectrum-estimated HIV incidence decline is not supported by the ANC-derived HIV prevalence in young females in the time period 2005-2010. Relatively few directly measured incidence data have been reported from HIV intervention trials or observational studies (we found 43 sources of measured incidence data from 10 of the selected countries); however, the reported HIV incidence levels tend to be higher than modelled national incidence estimates and are likely due to intentional targeting of high risk populations in research. We observed that modeled HIV incidence had begun to decline prior to ART scale-up, and in most cases where HIV data prior to 2004 were available, HIV prevalence trends in young females 15-24 supported this incidence decline prior to ART scale-up. This analysis, however, was not designed to assess the impact of the increasing coverage of ART on HIV incidence trends in the selected countries. Therefore, it is difficult to determine if or how much ART scale-up has contributed to incidence decline, though its effect cannot be ruled out, as recent data show that increased ART coverage reduces transmission risk in a South African hyperendemic HIV situation (Tanser et al. 2013). At the same time, new analyses from South Africa (Shisana et al. 2014) suggest no change in HIV incidence in two inter-survey periods stretching from 2005 to 2012, despite significant ART scale-up in that time period.

In conclusion, three main points can be taken from this analysis of HIV incidence trends in Sub-Saharan Africa: 1) Modeled HIV incidence and nationally reported HIV prevalence levels in young females suggest that national HIV incidence has declined since 2000 in all except three countries analyzed (stable estimated HIV trends in Burkina Faso, Burundi, and Uganda), but trial and survey data suggest that in some demographics, HIV incidence remains critically high; 2) All modelled national HIV incidence curves and most empirically observed trends commenced a downward trajectory prior to the introduction of ART programs around 2004, suggesting the contribution of other factors, such as HIV prevention programs and natural epidemic dynamics, to this decline; and 3) Modelled HIV incidence estimates including the incidence peaks in the past, exhibit much variation between Spectrum model versions and when new data is added, emphasizing the uncertainty of model outputs and the need to use incidence estimates with caution.

List of Acronyms

AIDS	Acquired Immune Deficiency Syndrome
ANC	Antenatal Clinic
AIS	AIDS Indicator Survey
ART	Antiretroviral Therapy
BAIS	Botswana AIDS Impact Survey
DHS	Demographic and Health Surveys
GARPR	Global AIDS Response Progress Reporting
HH	Household
HIV	Human Immunodeficiency Virus
UNAIDS	United Nations Joint Program on AIDS
UNGASS	United Nations General Assembly

List of Tables

List of Figures

1. RATIONALE

Accurate and representative HIV incidence estimates are imperative for policy makers and program managers to be able to assess progress in meeting HIV programmatic goals and make decisions in regard to allocation of financial and health resources. While modeled UNAIDS Spectrum incidence estimates are valuable, it is important to remember that these estimates are derived from ANC and DHS prevalence data and rely on multiple assumptions, which are imperfect for the reasons to be discussed further in this document.

Triangulation of multiple forms of incidence data, including from published studies and trials, provides a comprehensive illustration of HIV incidence trends, though few reports have done so. Some reports of incidence trends at the country level exist, but are restricted to those using sentinel surveillance and DHS/AIS data, with little, if any measured incidence data from clinical trials or other studies. Those that have done this for multiple countries within Sub-Saharan Africa have concentrated on comparing ANC, DHS, and Spectrum data (Mahy, Garcia-Calleja, and Marsh 2012; Montana, Mishra, and Hong 2008). None of these reports have also described these incidence trends in relation to ART scale-up. In a technical meeting on the large estimated declines in HIV incidence in countries with generalized HIV epidemics in 2013, the importance of going back to observational HIV data and drawing comparisons between such real-world data and modeled incidence trends was emphasized (HIV Modelling Consortium, 18-19 Sept 2013 London).

As such, the rationale for this data review was to triangulate multiple types of HIV incidence data and describe trends prior to and through ART scale-up within a select group of Sub-Saharan countries. Specifically, this document focuses on assessing incidence trends between 1990 and 2012, comparing directly measured incidence from clinical and observational cohort studies, indirectly measured incidence proxies (prevalence among females age 15-24), and modeled incidence estimates (Spectrum).

2. INTRODUCTION

To address and meet Millennium Development Goal (MDG) 6 targets of reversing HIV/AIDS spread by 2015, a firm commitment to HIV prevention efforts must be maintained globally and nationally. Indeed, national and regional strategies call for a 50% reduction in the number of new HIV infections by 2015 (Southern African Development Community 2009; Assembly 2012) and national-level indicators and targets have been established to monitor progress towards this goal.

As we near 2015, it is important to assess progress that has been made in reaching HIV prevention goals. Reducing HIV incidence is the main goal and indicator of successful HIV prevention, and therefore, accurate monitoring and assessment of temporal HIV incidence trends at national and sub-national levels is imperative. A number of methods exist in which the rate at which new HIV infections occur can be determined, though each method has its limitations and biases. Additionally, increasing ART coverage in many countries has introduced further complications of inferring incidence levels from HIV prevalence data. Since each of the current methods is imperfect at determining HIV incidence, it is useful to triangulate and compare different incidence estimates to gain an understanding of the rate new infections occur in a population.

The next sections describe the different methods and structures in place used to monitor incidence and how ART scale-up has influenced these estimates. This is followed by a discussion of methods and data sources used in this review and description of incidence trends country by country. Sub-Saharan countries with generalized HIV epidemics were chosen for this review, including: Botswana, Burundi, Burkina Faso, Congo, Central African Republic, Ethiopia, Ghana, Kenya, Lesotho, Namibia, Nigeria, Malawi, Mozambique, Rwanda, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe.

2.1. Monitoring HIV incidence

National HIV prevalence trends within the overall population have been used in the past to assess the success of HIV prevention efforts, with prevalence increases clearly indicating failure to prevent new infections. However, in an era of increasing ART coverage, this method is no longer suitable to accurately understand the dynamics of the HIV epidemic. More individuals infected with HIV are living longer lives due to increased access to and improved ART drugs, thereby influencing an upward trend in HIV prevalence, as they remain longer in the HIV+ population (Zaidi et al. 2013). Indeed, Rehle et al. showed that “excess HIV prevalence,” due to longer survival on ART, added on average 2.1 percentage points to prevalence within the population aged 15-49 in South Africa’s 2008 HH Survey (Rehle et al. 2010). As such, longitudinal prevalence

trends, especially as ART scale-up increases, can be misleading about the rate of acquisition of new infections in the overall population.

However, prevalence trends within specific population strata can be used as a proxy for incidence within larger populations and have been established as national-level indicator data. Estimating HIV incidence from prevalence within the entire HIV positive population is challenging, as the long average duration of HIV infection makes it difficult to detect changes in new infections within older age groups and these estimate are largely dependent on assumptions made on mortality, which are becoming more complex as ART prolongs survival. Therefore, prevalence trends within the younger population (adults 15-24) are regarded as a proxy for HIV incidence within the entire population, and the highest rates of new infections typically fall within young adults, especially females (UNAIDS 2012a, 2013a). For generalized epidemics, such as seen in the majority of Sub-Saharan Africa, HIV surveillance among antenatal clinic (ANC) attendees and routine Demographic and Health or AIDS Indicator Surveys (DHS/AIS) provide important HIV prevalence data to track HIV trends at national and global levels, including for the United Nations General Assembly Special Session on HIV/AIDS (UNGASS) and the Global AIDS Response Progress Report (GARPR) data collection. It is worth noting, however, that using HIV prevalence trends within youth may become more complicated as long-term survivors of mother-to-child transmission of HIV age, and therefore may bias prevalence increases within this indicator population, such as has been seen in Eastern Zimbabwe (Eaton et al. 2013).

2.1.1. Empirical measurements of HIV prevalence used to inform HIV incidence estimates

2.1.1.1. ANC Sentinel Surveillance

Anonymous and unlinked testing of samples from women attending antenatal clinics is used to measure HIV prevalence within a cross-section of the sexually active population and is used to generate HIV incidence estimates. These surveys have been completed every 1-3 years and thus, can be used to longitudinally monitor HIV epidemic trends, including being the primary (and until recently, with repeat DHS, the only available data on HIV infections over time in Africa) source of prevalence trends in young people for UNGASS and GARPR indicators.

However, sentinel surveillance has many limitations and biases. First, ANC data are limited to pregnant women using ANC sentinel site clinics, biasing the data upward, as these women are sexually active and at risk for sexual transmission of HIV, and HIV prevalence data are greatly influenced by changes within this demographic. Prior to the ART era, the ANC-derived HIV prevalence was chiefly affected by lower fertility in women with advanced HIV infections and by a selection bias for unprotected sexual activity especially among younger women. Now, ART scale-up has helped restore

fertility in HIV+ women (Kim Powers, personal communication). Family planning promotion in HIV+ women may reduce the numbers of them attending antenatal clinics. Second, ANC survey data represent only the geographical regions covered by participating antenatal sentinel sites. It is possible that those sites that were added in later years to the sentinel system are at an earlier HIV epidemic stage than those included early or represent lower level epidemics, if more highly affected areas were chosen first for surveillance. Finally, in sites having trouble reaching necessary sample size, or wanting better estimates for the incidence proxy, oversampling among 15-24 year olds has been recommended (WHO, UNAIDS, and CDC 2003). Any modifications in sampling/oversampling will bias the longitudinal HIV prevalence trend. The direction in which it would do so is difficult to predict and is largely dependent on compositional changes happening within ANC population sites, with regard to age, geographic residency, treatment coverage, fertility behaviors, etc.

2.1.1.2 Demographic and Health Surveys/AIDS Indicator Surveys

Data from national population-based surveys, including DHS/AIS, have also been used to estimate HIV incidence and supplement prevalence data from antenatal clinics. These surveys are typically done by sampling and testing for HIV within households for which the residents have given their individual consent. Although they have the advantage of including both male and female HIV data, population-based surveys are more expensive and logistically difficult to carry out, and therefore, are performed less frequently. Additionally, these data can be biased by non-response (either by individual refusal to participate or household absence at time of survey). As voluntary counseling and testing services become increasingly available, more non-response bias from individuals already knowing their HIV status, including those previously testing positive for HIV, may be introduced into DHS/AIS surveys (Kim Powers, personal communication), bringing in considerable uncertainty around the estimates when non-response is high. However, preliminary work suggests that DHS response rates are not declining, despite potential increases in testing, and therefore it is unlikely that any potential bias in survey data is increasing (Mark McGovern, personal communication).

DHS/AIS prevalence data obtained across two household sero-surveys can be used to mathematically estimate incidence, also incorporating cohort mortality or survival after infection data into the equation (Hallett et al. 2010; Hallett et al. 2008). These methods for inferring incidence are limited by the number of sero-surveys conducted, as incidence can only be estimated for the inter-survey period. Assessing temporal incidence trends will be only possible when countries have completed at least three of these surveys. In the meantime, as we have done here, focusing on DHS/AIS prevalence trends within females 15-24 is another way of descriptively inferring incidence, as most infections within this group are likely to be recent.

2.1.2. Empirical measurements of HIV incidence

2.1.2.1. Cohort studies and ALPHA Network

While ideal, directly and accurately measuring HIV incidence on a population level is challenging. Doing so requires prospectively following a cohort of HIV-negative individuals and diagnosing new HIV infections. This type of study is logistically complex and expensive and thus often considered to be unrealistic for measuring national incidence in resource poor settings. Importantly, enrollment into a cohort can influence behavior changes and bias HIV incidence estimates. Additionally, individuals or populations participating in biomedical trials may have been chosen for their high HIV risk.

Despite the challenges of maintaining them, several long-term cohorts have been established in various parts of Sub-Saharan Africa, generating invaluable epidemiological data. To facilitate meta-analysis of multiple cohort data, collaborations between groups with established HIV cohorts and comparable data sets have been facilitated through the ALPHA Network (Analysing Longitudinal Population-based HIV/AIDS data on Africa). Set up in 2005 with funding from The Wellcome Trust and coordinated by the Department of Population Health at the London School of Hygiene & Tropical Medicine, the ALPHA Network "aims to maximize the usefulness of data generated in community-based longitudinal HIV studies in Sub-Saharan Africa for national and international agencies involved in designing or monitoring interventions and epidemiological forecasting" (http://www.lshtm.ac.uk/eph/dph/research/alpha/index.html). The Network links 10 previously existing sites spread across Kenya (African Health Population Research Centre; Kisumu), Malawi (Karonga), South Africa (uMkhanyakude; Agincourt), Tanzania (Kisesa; Ifakara), Uganda (Masaka; Rakai), and Zimbabwe (Manicaland).

Prior to forming the Network, each site had been individually conducting its own studies on HIV spread and risk, prevention and treatment, and developing field and analytical methods. Now together, these sites have been able to replicate technical methods and analyses across cohorts and share the results of their studies in regular teaching and analytical workshops. A key finding from a joint HIV incidence analysis of ALPHA Network sites revealed a common age-sex distribution pattern of HIV incidence among young ages at all sites, but more inter-site variation at older ages (Todd et al. 2008). Further analysis revealed a secondary HIV incidence peak occurring among older participants in some of the sites, prompting investigation of HIV risk factors at all ages, not just among youth (Barnighausen et al. 2007; Barnighausen et al. 2008; Lopman et al. 2008). Additionally, more recent data from ALPHA Network sites have been used to inform the Spectrum model's assumptions on the age-pattern of HIV incidence and survival (UNAIDS Reference Group on Estimates 2012). However, no comprehensive

triangulation and comparison of these ALPHA site data against nationally reported HIV prevalence and modeled Spectrum incidence trends has been published.

2.1.2.2. Laboratory Assays and Laboratory-based Testing Algorithms

HIV incidence can be inferred in clinical trials and cohort studies through the use of laboratory assays detecting recent infection, including the BED capture enzyme immunoassay (BED-CEIA), which was, until recently, the only commercially and globally available assay. This assay measures a biomarker that rises during early infection, and can be used cross-sectionally to discriminate between recent (less than six months) and older HIV infections. However, this assay is prone to misclassification of individuals with older infections (Hargrove et al. 2008) and cross-sectional BED incidence estimates have been higher than those obtained from longitudinal follow-up (Karita et al. 2007; McDougal et al. 2006), thus raising concerns on the use of this assay to accurately measure incidence despite locally established correction factors.

Other laboratory-based assays used for measuring incidence exist, and can be used in combination with the BED-CEIA. Instead of measuring only biomarker quantity, the strength, or avidity, of the biomarker in an assay can also be measured, as avidity increases through early HIV infection. The Multi-Assay Algorithm (MAA) measures both avidity and quantity of the biomarker/antibody response, using the BED-CEIA assay along with a second assay that specifically measures binding strength. Additionally, the Limiting Antigen Avidity (LAg-Avidity) assay has been recently developed, improving upon the measurement of low and high avidity antibodies and using a more cross-reactive marker to eliminate bias from populations with different HIV subtypes (an issue with the BED-CEIA). Both the MAA and LAg-Avidity assays have been shown to have lower false recent rate than the BED-CEIA (Eshleman et al. 2013; Laeyendecker et al. 2013; WHO and UNAIDS 2013). The LAg-Avidity assay is now commercially available, and the United States Centers for Disease Control and Prevention (CDC) Division of Global HIV/AIDS (DGHA) has been recommended it for incidence surveillance, instead of the BED_CEIA, in countries outside of the US supported by President's Emergency Plan For AIDS Relief (PEPFAR) funding (WHO and UNAIDS 2013). In the 2012 HIV population-level HIV survey in South Africa, a HIV incidence algorithm was used based on the Lag-Avidity assay in combination with a negative ARV test and a viral load >1,000 copies/ml (Shisana et al., 2014). At the same time, indirect HIV incidence estimates were generated using the inter-survey mathematical modelling method according to Hallett et al. 2008 and 2010.

Current research and development efforts are focused on developing assays able to use dried blood spot specimens in validated incidence assays, which would make HIV detection more rapid and logistically feasible in resource-limited settings.

2.1.3. Modeled incidence

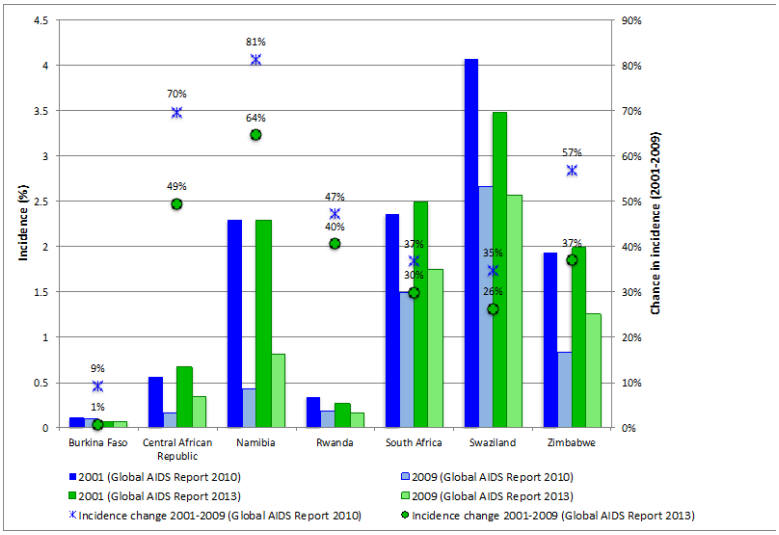
HIV epidemic dynamics, including incidence, can be inferred through mathematical modeling, taking into account multiple factors associated with the epidemic (demographics, risk factors, prevalence, probability of transmission, ART coverage, etc.). Several modeling approaches that estimate new HIV infections and incidence exist from individual research groups and organizations, including the Modes of Transmission (http://www.who.int/bulletin/volumes/90/11/12-102574/en/index.html) and Actuarial Society of South Africa models (http://aids.actuarialsociety.org.za/404.asp?pageid=3145). UNAIDS has been using Spectrum modeling software for over a decade to estimate national HIV epidemic trends, including recent reporting of incidence trends. Using a set of input parameters and model equations, the Estimation and Projection Package (EPP) with Spectrum estimates HIV incidence by fitting prevalence trends in ANC data (Brown et al. 2010; Bao et al. 2012), incorporating inputs such as ART coverage and mortality rates. These projections are then calibrated to national population-based survey estimates of HIV prevalence to generate national HIV prevalence and incidence estimates, and then stratified by age and sex based on demographic data. The most updated version of Spectrum (as of January 2014) now included DHS/AIS in the fitting process and has eliminated the second calibration step.

It is important to keep in mind that EPP/Spectrum generates estimates for both national HIV prevalence and incidence, which may or may not be in agreement with empirical measurements, including nationally reported data. Preliminary work from Eaton et al. suggested that when comparing EPP prevalence trends to that from DHS/HH survey data, prevalence declines may have been overestimated by the modelling process in southern African countries (Jeff Eaton, personal communication).

EPP and Spectrum are updated frequently, adding in new features to improve user interface and refine the model. These updates to the model include better assumptions and the addition of recent data that should improve upon previous estimates and more accurately model HIV population dynamics. While these improvements to the software package are positive, one must be aware that updates to the model can change previous estimates and outputs generated by earlier versions of Spectrum. Comparing estimates from 2010 and 2013 UNAIDS Global HIV/AIDS Reports (the 2012 Spectrum version represents an update from its 2010 version), there is no consistent trend in how the different versions influence historical incidence trajectories between 2001 and 2009 (**Figure 1** and **2**). Out of a group of Sub-Saharan African countries, some countries (Burkina Faso, Central African Republic, Namibia, Rwanda, South Africa, Swaziland, Zimbabwe) show a greater decrease in incidence rate from 2001-2009 using the 2010 Spectrum estimates (**Figure 1**); other countries (Botswana, Congo, Ghana, Kenya, Lesotho, Malawi, Mozambique, Nigeria, Tanzania, Uganda, Zambia) show greater decreases using 2012 Spectrum incidence rate estimates (**Figure 2**). Figures 1 and 2 are only meant to provide an illustration of how much incidence estimates can change

between updates in the model, and UNAIDS cautions against comparing Spectrum estimates from different models, as this may lead to misleading conclusions.[2] As such, only the most recent UNAIDS HIV incidence estimates available at the time of this report have been used in our main analysis. Nevertheless, it is important to point out how consecutively produced national Spectrum estimates can vary, especially as it may change the level of HIV programmatic success that was assumed to have been made in

Figure 1. Countries for which 2010 Spectrum software shows greater change 2001-2009



previous years.

Spectrum estimates are also sensitive to additional data; when comparing incidence

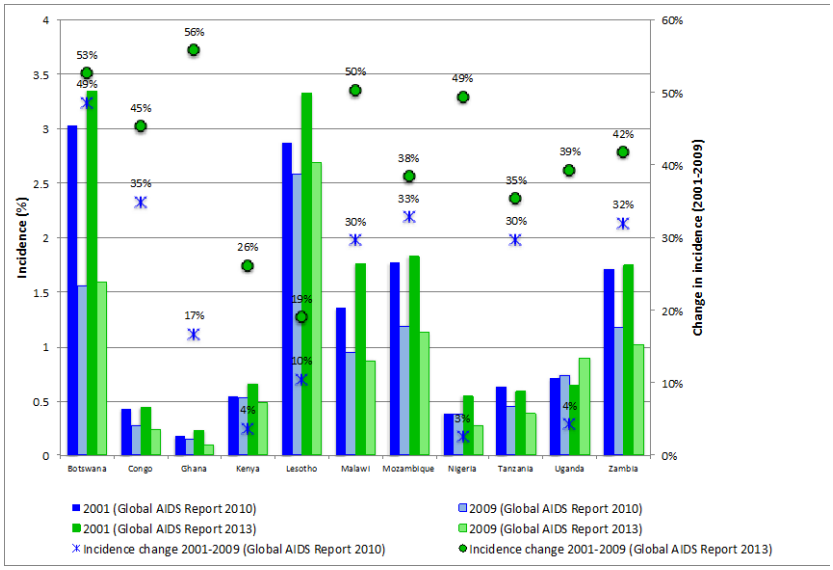


Figure 2. Countries for which 2012 Spectrum software shows greater change 2001-2009

[2] For more information regarding the Spectrum estimation methodology and changes between models, please refer to (Hogan and Salomon 2012; UNAIDS 2013b).

curves accessed from the AIDSinfo Online Database from the 2012 and 2013 UNAIDS reports, only differing by one more years of data, several countries showed considerable difference between the two incidence curves. In many cases estimated peak incidence was higher from the 2013 report (12 out of 19 countries had higher incidence peaks using the 2013 report data; median difference between highest incidence from 2013 to 2012 report among these 12 countries, 0.33, but as high as 1.37) sometimes occurring in a different year than the 2012 report, and these changes were evident as far back as 1990 (Annex 2).

Still, changes in incidence, estimated by Spectrum, have been important for measuring progress in the global fight against HIV/AIDS at regional and country levels. The 2012 Global AIDS report grouped countries by overall changes in incidence between 2001-2011, with those falling into categories of increasing incidence over 25%, stable incidence (less than 25% change in incidence, up or down), and those with reductions in incidence greater than 25% and 50%. Although the majority of countries in the 2012 report have estimated incidence reductions over 25%, a third of them are estimated to have experienced stable incidence, or worse, incidence increases over 25% between 2001 and 2011 (including Congo, Lesotho, Nigeria, Tanzania, and Lesotho, which have all experienced stable incidence over that period).

2.2. Effect of ART on prevalence data, mortality, and infectiousness

Achieving universal access to ART (reaching 80% of those in need of treatment) is a global priority, and the provision of ARVs is a key component of combination HIV prevention strategies, as ART reduces the likelihood of both sexual and mother-to-child transmission of HIV. Following the hallmark HPTN052 study showing that early HIV treatment of HIV positive partners among sero-discordant couples significantly reduced transmission to their partners (Cohen et al. 2011), there has been a push in the global community for using HIV treatment as prevention on a population level ('Treatment as prevention for HIV' 2011). As progress towards achieving universal access is made (global ART coverage was estimated at 65% in 2012), the effects of ART on national HIV epidemics and measurements of it will increasingly become more prominent.

HIV prevalence is determined by HIV incidence and mortality, and the availability of ART makes inferring incidence from prevalence – in the absence of good mortality data - more challenging. As already mentioned, ART also influences fertility patterns, and the tracking of ANC trends is complicated by the effects of ART and declining HIV incidence on the age-distribution of HIV prevalence, shifting it towards less fertile age-groups. Another factor to be considered is the influence of ART patient demographics, for instance on Spectrum projected incidence. HIV incidence is commonly estimated for the adult population 15-49, but not all patients on ART are within this demographic (10-20% of ART patients are already over 50, and this percentage will increase as the ART patient cohort ages. This factor affected the 2012 UNAIDS estimates, and this assumption was

changed for the 2013 round of UNAIDS estimates (which will be released later this year) to account for the increasing fraction of persons on ART who are over 50 (Jeff Eaton, personal communication).

Epidemic models allowing for ART effects on survival and infectiousness do so with the current incomplete understanding of such effects and can be affected by inaccuracies in reported numbers of individuals on ART. As ART is scaled-up and ART eligibility broadened, more error in the reporting of patient numbers may occur in the stretched ART programs. Additionally, self-reported adherence to therapy may be higher than actual adherence, thus potentially overestimating the effect of ART use on patients' infectiousness. Spectrum currently sets ART's transmission reduction effect at 92% (based on HPTN052 clinical trial), whereas real-world programmatic data suggest a lower effect, with 15-30% of patients on ART maintaining viral loads at infectious levels (Kranzer et al. 2013; National AIDS and STI Control Programme 2013; Justman et al. 2013). In the Spectrum model, assumptions around ART are most likely to affect the HIV incidence estimates of the most recent years, since HIV prevalence data are not sufficient to robustly infer HIV incidence in these recent years.

This brief account of how HIV incidence can be estimated through different direct and indirect methods, compared and tracked over time, illustrates that there is no perfect method, but that there are increasingly reliable ways to estimate this key metric of the HIV response.

3. METHODS OF ANALYSIS

For each of the 20 included countries, the following questions were posed:

1) Is modeled UNAIDS incidence rising/falling, and at what relative rate of change?
2) How well does empirical data (ANC, DHS/AIS, clinical trials and observational studies, including ALPHA Network) match modeled incidence trends?
3) How have these incidence trends changed prior to and during ART scale-up?

To address these questions, multiple forms and sources of incidence data have been used here: 1) Nationally reported prevalence data from ANC reports and DHS/AIS, focusing on females 15-24, 2) HIV prevalence and incidence data within young females obtained from ALPHA Network studies, 3) Directly measured incidence data from published clinical trials and/or observational studies (unrelated to ALPHA network), and 4) Modeled incidence and ART coverage data obtained from Spectrum.

Nationally reported HIV prevalence data in females 15-24 were obtained directly through ANC sentinel surveillance reports available online or from DHS/AIS reports found through MeasureDHS website's, http://www.measuredhs.com/ and http://www.statcompiler.com/. UNAIDS/GARPR Indicator 1.6 (HIV prevalence in young people) data were accessed from the AIDSinfo Online Database (http://www.aidsinfoonline.org/) and used to supplement when ANC or DHS/AIS reports were not available for later years. Although Indicator 1.6 data guidelines request antenatal clinic attendees data (aged 15-24) be used, the inclusion of population based survey data, for both sexes, is also allowed.

Directly measured HIV prevalence and incidence data were identified through PubMed and Google Scholar searches of published HIV trials or observational studies using keywords "HIV epidemiology" or "HIV incidence" paired with the name of the included countries. For ALPHA Network site data, the names of the various ALPHA sites combined with "HIV" were used in searches, and recent publications from the ALPHA Network were used to find older publications as per their citation lists.

Modeled incidence estimates from Spectrum were downloaded directly from the UNAIDS AIDSinfo website (http://www.unaids.org/en/dataanalysis/datatools/aidsinfo/). Estimated ART coverage among those eligible for treatment was obtained from a variety of sources: for the years 2004-2007 - UNAIDS Report on the global HIV/AIDS epidemic 2008 (based on ART eligibility CD4 at or <200); for the years 2009-2011 - UNAIDS Report on the global AIDS epidemic 2012 (based on ART eligibility CD4 at or <350) and http://aidsinfo.unaids.org (accessed June 2013); for 2012 – WHO Global update on HIV treatment 2013: results, impact and opportunities and http://aidsinfo.unaids.org (accessed October 2013) based on ART eligibility CD4 at or <350).

Incidence from HIV trials and cohort studies is commonly reported as a rate, as events (sero-conversions per 100 person years) of HIV negative individuals. Spectrum, on the other hand, reports an annual incidence figure, as a percentage. These two incidence measurements are not the same, but within a year time frame and so long as cumulative incidence is below 10%, both cumulative incidence and incidence rate will be very similar (Martin 2009). Incidence rates obtained from published trials and studies are very often calculated over several years, and therefore, the assumption was made that these rates are steady throughout that time period, in order to compare these data to the annual incidence estimate provided by Spectrum.

The following Sub-Saharan countries were selected for this analysis based on having a generalized HIV epidemic: Botswana, Burundi, Burkina Faso, Congo, Central African Republic, Ethiopia, Ghana, Kenya, Lesotho, Namibia, Nigeria, Malawi, Mozambique, Rwanda, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe. These countries have been subdivided into groups based on the slope of modeled incidence trends since the beginning of ART scale-up in 2004, including those showing stabilized incidence trends and those with downward trends. Most countries fell into the latter category and were further split into three groups based on the slope of the modeled incidence decline. The slope of incidence changes over percent reduction in incidence from 2004 was chosen to evaluate trends, as we found this to be more reflective of declining incidence trends. Percent reduction can be misleading in cases where a large percent reduction has been achieved with only a moderately declining slope, or a moderate percent reduction, but a steep declining slope is observed. The latter case indicates greater change for countries starting at a higher incidence level.

Tables have been used to summarize country specific data per group, but each country will be discussed in detail individually.

Table 1. Types of HIV incidence data to be analyzed and comparisons made

		Modelled incidence	Proxies of incidence			Directly measured incidence
		UNAIDS estimates from Spectrum	Prevalence in females 15-24 (ANC surveys)	Prevalence in females 15-24 (DHS/AIS)	Prevalence in young females (Published studies)	Published studies
Modelled incidence	UNAIDS estimates from Spectrum		Direction	Direction	Direction	Direction and magnitude
Proxies of incidence	Prevalence in females 15-24 (ANC surveys)	Direction		Direction and magnitude	Direction and magnitude	Direction
	Prevalence in females 15-24 (DHS/AIS)	Direction	Direction and magnitude		Direction and magnitude	Direction
	Prevalence in young females (Published studies)	Direction	Direction and magnitude	Direction and magnitude		Direction
Directly measured incidence	Published studies	Direction and magnitude	Direction	Direction	Direction	

Do the direction of incidence trends match?
Do the direction and magnitude of incidence trends match?

4. ANALYSIS OF INCIDENCE TRENDS

4.1 Countries with stabilized modeled HIV incidence trends 2004-2012

Three Sub-Saharan countries in this review have stabilized (slope of 0 from 2004-2012) modeled HIV incidence trends from 2004-2012: Burkina Faso, Burundi, and Uganda. If any change occurred during this period, it was only a very slight upward (Uganda) or downward (Burundi) trend. Spectrum estimates from both of the countries show an overall increasing incidence trend from 1996 (Uganda) and 2001 (Burundi) on. Empirical data in females 15-24 from ANC and DHS reports do not support modeled incidence trends for Burkina Faso and Burundi (ANC and DHS data show a downward trend, while modeled incidence does not), and it is difficult to identify a clear trend from measured incidence in Uganda. Burkina Faso and Burundi have among the lowest UNAIDS incidence estimates in this review (0.05% and 0.06%), while Uganda's incidence estimate for 2012 is 0.77%. Although estimated incidence trend in this group is level from 2004-2012, incidence changed between 3% (increase for Uganda) and 28% (decrease for Burundi) during this period. ART coverage among those eligible for it reached 58% and above in 2012 for all three countries.

Table 2. Summary of HIV incidence trends and ART coverage: Countries with a stabilized trend 2004-2012

	New infections in 2012 (ages 15+)	Modeled incidence from Spectrum					ART coverage 2012	Observations from measured incidence/ prevalence from trials and ALPHA network studies
		2004	2012	Slope 2000-2012	Slope 2004-2012	% change 2004-2012		
Burkina Faso	4,502	0.06	0.05	<0.01	<0.01	-12%	70%	*
Burundi	3,286	0.09	0.06	<0.01	<0.01	-28%	58%	*
Uganda	122,806	0.75	0.77	0.02	<0.01	3%	64%	Incidence rates higher in specific populations/ demographcis, but otherwise similar in general population

*Lack of studies reporting this data

4.1.1. Burkina Faso

(*Refer to Table 1, Figure 3, and Figure 4*)

The largest decreases in modeled incidence occurred prior to 2001 in Burkina Faso, dropping from 0.73 % to 0.06% (1990 – 2001). After that, relatively little change in estimated incidence occurred through 2012. Due to the low incidence, the overall rate of change from 2004 – 2011 was minor, and only a 12% reduction (0.06 – 0.05%) in incidence was achieved during the ART scale-up period. DHS HIV prevalence data from females 15-24 tell a different story, suggesting a steep decline in new infections in the youth during a period of stable Spectrum-modeled HIV incidence (it cannot be excluded

that HIV incidence shifted to older age groups). In Burkina Faso, Spectrum estimates the HIV incidence curve without available ANC data prior to the predicted incidence peak, which can be problematic. Although ART coverage reached 70% in 2012, modeled estimates suggest incidence had been declining well before ART scale-up began and changed very little through ART scale-up.

Figure 3. Burkina Faso: HIV prevalence (females 15-24) and modelled incidence (adults

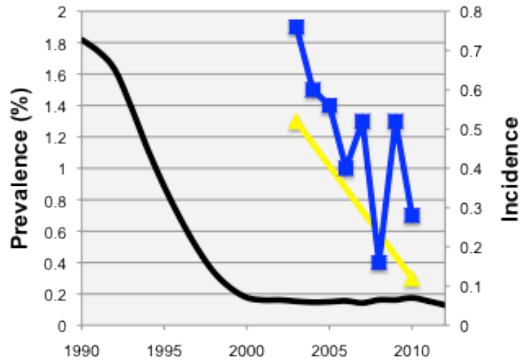
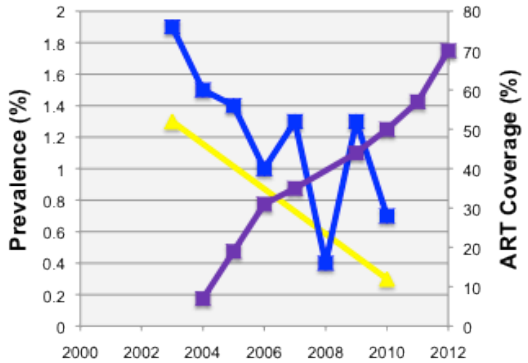


Figure 4. Burkina Faso: HIV prevalence (females 15-24) and national ART coverage



Modelled incidence (%), adults 15-49, from Spectrum software
Prevalence (%), females 15-24 (source: national DHS/AIS reports)
Prevalence (%), females 15-24 (source: national ANC reports)
ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

4.1.2. Burundi

(Refer to Table 1, Figure 5, and Figure 6)

According to UNAIDS estimates, Burundi has seen reduced modeled incidence rates over the past 15 years. HIV incidence peaked in 1993 at 0.95%, after which it dramatically declined to 0.06% in 2001. Between 2001 and 2012 modeled incidence rises and falls slightly, though overall, the trend is towards stability, settling at 0.06% in 2012. During ART scale-up (2004-2012) modeled incidence was reduced by 28% (though the slope was close to zero) and ART coverage reached 58% in 2012. Similar to Burkina Faso, the decrease in HIV prevalence in young females does not match the Spectrum-derived HIV incidence and it can be speculated that there could be increased HIV incidence in older people to lead to the present Spectrum-estimated trajectory.

Figure 5. Burundi: HIV prevalence (females 15-24) and modelled incidence (adults

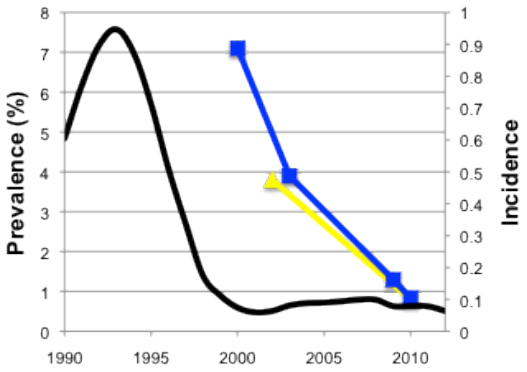
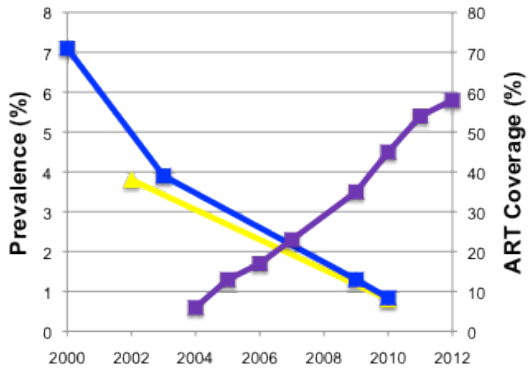


Figure 6. Burundi: HIV prevalence (females 15-24) and national ART coverage



Modelled incidence (%), adults 15-49, from Spectrum software
Prevalence (%), females 15-24 (source: national DHS/AIS reports)
Prevalence (%), females 15-24 (source: national ANC reports)
ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

4.1.3. Uganda

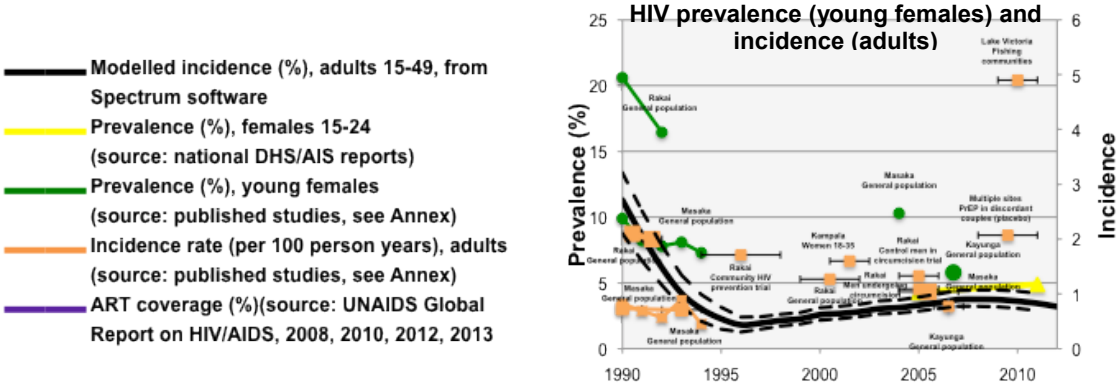
(Refer to Table 1, Figure 7, Figure 8, and Figure 9)

Estimated incidence in Uganda was on dramatic downward trend from 1990 - 1996 (2.71 – 0.44%, over 80% drop in incidence), after which there has been an overall slight upward trend, even through ART scale-up (2004-2012), which reached 64% in ART coverage levels in 2012. Estimated incidence peaked within this period at 0.9% in 2008. Modeled incidence then dropped to 0.77% in 2012, and 122,806 new cases in adults were estimated that year.

Uganda has hosted many clinical trials and observational studies and maintains two ALPHA Network field sites. In most cases, directly measured incidence rates from studies focusing on the general population are slightly higher or lower (1990-1994) than UNAIDS estimates, falling just outside of the upper and lower estimate range. Incidence rates measured in intervention trials or within specific demographics are considerably higher than modeled incidence. There were few nationally reported prevalence data in females 15-24 available for this review, but this proxy of incidence from AIS reports does support a slight upward trend from 4.3% in 2005 to 4.9% in 2011. Additionally, directly measured prevalence from ALPHA Network studies supports a downward incidence trend between 1990 and 1994, with wide prevalence variation between sites (see Annex

2). Considering that Uganda hosts two ALPHA sites, it is surprising that more empirical HIV incidence and prevalence data could not be found past 1994.

Figure 7. Uganda: HIV prevalence (young females) and incidence (adults)



-----High and low incidence estimates from Spectrum software

Figure 8. Uganda: HIV prevalence (young females) and national ART coverage

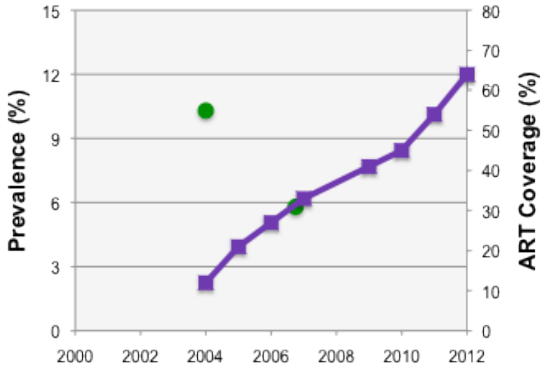
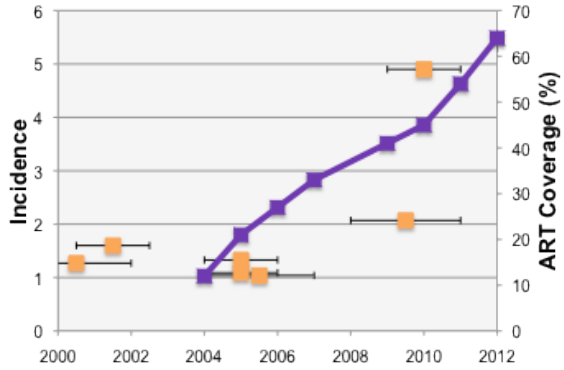


Figure 9. Uganda: HIV incidence (adults) and national ART coverage



*Horizontal error bars denote time period in which prevalence or incidence was measured. Value is at midpoint of time period.

4.2 Countries with a downward modeled HIV incidence trend (modest decline 2004-2012)

Most countries in this analysis had downward trends in Spectrum-modeled incidence between 2004 and 2012, though there is much variance in the slope of the decline. The following countries show only modest declines (slope -0.01 to -0.03) during this period: Central African Republic, Congo, Ethiopia, Ghana, Kenya, Nigeria, Rwanda, and Tanzania.

There are no unifying trends within this group, with the exception of all countries having reached a low to medium modeled incidence level in 2012 (ranging 0.03 – 0.41%) (Table 2). Despite the relatively low incidence level, there is much diversity in the size of the HIV epidemic with regard to the number of new infections each year in these countries.

For instance, Ethiopia had a very low modeled national incidence in 2012 (0.03%), but contributed an estimated 10,503 new adult cases to the global burden, whereas Congo's estimated incidence in 2012 (0.16%) led to an estimated 3,371 new adult infections in 2012 (Table 2). Kenya and Nigeria had an estimated 85,263 and almost 200,000 new adult infections that same year, respectively (Table 2). Similarly, a wide range of ART coverage values in 2012 (22-87%) and of percent reduction in incidence since ART scale-up (25% - 76%) exists in this group (Table 2).

Table 3. Summary of HIV incidence trends and ART coverage: Countries with a modest downward trend 2004-2012

	New infections in 2012 (ages 15+)	Modeled incidence from Spectrum					ART coverage 2012	Observations from measured incidence/ prevalence from trials and ALPHA network studies
		2004	2012	Slope 2000-2012	Slope 2004-2012	% change 2004-2012		
CAR**	8,200	0.53	0.29	-0.04	-0.03	-45%	22%	*
Congo	3,371	0.34	0.16	-0.02	-0.02	-52%	39%	*
Ethiopia	10,503	0.11	0.03	-0.03	-0.01	-76%	60%	*
Ghana	7,120	0.17	0.05	-0.02	-0.01	-70%	58%	Peterson et al shows higher incidence rate in women from microbicide trial
Kenya	85,263	0.54	0.41	-0.02	-0.02	-25%	73%	Incidence rates higher in trial studies
Nigeria	199,921	0.45	0.23	-0.03	-0.03	-49%	32%	*
Rwanda	6,854	0.22	0.13	-0.02	-0.01	-42%	87%	Braunstein et al shows much higher rates among female sex workers
Tanzania	68,683	0.50	0.32	-0.03	-0.02	-38%	61%	Incidence rates higher in studies after 2000

*Lack of studies reporting this data
**Data only until 2011

4.2.1. Central African Republic

(Refer to Table 2, Figure 10, and Figure 11)

Modeled HIV incidence in the Central African Republic has been on a steady downward trend since 1995. In spite of having very poor ART coverage (22% in 2011), estimated HIV incidence was reduced by 45% (0.53 to 0.29%) between 2004 and 2011. ANC prevalence data in females aged 15-24 support the downward trend, although at a steeper decline, and Mahy et al. reported that between 2000 and 2011, DHS prevalence in that same demographic was reduced by 26% (Mahy, Garcia-Calleja, and Marsh 2012).

Figure 10. Central African Republic: HIV prevalence (females 15-24) and modelled incidence (adults 15-49)

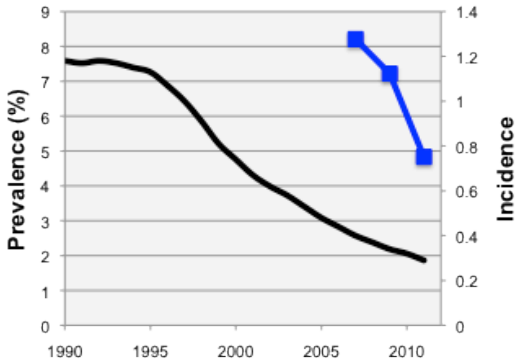
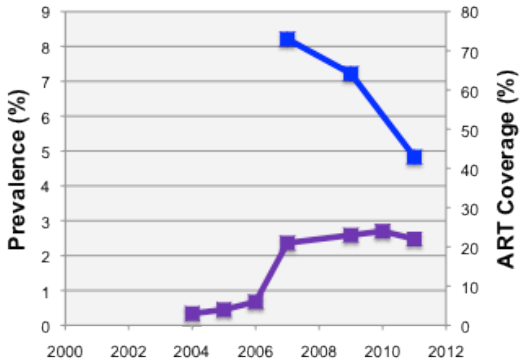


Figure 11. Central African Republic: HIV prevalence (females 15-24) and national ART coverage



Modelled incidence (%), adults 15-49, from Spectrum software
Prevalence (%), females 15-24 (source: national ANC reports)
ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

4.2.2. Congo

(Refer to Table 2, Figure 12, and Figure 13)

Congo's modeled HIV incidence has been on a steady downward trend since 1991, and between 2004 and 2012, estimated HIV incidence was reduced by 52% (0.34-0.16%). Indicator 1.6 (young people) prevalence data also support this decline. ART scale-up has been poor, estimated at 39% coverage in 2012.

Figure 12. Congo: HIV prevalence (females 15-24) and modeled incidence (adults 15-

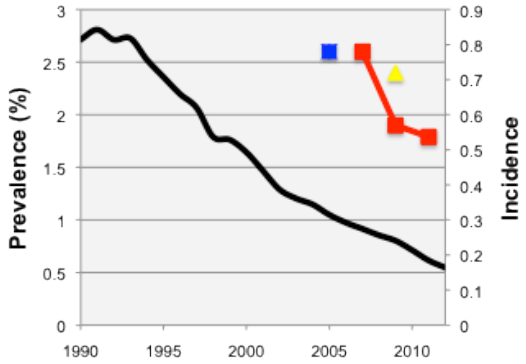
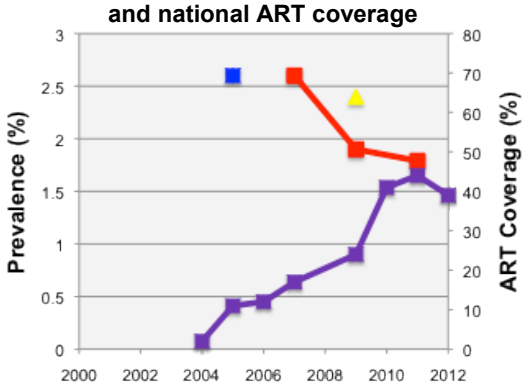


Figure 13. Congo: HIV prevalence (females 15-24) and national ART coverage



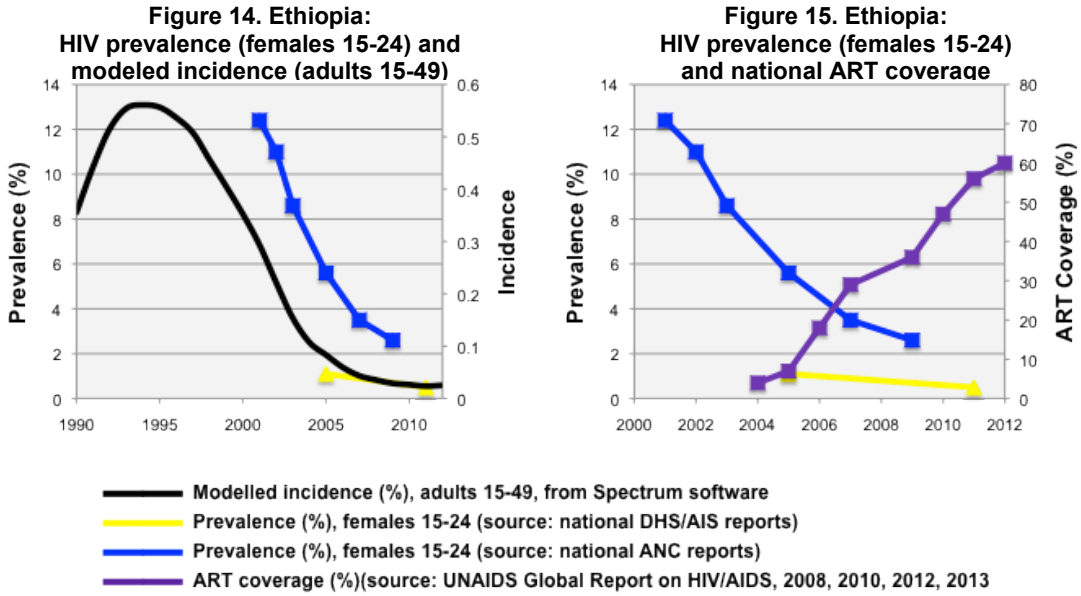
Modelled incidence (%), adults 15-49, from Spectrum software
Prevalence (%), females 15-24 (source: national DHS/AIS reports)
Prevalence (%), females 15-24 (source: national ANC reports)
Prevalence (%), young people, UNAIDS Indicator 1.6 (source: AIDSinfo database
ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

4.2.3. Ethiopia

(Refer to Table 2, Figure 14, and Figure 15)

Ethiopia has seen great declines in modeled incidence estimates since 1995, especially between 1995 and 2004 (0.56 – 0.11%), and less so from 2004-2012 (0.11 – 0.03%). A 76% reduction in modeled incidence since 2004 was achieved during ART scale-up, and ART coverage reached 60% in 2012. Despite overall great success in reducing incidence, Ethiopia's HIV epidemic should not be overlooked; there were 10,503 estimated new adult cases in 2012.

DHS prevalence data in females 15-24 are lower than that from ANC surveys, but both data sets follow a similar trend and show curves that are consistent with the modeled incidence data. While this is not altogether surprising, as these data sets inform the Spectrum model, not all prevalence data from national surveys match incidence trends so well; Swaziland is an excellent example in which HIV prevalence derived from antenatal surveillance within females 15-24 does not show similar dramatic declines as UNAIDS modeled incidence estimates.



Published literature analyzing nationally reported HIV prevalence trends in Ethiopia also supports declining incidence. Hladik et al. describes inter-ANC site variation, but more prevalence declines within the 15-24 age group for both rural and urban sites (Hladik et al. 2006). Mahy et al. report that ANC and DHS prevalence among women 15-24 was

reduced by 83% and 55%, respectively, from 2000-2011 (Mahy, Garcia-Calleja, and Marsh 2012).[3]

4.2.4. Ghana

(Refer to Table 2, Figure 16, and Figure 17)

Modeled HIV incidence in Ghana has been on a downward trend since 1996, including through ART scale-up. Incidence was on the decline before ART scale-up, though there was a 70% reduction in incidence (0.17 – 0.05%) during that period (2004-2012), at the end of which ART coverage reached 58%.

ANC prevalence in females 15-24 show a more dramatic decline than modeled incidence between 2002 and 2005. It continues on an overall downward trend through 2011, though it rises and falls between some years. Between 2000 and 2011, Mahy et al. described a 46% change in ANC prevalence among women 15-24 (Mahy, Garcia-Calleja, and Marsh 2012). Few studies reporting directly measured incidence in Ghana have been carried out, though one study reported an incidence rate of 1.09/100 person years

Figure 16. Ghana: HIV prevalence (females 15-24) and incidence (adults)

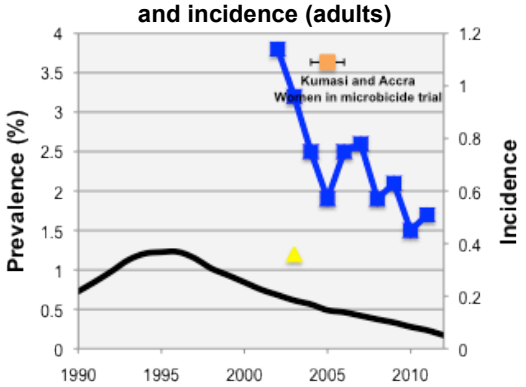
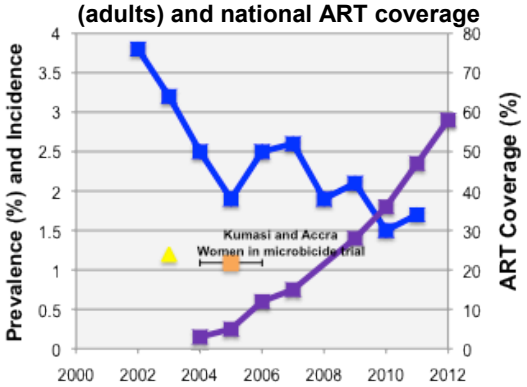


Figure 17. Ghana: HIV prevalence (females 15-24), incidence (adults) and national ART coverage



*Horizontal error bars denote time period in which prevalence or incidence was measured. Value is at midpoint of time period.

- Modelled incidence (%), adults 15-49, from Spectrum software
- Prevalence (%), females 15-24 (source: national DHS/AIS reports)
- Prevalence (%), females 15-24 (source: national ANC reports)
- Incidence rate (per 100 person years), adults (source: published studies, see Annex)
- ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

[3] Montana et al. point out that ANC data in younger women (ages 15-24) is not representative of all women within this age group; this study found that HIV prevalence was significantly lower among DHS samples from young women living within 15km of ANC sites than actual prevalence measured from ANC surveys between 2003 and 2005 (Montana, Mishra, and Hong 2008).

among women in a microbicide trial occurring 2004-2006. (Peterson et al. 2007). This incidence rate is much higher than the UNAIDS incidence annual estimates for that same period (0.17% in 2004, 0.15% in 2005, 0.14% in 2006), presumably because the trial enrolled women with above-average HIV risk.

4.2.5. Kenya

(Refer to Table 2, Figure 18, and Figure 19)

In 2012, it was estimated by UNAIDS that Kenya experienced 85,263 new HIV infections in adults and children, with modeled incidence at 0.41% for the adult population. These modeled estimates show the steepest declines in HIV incidence happening between 1994 and 1999 (2.15 – 0.7%), after which the downward trend continues, but at a much slower rate. During ART scale-up (2004-2012), modeled incidence declined by 25% (0.54 – 0.41%), while ART coverage reaching 73% in 2012.

Figure 18. Kenya: HIV prevalence (young females) and incidence (adults)

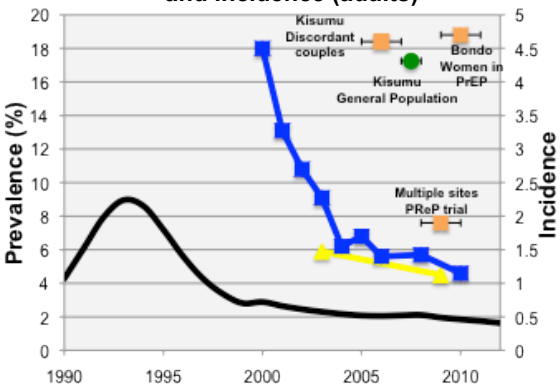
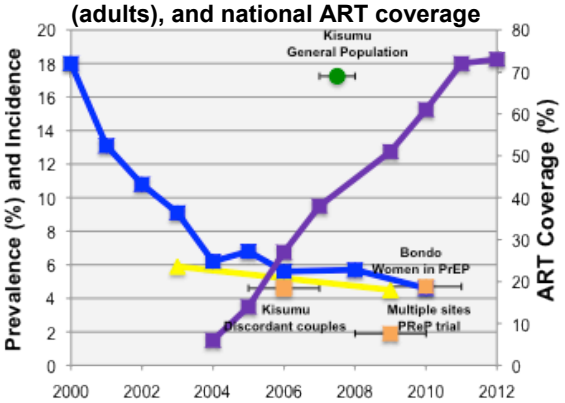


Figure 19. Kenya: HIV prevalence (young females), incidence (adults), and national ART coverage



*Horizontal error bars denote time period in which prevalence or incidence was measured. Value is at midpoint of time period.

- Modelled incidence (%), adults 15-49, from Spectrum software
- Prevalence (%), females 15-24 (source: national DHS/AIS reports)
- Prevalence (%), females 15-24 (source: national ANC reports)
- Prevalence (%), young females (source: published studies, see Annex)
- Incidence rate (per 100 person years), adults (source: published studies, see Annex)
- ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

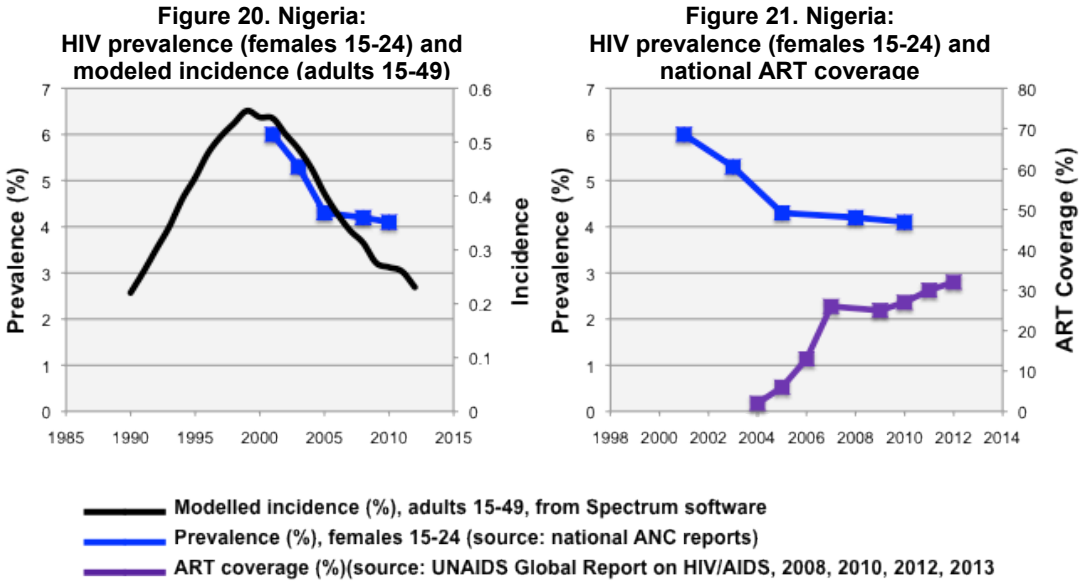
Trends from HIV prevalence in females 15-24 measured by ANC sentinel surveillance and DHS show similar curves, although they appear to have happened after modeled incidence trends began to decline. The steepest decline in the prevalence trend from ANC data happened between 2000 and 2004, as compared to the most dramatic declines in modeled incidence occurring between 1994 and 1999. Similarly, the slower decline in both ANC and DHS prevalence started between 2003 and 2004, whereas this

began in 1999 for modeled incidence. However, ANC and DHS prevalence data were not available prior to 2001, so it is unknown how these trends compared to incidence trends during that same period. Mahy reported that there was a 69% and 24% reduction in ANC and DHS prevalence, respectively, among women 15-24 from 2000-2011, though the change in DHS prevalence was not statistically significant (Mahy, Garcia-Calleja, and Marsh 2012).

Despite having a large population at risk and hosting two recently joined ALPHA Network sites, there are very few published studies reporting measured HIV incidence or prevalence within females aged 15-24. However, in the few studies that have reported this data, the values have been much higher than national HIV prevalence data and modeled incidence estimates. Although Chege et al. focused on females aged 18-24 in Kisumu, prevalence in this age group and region of Kenya between 2007 and 2008 (17.24%) far exceeds nationally reported prevalence data for that same time period (5.7%, ANC 2008)(Chege et al. 2012). Measured incidence rates were also much higher than modeled incidence, though these rates were taken from high-risk populations, including discordant couples and highly sexually active women, and not representative of the general Kenyan adult population.

4.2.6. Nigeria

(Refer to Table 2, Figure 20, and Figure 21)



Spectrum estimated incidence had been on the rise in Nigeria until 1999, after which there is a downward trend through 2012. Between 2004 and 2012, modeled incidence was reduced by 49% (0.45-0.23%). Sentinel surveillance data reveal a similar curve

through 2005, but the curve levels off after this point and does not support the continued decline shown by modeled incidence data, though few data during this period brings uncertainty to recent HIV epidemic trends in Nigeria. Despite current estimates of the HIV incidence rate in Nigeria being relatively low, Nigeria had an estimated 199,921 new HIV infections in adults in 2012.

Nigeria also has among the lowest ART coverage in the countries surveyed, reaching only 32% in 2012.

4.2.7. Rwanda

(Refer to Table 2, Figure 22, and Figure 23)

There has been a steady downward trend in Rwanda's modeled incidence since 1991, reaching 0.13% in 2012. ART scale-up happened relatively quickly, rising from 10% to 71% between 2004 and 2007 and achieving 87% ART coverage by 2012. During this same period, modeled HIV incidence was reduced by 42%.

Very few nationally reported HIV prevalence data were found for Rwanda, and what was available does not show any consistent trend. DHS prevalence data among young

Figure 22. Rwanda: HIV prevalence (females 15-24) and incidence (adults)

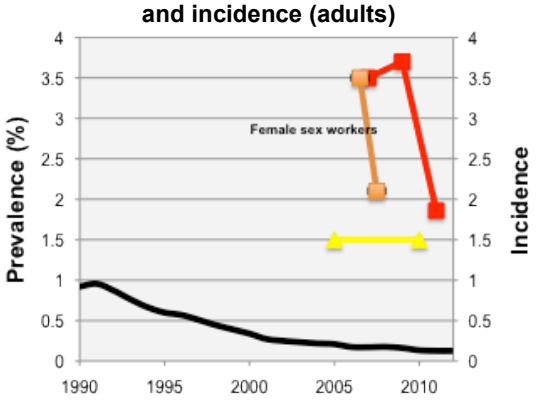
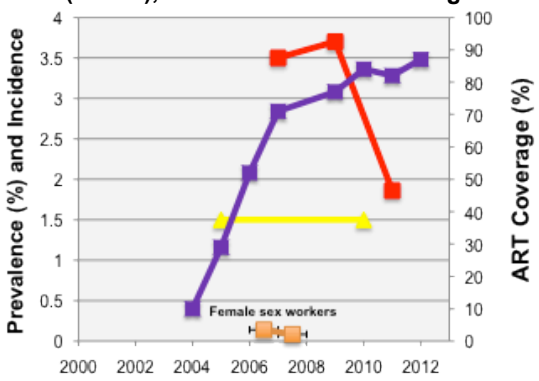


Figure 23. Rwanda: HIV prevalence (females 15-24), incidence (adults), and national ART coverage



*Horizontal error bars denote time period in which prevalence or incidence was measured. Value is at midpoint of time period.

- Modelled incidence (%), adults 15-49, from Spectrum software
- Prevalence (%), females 15-24 (source: national DHS/AIS reports)
- Prevalence (%), young people, UNAIDS Indicator 1.6 (source: AIDSinfo database)
- Incidence rate (per 100 person years), adults (source: published studies, see Annex)
- ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

women show very little change between 2005 and 2010, whereas prevalence data from UNAIDS Indicator 1.6 are grossly not in agreement with that from DHS.

There are also few published studies on prevalence and incidence trends in Rwanda. Kayirangwa et al. reported that prevalence, including among females aged 15-24, was higher in urban vs. rural ANC clinics between 1998 and 2003 (Kayirangwa et al. 2006) and Kayibanda et al. noted that prevalence measured from ANC clinics is higher than that measured from DHS in 2005 (Kayibanda et al. 2011). Only one study was found reporting directly measured incidence in Rwanda, and it measured an incidence decline (3.5 -2.1/100 person years) between 2006 and 2008 (Braunstein et al. 2011), though this was within female sex workers and is not generalizable to the adult population.

4.2.8. Tanzania

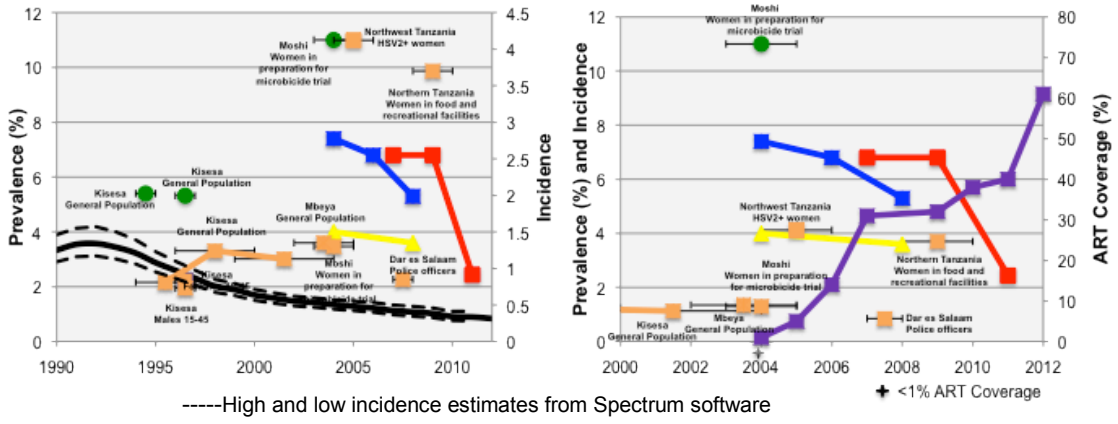
(Refer to Table 2, Figure 24, and Figure 25)

Modeled HIV incidence in Tanzania has been on a downward trend since 1992, reaching 0.32% in 2012. A 38% reduction in modeled incidence was seen between 2004 and 2012 (0.5 – 0.32%), and ART coverage reached 61% at the end of this period.

There are few nationally reported prevalence data available to infer and/or support incidence trends, and the data available do not agree with each other. ANC prevalence

Figure 24. Tanzania: HIV prevalence (young females) and incidence (adults)

Figure 25. Tanzania: HIV prevalence (young females), incidence (adults), and national ART coverage



-----High and low incidence estimates from Spectrum software

*Horizontal error bars denote time period in which prevalence or incidence was measured. Value is at midpoint of time period.

- **Modelled incidence (%), adults 15-49, from Spectrum software**
- **Prevalence (%), females 15-24 (source: national DHS/AIS reports)**
- **Prevalence (%), females 15-24 (source: national ANC reports)**
- **Prevalence (%), young people, UNAIDS Indicator 1.6 (source: AIDSinfo database)**
- **Prevalence (%), young females (source: published studies, see Annex)**
- **Incidence rate (per 100 person years), adults (source: published studies, see Annex)**
- **ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013**

in females aged 15-24 more closely mimics the little change seen in modeled incidence between 2004 and 2008, whereas prevalence obtained from AIS and Indicator 1.6

suggests a downward trend from 2004 to 2011. Furthermore, the prevalence values within that period from ANC, AIS, and Indicator 1.6 sources widely vary from each other, with ANC prevalence being higher than that of AIS. Mishra et al. also noted that lower HIV prevalence was found in AIS samples from women located within 15km of ANC clinics that prevalence from the clinics themselves (Montana, Mishra, and Hong 2008).

Tanzania has two ALPHA Network field sites and has hosted a number of HIV trials and studies within the general adult population and specific demographics. With the exception of a few early cases, these measured incidence rates are higher than modeled incidence estimates, falling well outside the higher confidence bound of the UNAIDS incidence estimates. Additionally, HIV prevalence within women in Moshi was higher than nationally reported estimates between 2003 and 2004 (Ramjee et al. 2008).

4.3. Countries with a downward HIV incidence trend (moderate decline 2004-2012)

Three countries show moderate declines (slopes -0.05 to -0.06) in modeled HIV incidence: Lesotho, South Africa, and Zimbabwe. UNAIDS incidence estimates for 2012 in this group are among the highest out of countries surveyed in this report, but no other unifying trends exist besides similar slopes during ART scale-up.

Table 4. Summary of HIV incidence trends and ART coverage: Countries with a moderate downward trend 2004-2012

	New infections in 2012 (ages 15+)	Modeled incidence from Spectrum					ART coverage 2012	Observations from measured incidence/ prevalence from trials and ALPHA network studies
		2004	2012	Slope 2000-2012	Slope 2004-2012	% change 2004-2012		
Lesotho	22,655	2.66	2.26	-0.09	-0.06	-15%	54%	*
South Africa	346,034	1.96	1.37	-0.08	-0.05	-30%	80%	Considerbly higher measured incidence rates from published studies
Zimbabwe	59,418	1.45	0.96	-0.09	-0.05	-34%	79%	Incidence rates higher in trial studies

*Lack of studies reporting this data

4.3.1. Lesotho

(Refer to Table 3, Figure 26, and Figure 27)

Between 1990 and 1997, modeled HIV incidence in Lesotho rapidly and drastically increased, peaking at an estimated 5.04%. The trend then turned around, declining to 2.66% by 2004. After that period, modeled incidence changes occurred much less

rapidly, with a reduction of only 15% between 2004 and 2012 (2.66 – 2.26%). Nationally reported prevalence data (ANC and DHS in females aged 15-24 combined with Indicator 1.6 data) support this downward trend from 2000-2011; however, it is these data that inform the Spectrum model. The greatest modeled incidence declines occurred well before initiation of ART scale-up, but it cannot be excluded that the increasing ART coverage from 26% in 2007 to 58% in 2011 helped halt, and then turn around, incidence that had been slowly rising between 2005 and 2008.

Figure 26. Lesotho: HIV prevalence (females 15-24) and modeled incidence (adults 15-49)

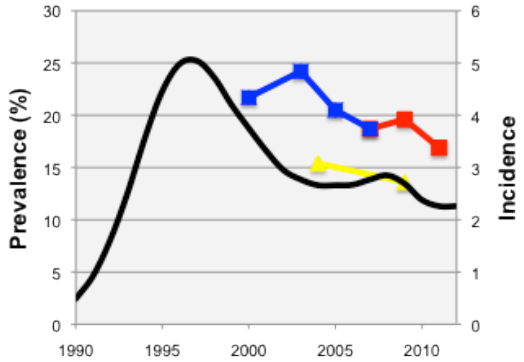
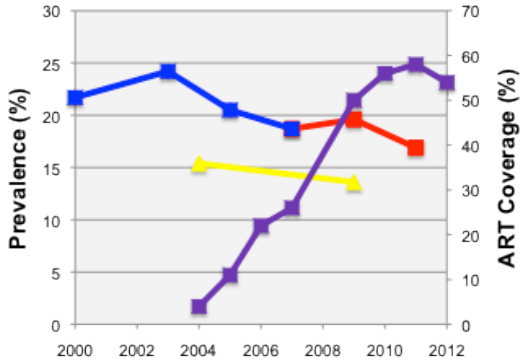


Figure 27. Lesotho: HIV prevalence (females 15-24) and national ART coverage



Modelled incidence (%), adults 15-49, from Spectrum software
Prevalence (%), females 15-24 (source: national DHS/AIS reports)
Prevalence (%), females 15-24 (source: national ANC reports)
Prevalence (%), young people, UNAIDS Indicator 1.6 (source: AIDSinfo database)
ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

4.3.2. South Africa

(Refer to Table 3, Figure 28, Figure 29, Figure 30, and Figure 31)

South Africa is suffering from the largest HIV epidemic in the world, including new infections. In 2012, it was estimated that there were 346,034 new cases of HIV in adults. Modeled incidence rose dramatically from 1990 – 1998, reaching 2.85%. It has been on a downward trend since then and was reduced by 30% from 2004 – 2012 (1.96-1.37%). ART coverage reached 80% at the end of that period.

Comprehensive HIV incidence estimates are available from the South African National HIV Prevalence, Incidence, and Behavior Survey, 2012. HIV incidence in adults aged 15-49 years was directly measured at 1.72% (CI95% 1.38; 2.06) for 2012, using a multi-assay testing algorithm. This is higher than the 2012 Spectrum estimate for 2012 of 1.37%. In addition, HIV incidence was indirectly estimated through modelling from three surveys to be 2.2% (2002-2005), 1.9% (2005-2008), and 1.9% (2008-2012) (Shisana et al. 2014). These estimates are slightly higher than UNAIDS estimates for the same period up until 2011 (which extend from 2.26% in 2002 to 1.72% in 2011).

Figure 28. South Africa: HIV prevalence (young females) and incidence (adults)

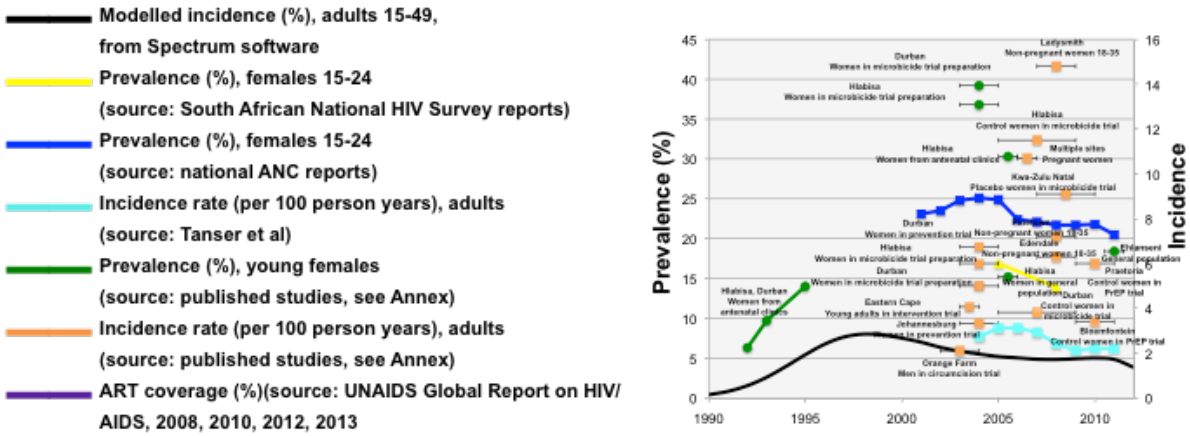


Figure 29. South Africa: HIV prevalence (young females) and national ART coverage

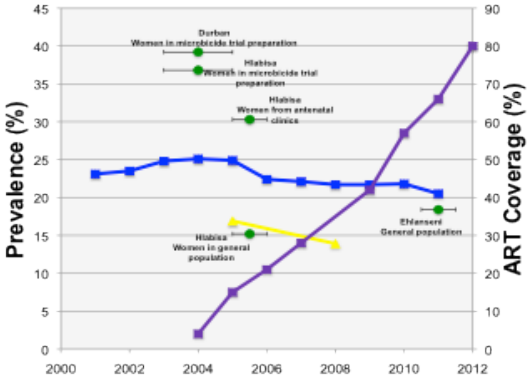
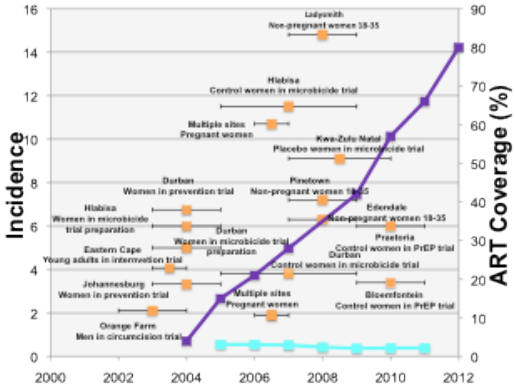


Figure 30. South Africa: HIV incidence (adults) and national ART coverage



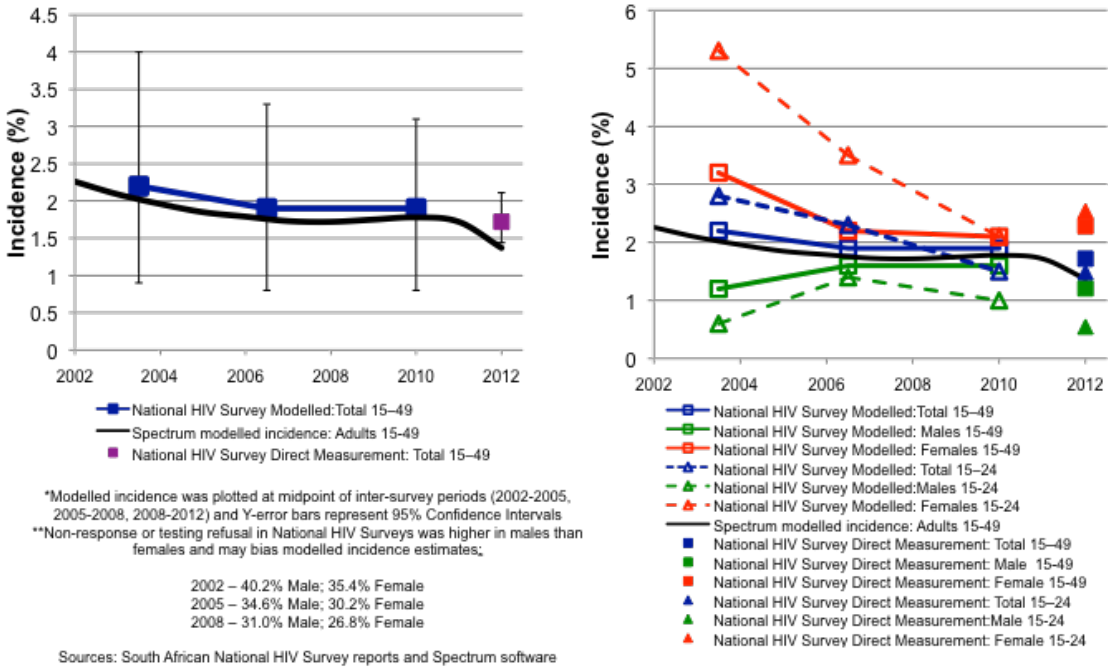
*Horizontal error bars denote time period in which prevalence or incidence was measured. Value is at midpoint of time period.

Nationally reported HIV prevalence data in females aged 15-24 suggest a downward incidence trend, however, the recent analysis by Shisana et al. suggests that the strong HIV incidence declines in youth (from 2.8% in 2002/05 to 1.5% in 2008/12) are not reflected in older adults, leading to an overall stable HIV incidence situation as described above(Shisana et al. 2014).[4] Survey data also suggest that HIV prevalence levels in young females in the general population are lower than those in young ANC clients, with a steeper downward trend. Mahy et al. reported that between 2000 and 2011 there was a 17% change in population-survey-derived HIV prevalence in young females (Mahy, Garcia-Calleja, and Marsh 2012). Johnson et al., using an adapted STI–HIV Interaction

[4] Notably, modelled incidence from Shishana et al in males is lower than females, but this could be biased from higher non-response and testing refusal from males.

model and the ASSA2003 AIDS and Demographic model, reported that HIV incidence rates in 15–49 year olds declined significantly between 2000 and 2008 (by 27% in the STI–HIV model and by 31% in the ASSA2003 model). Both models also estimated a small reduction in HIV incidence owing to ART by 2008 (Johnson et al. 2012).

Figure 31. South Africa:
Modelled and Directly Measured HIV incidence (adults)



South Africa has been a site of many HIV clinical trials and studies, including those from two ALPHA Network sites. Most of these studies that have directly measured and reported incidence have focused on women, and the incidence rates measured from them are much higher than UNAIDS estimates. Prevalence measured from these studies also tends to be higher than nationally reported values from sentinel surveillance and DHS-type household studies.

Tanser et al. reported incidence rates in a general population cohort from 2007 – 2011 in KwaZulu-Natal, and data from this study show a downward trend in incidence rates, with values closer to Spectrum estimated incidence. Additionally, this study showed that increasing ART coverage in a community affected individuals' risk of acquiring HIV. Just by living in a community with high ART coverage (30 to 40% of all HIV-infected individuals on ART), an HIV-uninfected individual was 38% less likely to acquire HIV than someone living in a community where ART coverage was low (<10% of all HIV-infected individuals on ART) (Tanser et al. 2013).

4.3.3. Zimbabwe

(Refer to Table 3, Figure 32, and Figure 33)

Zimbabwe had been experiencing a terrible HIV epidemic in the early 1990s, based on modeled incidence, peaking at an estimated 5.84% in 1993. However, over the next 11 years incidence steeply dropped to 1.45% in 2004. Change in incidence after that (2004-2012) was less drastic. However, a 34% reduction in incidence (1.45 – 0.96%) was achieved during this period, and ART coverage levels peaked at 83% in 2011, declining slightly to 79% the next year.

Figure 32. Zimbabwe: HIV prevalence (young females and incidence (adults)

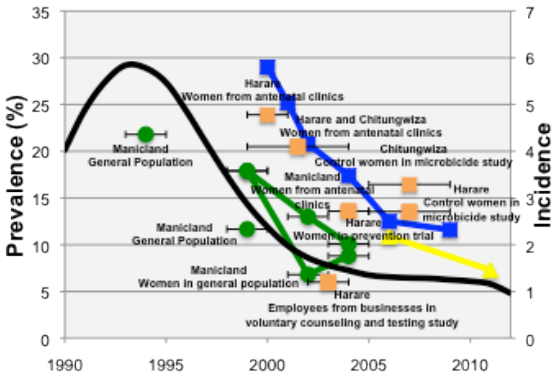
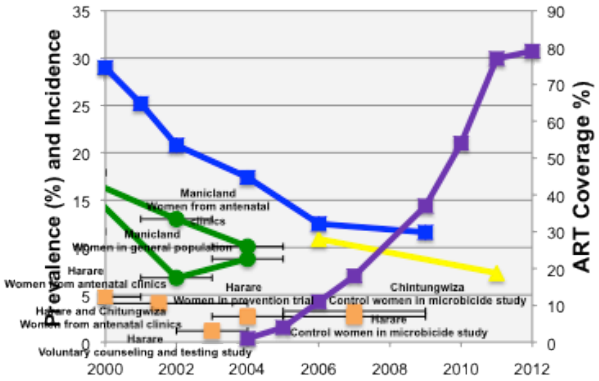


Figure 33. Zimbabwe: HIV prevalence (young females), incidence (adults) and national ART coverage



Modelled incidence (%), adults 15-49, from Spectrum software
Prevalence (%), females 15-24 (source: national DHS/AIS reports)
Prevalence (%), females 15-24 (source: national ANC reports)
Prevalence (%), young females (source: published studies, see Annex)
Incidence rate (per 100 person years), adults (source: published studies, see Annex)
ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

Nationally reported prevalence data support the downward trend in modeled incidence. ANC and DHS prevalence in females aged 15-24 together follow a similar curve, but it occurs slightly later. Overall, Mahy et al. reported a 63% and 34% change in ANC and DHS prevalence, respectively, in this same demographic between 2000 and 2001 (Mahy, Garcia-Calleja, and Marsh 2012).

Directly measured prevalence and incidence from trials and studies, including those data from the ALPHA Network site in Manicaland, also support HIV incidence declines. Although most of the data are derived from females and both prevalence and incidence tend to be higher than nationally reported and modeled estimates, there is a general trend downward.

4.4. Countries with downward HIV incidence trends (steep decline 2004-2012)

Countries within this group have experienced the steepest declines (slope -0.08 to -0.14) by UNAIDS HIV incidence estimates. All of the countries within this group had high modeled incidence estimates in 2012 and reductions in incidence between 37% and 47%. With the exception of Mozambique, ART scale-up has been successful and was 69% and above in 2012. The size of the epidemic in this group is variable – Swaziland has the highest 2012 incidence estimate in this group and is almost two times that of Mozambique's (2.04% vs. 1.03%, but ten times as many new infections were estimated in Mozambique (103,514) than Swaziland (10,287).

Table 5. Summary of HIV incidence trends and ART coverage: Countries with a steep downward trend 2004-2012

	New infections in 2012 (ages 15+)	Modeled incidence from Spectrum					ART coverage 2012	Observations from measured incidence/ prevalence from trials and ALPHA network studies
		2004	2012	Slope 2000-2012	Slope 2004-2012	% change 2004-2012		
Botswana	12,024	2.23	1.25	-0.20	-0.12	-44%	95%	*
Malawi	55,032	1.37	0.77	-0.10	-0.08	-44%	69%	Incidence rates higher in trial studies
Mozambique	103,514	1.64	1.03	-0.08	-0.08	-37%	45%	*
Namibia	9,650	1.53	0.81	-0.15	-0.09	-47%	90%	Aulagnier et al shows higher incidence in Winhoek adult general population
Swaziland	10,287	3.29	2.04	-0.12	-0.14	-38%	82%	*
Zambia	46,381	1.49	0.79	-0.08	-0.08	-47%	79%	Abdool et al shows higher incidence rate in women from microbicide trial

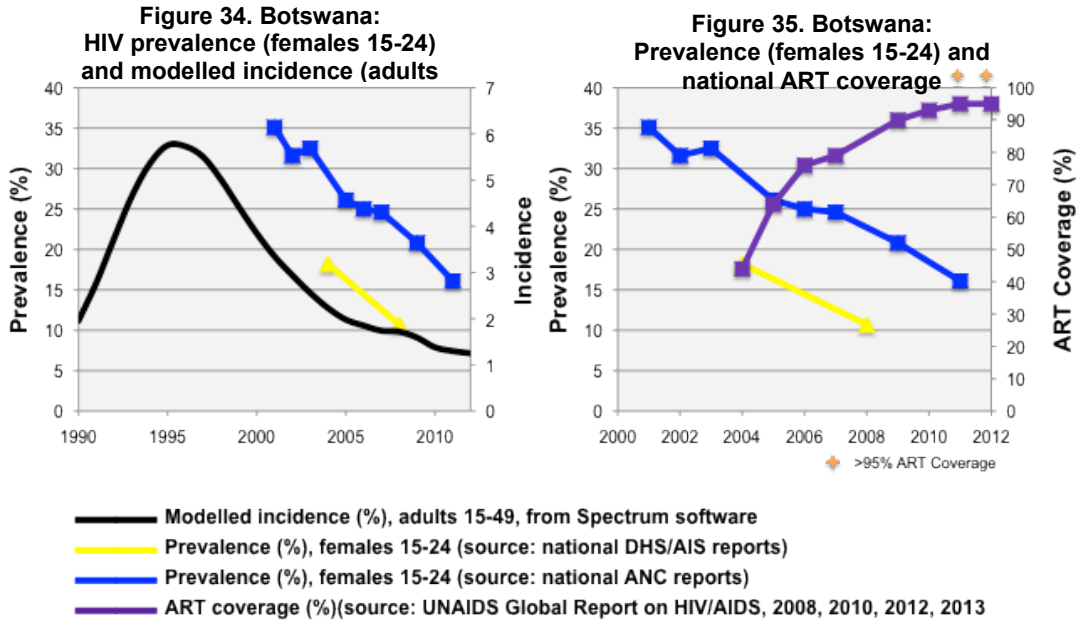
*Lack of studies reporting this data

4.4.1. Botswana

(Refer to Table 4, Figure 34, and Figure 35)

Based on Spectrum estimates, Botswana has made great progress in reducing HIV incidence. Modeled incidence peaked in 1995 at 5.75%, but since then, it has been rapidly declining. ART scale-up has also been highly successful; within eight years coverage went from 44% to over 95%. HIV incidence was reduced by 44% (2.23 – 1.25%) in that same period, but it is important to note that a steep downward trend had begun years prior to ART roll-out in 2004.

Both ANC and BAIS prevalence data in females aged 15-24 also support the modeled HIV incidence trend in Botswana, with Mahy et al. reporting a 63% and 41% change in ANC and DHS prevalence, respectively, between 2000 and 2011 (Mahy, Garcia-Calleja, and Marsh 2012).



4.4.2. Malawi

(Refer to Table 4, Figure 36, and Figure 37)

Modeled HIV incidence in Malawi has been on a downward trend since 1995, continuing through 2012. Between 2004 and 2012, estimated incidence was reduced by 44% (from 1.37% to 0.77%), and ART coverage reached 69%. From 2003 and on, nationally reported prevalence data in females aged 15-24 support modeled incidence trends, though the decline is considerably steeper. Mahy et al. reported a 68% and 43% reduction in ANC and DHS prevalence in females 15-24, respectively, from 2000 – 2011 (Mahy, Garcia-Calleja, and Marsh 2012).

Malawi has hosted a number of HIV trials and studies, including those from the Karonga site of the ALPHA network. In general, directly measured incidence rates from these trials show no specific upward or downward trend, but are higher than modeled incidence estimates. The higher incidence data from trials may be explained by a high risk female population recruited for these microbicide efficacy studies. On the other hand, prevalence levels from these studies are lower than nationally reported prevalence data. It should be noted that these data were measured in young women in

Karonga, suggesting how variable prevalence data may be at the local level in Malawi, stressing how any one site may deviate from national data.

Figure 36. Malawi: HIV prevalence (young females) and incidence (adults)

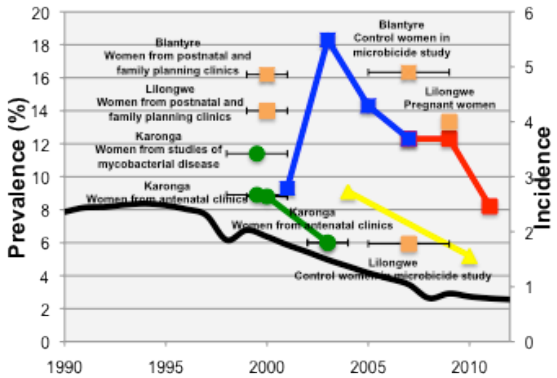
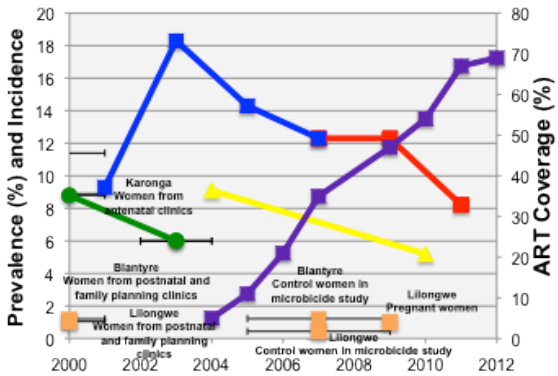


Figure 37. Malawi: HIV prevalence (young females), incidence (adults), and national ART coverage



*Horizontal error bars denote time period in which prevalence or incidence was measured. Value is at midpoint of time period.

- Modelled incidence (%), adults 15-49, from Spectrum software
- Prevalence (%), females 15-24 (source: national DHS/AIS reports)
- Prevalence (%), females 15-24 (source: national ANC reports)
- Prevalence (%), young people, UNAIDS Indicator 1.6 (source: AIDSinfo database)
- Prevalence (%), young females (source: published studies, see Annex)
- Incidence rate (per 100 person years), adults (source: published studies, see Annex)
- ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

4.3.3. Mozambique

(Refer to Table 4, Figure 38, and Figure 39)

Mozambique has a large HIV epidemic, with an estimated 103,514 new cases in adults in 2012. Modeled incidence had been on the rise until 2002, at which point it was estimated at 1.83%. It then turned around and followed a downward trend reaching 1.03% in 2012.

The shape of the curve from ANC prevalence in females 15-24 is similar to and supports the modeled incidence trends, albeit, it is shifted just after incidence – the high prevalence peak and subsequent decline occur a few years after the Spectrum incidence peak and decline. This is based on the assumption that the 2004 ANC data point is not an outlier, and indeed, is representative of overall prevalence trends within young females. If not, very little change occurred in ANC prevalence within this demographic between 2001 and 2009.

ART coverage in Mozambique was reported at 45% in 2012. Although modeled incidence had begun a downward trend prior to ART scale-up initiation in 2004, it was further reduced by 37% (from values of 1.64% to 1.03%), with a steady decline through that period.

Figure 38. Mozambique: HIV prevalence (females 15-24) and modeled incidence (adults 15-49)

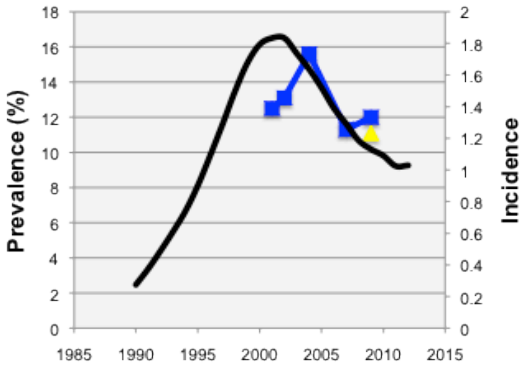
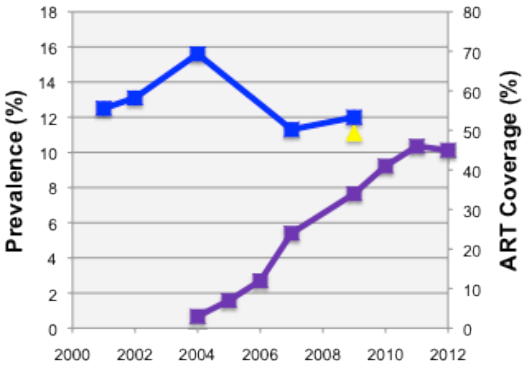


Figure 39. Mozambique: HIV prevalence (females 15-24) and national ART coverage



Modelled incidence (%), adults 15-49, from Spectrum software
Prevalence (%), females 15-24 (source: national DHS/AIS reports)
Prevalence (%), females 15-24 (source: national ANC reports)
ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

4.4.4. Namibia

(Refer to Table 4, Figure 40, and Figure 41)

According to Spectrum outputs, HIV incidence rose quickly in Namibia, peaking at 2.7% in 1998, and then turned around, with steep declines until 2007 and then a slower rate of change through 2012. ANC prevalence in females aged 15-24 supports the downward decline, and Mahy et al. also reported a 59% change in this same demographic from 2000 – 2011 (Mahy, Garcia-Calleja, and Marsh 2012).

While the steepest declines in incidence happened prior to ART scale-up, it is worth noting that Namibia, a country with a high incidence in 2004, experienced a 47% reduction (1.53 – 0.81%) in incidence by 2012. At this point, ART coverage had reached over 95% in 2011 and dropped slightly to 90% in 2012.

Only one study could be found reporting measured incidence from a trial or study in Namibia. This study found that between 2007 and 2009, HIV incidence in the general population of the Windhoek region was 2.1/100 person years (Aulagnier et al. 2011). This measured value is higher than Spectrum estimates for that same period (0.96-

0.81%). This is not surprising, as it is expected that an urban area, and this country's capital, would have a higher incidence than the national value.

Figure 40. Namibia: HIV prevalence (females 15-24) and incidence (adults)

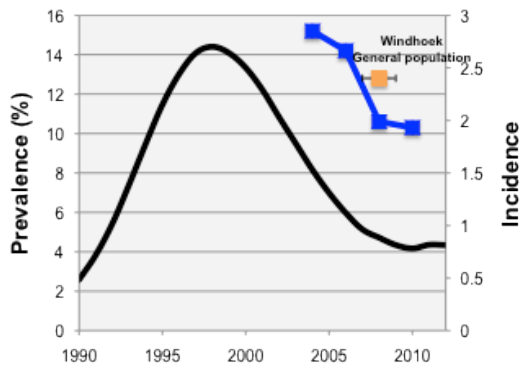
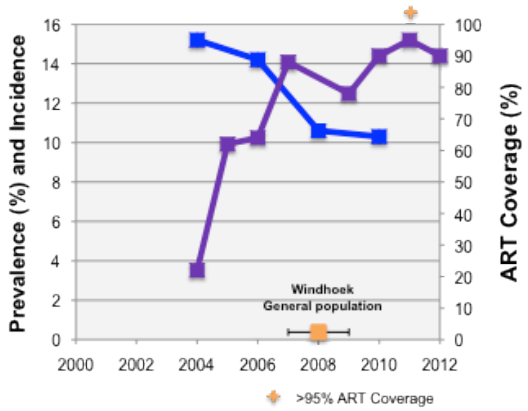


Figure 41. Namibia: HIV prevalence (females 15-24), incidence (adults) and national ART coverage



*Horizontal error bars denote time period in which prevalence or incidence was measured. Value is at midpoint of time period.

Modelled incidence (%), adults 15-49, from Spectrum software
Prevalence (%), females 15-24 (source: national ANC reports)
Incidence rate (per 100 person years), adults (source: published studies, see Annex)
ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

4.4.5. Swaziland

(Refer to Table 4, Figure 42, and Figure 43)

Swaziland had one of the world's highest modeled HIV incidence rates in 2012, at 2.04%, but contributed far fewer new infections in adults that same year (10,287) than the majority of the countries in this group. Between 1990 and 1996, modeled incidence steeply rose to 5.07%, but then declined through 2012. However, this trend is not reflected in ANC prevalence data; instead, there is very little change in prevalence among females aged 15-24 between 2000 and 2011.

Swaziland is in the unique position to have nationally-representative directly observed HIV incidence data from the Swaziland HIV Incidence Measurement Survey (SHIMS) conducted in 2011. HIV incidence in adults aged 18-49 years was 2.4% (Kingdom of Swaziland Ministry of Health 2012), which compares very well to the Spectrum HIV incidence estimate of 2.47% for 2011. Incidence estimates obtained using LAg-Avidity EIA (2.6%) and a nucleic acid amplification test (2.6%) compared favourably to directly observed incidence (2.4%). The incidence estimate derived from the BED assay (13.1%) was not comparable to directly observed incidence, indicating that the BED assay overestimates incidence and is not appropriate for use in populations with high ART coverage.

ART scale-up has been successful, reaching 83% and 82% in 2011 and 2012. During that same period (2004 – 2012), there was a 38% reduction in modeled HIV incidence (3.29 – 2.04%), though incidence had been declining prior to ART scale-up initiation.

Figure 42. Swaziland: HIV prevalence (females 15-24), and modeled incidence (adults 15-49)

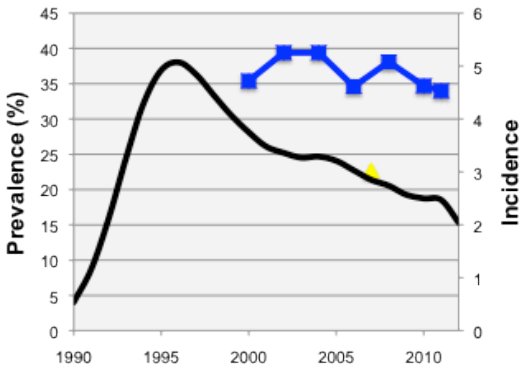
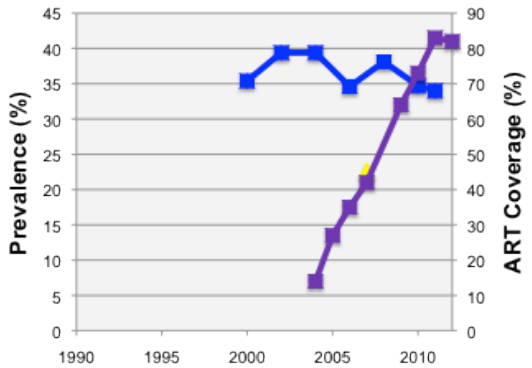


Figure 43. Swaziland: HIV prevalence (females 15-24) and national ART coverage



Modelled incidence (%), adults 15-49, from Spectrum software
Prevalence (%), females 15-24 (source: national DHS/AIS reports)
Prevalence (%), females 15-24 (source: national ANC reports)
ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013

4.4.6. Zambia

(Refer to Table 4, Figure 44, and Figure 45)

Modeled HIV incidence in Zambia has been on an overall decline since 1992, starting at 2.59% and reaching 0.79% in 2012. Zambia achieved high levels of ART coverage (82% in 2011 and 79% in 2011), and during the period of scale-up (2004 – 2011), incidence was reduced by 47% (1.49 – 0.79%).

DHS and Indicator 1.6 data reflect a downward trend, and Mahy et al. reported a 23% change in DHS prevalence among women aged 15-24 (Mahy, Garcia-Calleja, and Marsh 2012) between 2000 and 2011. However, there is very little overall change in ANC prevalence among this same demographic from 2002 to 2007. Few trials or studies have measured HIV prevalence or incidence in Zambia, but those that have reported higher values than nationally reported prevalence or UNAIDS incidence estimates.

Figure 44. Zambia:
HIV prevalence (young females) and incidence (adults)

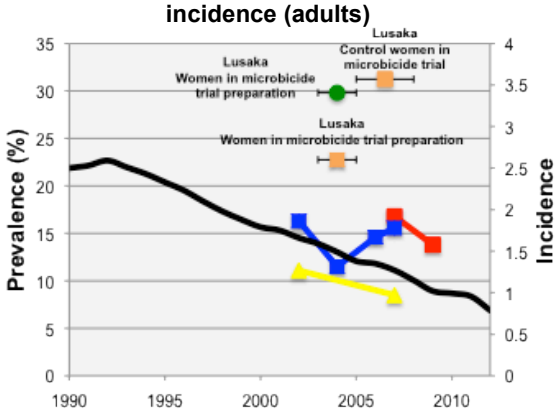


Figure 45. Zambia:
HIV prevalence (young females), incidence (adults), and national ART coverage

*Horizontal error bars denote time period in which prevalence or incidence was measured. Value is at midpoint of time period.

- **Modelled incidence (%), adults 15-49, from Spectrum software**
- **Prevalence (%), females 15-24 (source: national DHS/AIS reports)**
- **Prevalence (%), females 15-24 (source: national ANC reports)**
- **Prevalence (%), young people, UNAIDS Indicator 1.6 (source: AIDSinfo database)**
- **Prevalence (%), young females (source: published studies, see Annex)**
- **Incidence rate (per 100 person years), adults (source: published studies, see Annex)**
- **ART coverage (%)(source: UNAIDS Global Report on HIV/AIDS, 2008, 2010, 2012, 2013**

5. DISCUSSION

The purpose of this review was to comprehensively triangulate, describe, and analyze longitudinal HIV incidence trends in select Sub-Saharan African countries between 1990 and 2012. Proxies of HIV incidence (HIV prevalence in young females) from nationally reported sources and published studies were compared to each other, and UNAIDS modeled HIV incidence curves were compared to HIV incidence empirically obtained from trials and studies. In addition, HIV incidence trends were related to temporal trends in ART scale-up from 2004 to 2012.

One challenge encountered in this review was the scarcity of *measured* HIV incidence data in many countries. There is a dearth of published studies reporting directly measured HIV incidence, including those from the ALPHA Network, and for many countries, no measured HIV incidence data could be identified. The scarcity of data is most profound before 2001, which presents a challenge to the certainty in which national HIV epidemics can be modeled prior to this year. Uganda, Zimbabwe, and South Africa are exceptions to this general lack of measured incidence data, as a number of studies reporting HIV incidence rates from intervention trials or observational studies have been carried out in these countries. In general, measured HIV incidence rates tend to be higher in sub-national studies in specific demographics than corresponding UNAIDS incidence estimates for these three countries, though incidence rates measured within the general population (not specific demographics or high-risk groups) of Uganda tend to be similar to the UNAIDS estimates and the overall incidence trend in Zimbabwe mirrors that projected by Spectrum.

Another difficulty in longitudinally assessing incidence trends was the scarcity of *repeat* cross-sectional, nationally representative HIV prevalence surveys. In many cases, only a few ANC and DHS/AIS reports through the years of interest could be readily found, leaving few data points from which to infer long-term incidence trends. While many of the individual reports from sentinel surveillance or DHS/AIS surveys could be obtained from Measure DHS, governmental websites, or other online sources, a central repository for these reports, even within the UNAIDS website, would be a useful resource for those conducting similar analyses. Recently (as of late 2013, before compilation of data in this review), national Spectrum files used to estimate prevalence were made available by UNAIDS through request at http://apps.unaids.org/spectrum/.

ANC data was more abundant than DHS/AIS data, which comes as no surprise due to the logistical and financial challenges of carrying out household-based surveys. However, as pointed out by Montana et al., in the cases of Ethiopia and Tanzania (Mahy, Garcia-Calleja, and Marsh 2012), and also found here in other countries (Lesotho, South Africa, and Botswana), HIV prevalence in young ANC clients aged 15-24 is higher than prevalence measured in females from DHS/AIS in the same age bracket, a chief reason being different sexual behaviors in these two groups. Also, ANC data are subject to a

number of influencers and biases, including natural and HIV/ART related fertility changes within a population and the varying composition of the surveillance sample as new sites are included in surveys. Data from DHS also carry their own unique biases such as test refusal; therefore, the sources of data available and used in the Spectrum model, along with their inherent biases, will greatly influence UNAIDS estimates, potentially in a way that may not accurately reflect incidence within the general population. It is difficult to predict in what direction these biases may affect the resulting modeled incidence trends, as the overall effect will likely be multi-factorial and change over time. However, preliminary work is being conducted to specifically investigate the effects of biases on HIV prevalence data, including underestimation of HIV prevalence due to testing refusal of survey respondents knowing their positive status.

In general, most nationally reported HIV prevalence trends within females 15-24 are in agreement with the *direction* of modeled incidence trends from Spectrum (e.g. Central African Republic, Congo, Ethiopia, Ghana, Kenya, Tanzania, Lesotho, South Africa, Zimbabwe, Botswana, and Namibia), though the *relative amount* of change may be quite different in these two data sources (e.g. Tanzania, Swaziland, Zambia), or the *timing* of changes may (e.g. Burundi and Kenya) may not match. Since ANC and DHS/AIS prevalence data inform the Spectrum model, it is not surprising that most of these trends reflect each other.

Few research trials or studies exist in which measured HIV incidence trends have been assessed over long –periods of time; most incidence rates were measured over a few years to assess the impact of an intervention or suitability of a site for an intervention trial. A consistent finding in countries with directly measured HIV incidence from trials or studies was that these empirical incidence rates were higher than the modeled UNAIDS estimates. This is likely due to such studies focusing on higher-risk demographics (ex. high-risk young women, discordant couples), or geographic areas with higher HIV transmission intensity than the national average situation. Most studies included in this review are not representative of national incidence, as very few have included more than one trial site or region within a country[5]. Trial and study sites/populations are also atypical, as they have more resources with regard to service provision and ability to implement ART scale-up and other interventions. Altogether, these findings suggest that modeled national incidence estimates are not indicative of incidence within specific demographics and/or regions. The wide range of HIV incidence levels in different demographics is well illustrated by the South African 2012 national HIV incidence estimates (Shisana et al., 2014): At 1.72% for adults aged 15.49 years, but 0.55% in young men, 2.54% in young women, 3.08% in adults cohabiting, and 4.54% in

[5] One important exception is the SHIMS study, whose directly measured incidence value of 2.4% in 2011 is in close accordance with the Spectrum incidence estimate of 2.47%. The SHIMS incidence survey was designed to be nationally representative.

Black African females aged 20-34 years (Spectrum estimate national level for 2012 at 1.37%).

In all countries included here, there has been a considerable decrease in modeled HIV incidence from peak levels, with variations in how much and at what rate this fall in modeled incidence may have occurred in different countries. Although HIV prevention progress can be assessed by a few measures of incidence reduction (percent change, value in 2012, rate of change), it is important to consider all of them on a country-by-country basis, as only using one may provide the full picture of the progress that has been made in addressing the national HIV epidemic or its current state. High or low HIV incidence rates can translate into very different number of new HIV infections depending on the countries' population sizes. Ethiopia had a very low incidence rate in 2012 (0.03%), but it still experienced an estimated 10,503 new infections that same year. Nigeria had a lower estimated incidence rate than Tanzania (0.23% vs. 0.32%), but it had nearly three times as many estimated new infections in 2012 (199,921 vs. 68,683). On the other hand, Swaziland, a much less populous country, had a high estimated incidence in 2012 (2.04%), but the number of new HIV cases in adults was much smaller at 10,287. Historical numbers of new HIV infections determine current ART needs and expenditures, while current (and future) new infections determine the additional, long-term treatment liabilities in countries.

Percent reduction of modeled incidence is another useful measure to assess progress in addressing the HIV epidemic, but it, too, cannot provide the whole picture. For example, while Ghana's modeled incidence dropped 70%, from 0.18% to 0.05%, the slope of Botswana's decline (2.23% to 1.25%) from 2004-2012 is steeper, despite a lower percent reduction in incidence (44%). Additionally, this measure is strongly influenced by its *historical* incidence data and the height of the incidence peaks in the past, which can be problematic, as different versions of Spectrum can provide varying estimated levels, resulting in different percent reductions across software versions. When comparing longitudinal incidence trends using estimates from both 2010 and 2012 Spectrum software, it was found that incidence reduction was greater for some countries using 2010 Spectrum estimates (Burkina Faso, Central African Republic, Namibia, Rwanda, South Africa, Swaziland, Zimbabwe), and greater for others (Botswana, Congo, Ghana, Kenya, Lesotho, Malawi, Mozambique, Nigeria, Tanzania, Uganda, Zambia) using 2012 Spectrum (Fig. 1 and 2). These differences in incidence reduction comparing 2012 vs 2010 Spectrum estimates are quite extreme in some cases: Ghana (56% vs 17%), Nigeria (49% vs 3%), and Uganda (39% vs 4%).

If different Spectrum versions or the addition of one more year of data into the current Spectrum software (see Annex 2) result in different incidence estimates and historical peaks, this suggests some uncertainty in past estimations and future projections of HIV incidence, and complicates the assessment of the HIV epidemic. This is especially important as UNAIDS determines national progress using modeled HIV incidence changes, categorized by increasing incidence over 25%, stable incidence (less than 25%

change in incidence, up or down), and incidence reduction greater than 25% and 50%. Additionally, variable HIV incidence data across years may over/underestimate those in need of treatment in the present and future. In some cases, recent modeled HIV incidence estimates and trends may be too optimistic. ANC data from Nigeria suggest that HIV incidence has stabilized, whereas Spectrum estimates continue to decline. Also, in cases where incidence has been directly measured in trials or studies, these values are often higher than modeled incidence (a large caveat being that many of these studies have been done in high-risk populations). Because of this potential uncertainty in Spectrum estimates and its recent trends, it will be very important in the future to continue to collect and analyze empirical incidence data, directly and indirectly measured.

Thus, it was chosen to group countries and assess overall progress in reducing incidence by the rate of change in modeled incidence between 2004 and 2012. By this measure, Botswana and Swaziland have made the most recent progress in reducing national incidence. In these cases, and the other countries with steep Spectrum modeled incidence declines (Malawi, Mozambique, Namibia, and Zambia) the downward trend in HIV incidence began prior to ART scale-up; thus, additional mechanisms are likely responsible for the reduction before and through this period. Investigation of what factors influenced the decline, including prevention programs and/or natural epidemic declines, in these countries is warranted (an analysis of epidemic, behavioral and program data to understand reasons for epidemic change in selected countries is being conducted by Imperial College London and funded by the World Bank).

Three countries in this analysis have shown very little change in, or stabilized, modeled incidence between 2004 and 2011. These countries include Burkina Faso, Burundi, and Uganda. Both Burkina Faso and Burundi support small HIV epidemics (no more than 4,502 estimated new infections in 2012) with recently low estimated incidence levels, so the stabilized trend is not as concerning compared to Uganda's large epidemic. (122,806 new estimated infections in Uganda for 2012).

A focus of this review was to describe how incidence trends changed, if at all, during ART scale-up, with the acknowledged caveat that doing so is complicated by the inclusion of ART into the Spectrum estimation process, and the resulting incidence curves cannot be interpreted to assess ART effects on national-level HIV incidence. Additionally, the extent to which ART scale-up contributed to incidence trends cannot be determined without examining the effects that other HIV prevention programs (male circumcision and voluntary counseling and testing), HIV risk behavior changes in the population, or natural epidemic dynamics, could have also had (as previously mentioned, the Imperial College analysis addresses this issue). Despite these significant limitations to our analysis, it is evident that in all countries, modeled HIV incidence had started to decline prior to ART scale-up, and in most of these cases, the steepest declines happened well before 2004. In some cases, there was very little change or even an upward trend in modeled incidence during ART scale-up (2004-2012), but the design

of this assessment is unable to determine what effect, if any, ART had on national HIV incidence trends. It is interesting to note that the inter-survey HIV incidence levels in South Africa are level at 1.9% for 2005-08 (ART coverage in the range of 20-30% [CD4 200 threshold]) and equally 1.9% for 2008-12 (ART coverage rising to 66% in 2011 [CD4 350 threshold]), hence showing no clear impact of the significant ART scale-up on model-inferred HIV incidence. While unable to conclude through this analysis, it is possible that ART might have had an influence on sustaining the downward trajectory of the epidemics in some countries.

6. CONCLUSION

The purpose of this document was to longitudinally describe and analyze HIV incidence trends in 20 Sub-Saharan African countries, using multiple sources and forms of data, empirical and modeled, and to assess how these data related to each other. It was found that modeled incidence trends are generally in congruence with nationally reported incidence proxy data from ANC and DHS/AIS reports, and both sets of data indicate that incidence has been on the decline in all countries analyzed here. However, measured incidence rates and prevalence coming from published studies and ALPHA network sites show variation from the modeled and nationally reported data, more often with higher values. A caveat is that these data come from discrete field sites and regions, and too few studies have provided temporal data across multiple sites for comparison with nationally reported data to help validate modeled HIV incidence trends. More focus should be given to efforts to longitudinally measure and monitor incidence within and across geographical areas.

This analysis also sought to investigate the dynamics of incidence trends prior to and during ART scale-up. In all countries, a downward trend in modeled incidence had begun prior to scale-up, suggesting other factors responsible for reduced incidence, such as HIV risk behavior changes or the natural rises and falls of an epidemic. While it cannot be ruled out that increased national ART coverage helped maintain downward modeled incidence trends, but concluding so was beyond the scope of this review. Furthermore, it is likely too early for the effects of ART scale-up to be observed at the population level, even for descriptive purposes, and current efforts are going into investigating what led to incidence declines prior to scale-up (previously mentioned Imperial College studies, funded by the World Bank).

In conclusion, while modeled incidence trends are encouraging and suggest a positive evolution towards lower national HIV incidence levels, maintaining this progress or rejuvenating efforts to break stagnant incidence trends will be helped with accurate and representative incidence data and a better understanding of how and why incidence began to decline within each country (and whether these declines have stabilized or continue to decline in recent years). This requires continual updates to Spectrum software based on the latest understanding of how various factors influence HIV epidemic dynamics (ART's and other interventions' effects on prevalence data and risk of transmission, biases from prevalence data, ART adherence and efficacy estimates, and changing/aging HIV+ population dynamics). Finally, increased availability and measurement of empirical HIV epidemiological data (as for instance through the ongoing TasP trials) will greatly improve the understanding of the HIV epidemic on the ground and provide further information to improve the Spectrum model.

ANNEX 1: Country and year specific incidence and prevalence data, including sources

Botswana

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	1.95	-
1991	-	-	2.77	-
1992	-	-	3.73	-
1993	-	-	4.65	-
1994	-	-	5.35	-
1995	-	-	5.75	-
1996	-	-	5.73	-
1997	-	-	5.50	-
1998	-	-	5.01	-
1999	-	-	4.42	-
2000	-	-	3.85	-
2001	35.1	-	3.35	-
2002	31.6	-	2.94	-
2003	32.5	-	2.56	-
2004	-	18.2	2.23	44
2005	26.1	-	1.98	64
2006	25.0	-	1.85	76
2007	24.6	-	1.74	79
2008	-	10.7	1.72	-
2009	20.8	-	1.59	90
2010	-	-	1.38	93
2011	16.1	-	1.30	>95
2012	-	-	1.25	95

ANC data sources: Botswana Second Generation HIV/AIDS Antenatal Sentinel Surveillance Technical Report 2009 and 2011

National DHS and AIS data sources: Botswana AIDS Impact Survey 2004 and 2008

Burkina Faso

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	0.73	-
1991	-	-	0.70	-
1992	-	-	0.65	-
1993	-	-	0.56	-
1994	-	-	0.45	-
1995	-	-	0.35	-
1996	-	-	0.27	-
1997	-	-	0.20	-
1998	-	-	0.14	-
1999	-	-	0.10	-
2000	-	-	0.07	-
2001	-	-	0.06	-
2002	-	-	0.06	-
2003	1.9	1.3	0.06	-
2004	1.5	-	0.06	7
2005	1.4	-	0.06	19
2006	1.0	-	0.06	31
2007	1.3	-	0.06	35
2008	0.4	-	0.07	-
2009	1.3	-	0.06	44
2010	0.7	0.3	0.07	50
2011	-	-	0.06	57
2012	-	-	0.05	70

ANC data sources: Burkina Faso UNGASS Report 2008 and Burkina Faso GARPR 2012

National DHS and AIS data sources: Burkina Faso DHS 2005 and 2010

Burundi

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	0.61	-
1991	-	-	0.77	-
1992	-	-	0.90	-
1993	-	-	0.95	-
1994	-	-	0.87	-
1995	-	-	0.71	-
1996	-	-	0.51	-
1997	-	-	0.34	-
1998	-	-	0.17	-
1999	-	-	0.11	-
2000	7.1	-	0.07	-
2001	-	-	0.06	-
2002	-	3.8	0.06	-
2003	3.9	-	0.08	-
2004	-	-	0.09	6
2005	-	-	0.09	13
2006	-	-	0.09	17
2007	-	-	0.10	23
2008	-	-	0.10	-
2009	1.3	-	0.08	35
2010	0.8	0.8	0.08	45
2011	-	-	0.08	54
2012	-	-	0.06	58

ANC data sources: HIV and AIDS epidemiological surveillance report for the WHO African region: 2007 update, Burundi UNGASS Report 2010, Burundi Bilan des Realisation du Plan d'Action National de Lutte contre le SIDA 2011

National DHS and AIS data sources: Burundi HH 2002 and DHS 2010

Central African Republic

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	1.18	-
1991	-	-	1.17	-
1992	-	-	1.18	-
1993	-	-	1.17	-
1994	-	-	1.15	-
1995	-	-	1.13	-
1996	-	-	1.07	-
1997	-	-	1.00	-
1998	-	-	0.91	-
1999	-	-	0.81	-
2000	-	-	0.74	-
2001	-	-	0.67	-
2002	-	-	0.62	-
2003	-	-	0.58	-
2004	-	-	0.53	3
2005	-	-	0.48	4
2006	-	-	0.44	6
2007	8.21	-	0.40	21
2008	-	-	0.37	-
2009	7.22	-	0.34	23
2010	-	-	0.32	24
2011	4.83	-	0.29	22

ANC data sources: Central African Republic UNGASS Report 2008 and 2010, Comite National de Lutte Contre le SIDA 2012 Rapport d'Activite au Niveau du Pays Republique Centrafricaine

Congo

	Prevalence among females 15-24 (%)		Spectrum estimates		
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)	Indicator 1.6 - HIV prevalence in young people 15-24 (%)
1990	-	-	0.81	-	-
1991	-	-	0.84	-	-
1992	-	-	0.81	-	-
1993	-	-	0.82	-	-
1994	-	-	0.76	-	-
1995	-	-	0.71	-	-
1996	-	-	0.66	-	-
1997	-	-	0.62	-	-
1998	-	-	0.54	-	-
1999	-	-	0.53	-	-
2000	-	-	0.49	-	-
2001	-	-	0.44	-	-
2002	-	-	0.39	-	-
2003	-	-	0.36	-	-
2004	-	-	0.34	2	-
2005	2.6	-	0.31	11	-
2006	-	-	0.29	12	-
2007	-	-	0.27	17	2.6
2008	-	-	0.26	-	-
2009	-	2.4	0.24	24	1.9
2010	-	-	0.21	41	-
2011	-	-	0.18	44	1.79
2012	-	-	0.16	39	-

ANC data source: Congo UNGASS Report 2008

National DHS and AIS data source: Congo AIS 2009

Ethiopia

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	0.36	-
1991	-	-	0.44	-
1992	-	-	0.52	-
1993	-	-	0.55	-
1994	-	-	0.56	-
1995	-	-	0.56	-
1996	-	-	0.54	-
1997	-	-	0.51	-
1998	-	-	0.46	-
1999	-	-	0.41	-
2000	-	-	0.35	-
2001	12.4	-	0.29	-
2002	11.0	-	0.22	-
2003	8.6	-	0.15	-
2004	-	-	0.11	4
2005	5.6	1.1	0.08	7
2006	-	-	0.06	18
2007	3.5	-	0.04	29
2008	-	-	0.04	-
2009	2.6	-	0.03	36
2010	-	-	0.03	47
2011	-	0.5	0.02	56
2012	-	-	0.03	60

ANC data source: Report on the 2009 Round Antenatal Care Sentinel HIV Surveillance in Ethiopia

National DHS and AIS data sources: Ethiopia DHS 2005 and 2011

Ghana

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	0.22	-
1991	-	-	0.25	-
1992	-	-	0.29	-
1993	-	-	0.34	-
1994	-	-	0.36	-
1995	-	-	0.37	-
1996	-	-	0.37	-
1997	-	-	0.34	-
1998	-	-	0.31	-
1999	-	-	0.28	-
2000	-	-	0.25	-
2001	-	-	0.23	-
2002	3.8	-	0.20	-
2003	3.2	1.2	0.18	-
2004	2.5	-	0.17	3
2005	1.9	-	0.15	5
2006	2.5	-	0.14	12
2007	2.6	-	0.13	15
2008	1.9	-	0.11	-
2009	2.1	-	0.10	28
2010	1.5	-	0.08	36
2011	1.7	-	0.07	47
2012	-	-	0.05	58

ANC data sources: Ghana HIV Sentinel Survey Report 2007, Ghana UNGASS Report 2008, Ghana Country AIDS Progress Report 2012

National DHS and AIS data source: Ghana DHS 2003

Study reference	Incidence rate/100 person years	Time frame of study	Study/Trial population	Region
Peterson et al., PLoS One 2007	1.09	2004-2006	Women in microbicide trial	Kumasi and Accra

Kenya

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	1.07	-
1991	-	-	1.53	-
1992	-	-	1.99	-
1993	-	-	2.24	-
1994	-	-	2.15	-
1995	-	-	1.80	-
1996	-	-	1.40	-
1997	-	-	1.07	-
1998	-	-	0.84	-
1999	-	-	0.70	-
2000	18.0	-	0.72	-
2001	13.1	-	0.66	-
2002	10.8	-	0.61	-
2003	9.1	5.9	0.58	-
2004	6.2	-	0.54	6
2005	6.8	-	0.52	14
2006	5.6	-	0.51	27
2007	-	-	0.52	38
2008	5.7	-	0.53	-
2009	-	4.5	0.49	51
2010	4.6	-	0.46	61
2011	-	-	0.44	72
2012	-	-	0.41	73

ANC data sources: Sentinel Surveillance of HIV & STDS in Kenya Report 2006 and Sentinel Surveillance of HIV & Syphilis from Antenatal Clinics in Kenya Report 2010

National DHS and AIS data sources: Kenya DHS 2003 and 2008-2009

Study reference	Prevalence among females 15-24 (%)	Incidence rate/100 person years	Time frame of study	Study/Trial population	Region
Brubaker et al., HIV Med 2011		4.6	2005-2007	Discordant couples	Kisumu
Chege et al., J Infect Dev Ctries 2012	17.24 (18-24)		2007-2008	Adult general population	Kisumu
Van Damme, NEJM 2012		4.7	2009-2011	PrEP among women 18-35 (control)	Bondo
Baeten et al., NEJM 2012		1.9	2008-2010	PrEP in discordant couples (placebo)	Eldoret, Kisumu, Nairobi, Thika

ALPHA network study

Lesotho

	Prevalence among females 15-24 (%)		Spectrum estimates		Indicator 1.6 - HIV prevalence in young people 15-24 (%)
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)	
1990	-	-	0.49	-	-
1991	-	-	0.93	-	-
1992	-	-	1.62	-	-
1993	-	-	2.52	-	-
1994	-	-	3.57	-	-
1995	-	-	4.46	-	-
1996	-	-	4.98	-	-
1997	-	-	5.04	-	-
1998	-	-	4.72	-	-
1999	-	-	4.20	-	-
2000	21.7	-	3.75	-	-
2001	-	-	3.32	-	-
2002	-	-	2.95	-	-
2003	24.2	-	2.77	-	-
2004	-	15.4	2.66	4	-
2005	20.5	-	2.66	11	-
2006	-	-	2.67	22	-
2007	18.7	-	2.77	26	18.7
2008	-	-	2.85	-	-
2009	-	13.6	2.69	50	19.6
2010	-	-	2.38	56	-
2011	-	-	2.26	58	16.88
2012	-	-	2.26	54	-

ANC data sources: Lesotho ANC HIV and Syphilis Sentinel Surveillance Synopsis 2003, 2005, and 2007

National DHS or AIS data sources: Lesotho DHS 2004 and 2009

Malawi

	Prevalence among females 15-24 (%)		Spectrum estimates		Indicator 1.6 - HIV prevalence in young people 15-24 (%)
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)	
1990	-	-	2.36	-	-
1991	-	-	2.44	-	-
1992	-	-	2.45	-	-
1993	-	-	2.49	-	-
1994	-	-	2.51	-	-
1995	-	-	2.48	-	-
1996	-	-	2.41	-	-
1997	-	-	2.30	-	-
1998	-	-	1.85	-	-
1999	-	-	2.03	-	-
2000	-	-	1.91	-	-
2001	9.3	-	1.76	-	-
2002	-	-	1.63	-	-
2003	18.3	-	1.49	-	-
2004	-	9.1	1.37	5	-
2005	14.3	-	1.25	11	-
2006	-	-	1.15	21	-
2007	12.3	-	1.04	35	12.3
2008	-	-	0.79	-	-
2009	-	-	0.88	47	12.3
2010	-	5.2	0.82	54	-
2011	-	-	0.79	67	8.21
2012	-	-	0.77	69	-

ANC data source: Malawi HIV and Syphilis Sero–Survey and National HIV Prevalence and AIDS Estimates Report for 2007

National DHS or AIS data sources: Malawi DHS 2004 and 2010

Malawi

	Prevalence among females 15-24 (%)	Incidence rate/100 person years	Time frame of study	Study/Trial population	Region
Crampin *et al.*, AIDS 2003	8.9 (ANC), 11.4 (general population)		1998-2001	Women from antenatal clinics and studies of mycobacterial disease (control)	Karonga
Kumwenda et al., Sex Transm Dis 2006		4.86	1999-2001	Women from postnatal or family planning clinics	Blantyre
Kumwenda et al., Sex Transm Dis 2006		4.2	1999-2001	Women from postnatal or family planning clinics	Lilongwe
Crampin et al., J Acquir Immune Defic Syndr 2008	8.8 (1999-2001), 6.0 (2002-2004)		1999-2004	Women from antenatal clinics	Karonga
Abdool et al., AIDS 2011		1.78	2005-2009	Women in microbicide study (control)	Lilongwe
Abdool et al., AIDS 2011		4.9	2005-2009	Women in microbicide study (control)	Blantyre
Keating et al., PLoS One 2011		4	2009	Pregnant women Lilongwe	Lilongwe

ALPHA network study

Mozambique

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	0.27	-
1991	-	-	0.38	-
1992	-	-	0.49	-
1993	-	-	0.61	-
1994	-	-	0.74	-
1995	-	-	0.90	-
1996	-	-	1.09	-
1997	-	-	1.29	-
1998	-	-	1.50	-
1999	-	-	1.67	-
2000	-	-	1.79	-
2001	12.5	-	1.83	-
2002	13.1	-	1.83	-
2003	-	-	1.74	-
2004	15.6	-	1.64	3
2005	-	-	1.52	7
2006	-	-	1.39	12
2007	11.3	-	1.29	24
2008	-	-	1.19	-
2009	12.0	11.1	1.13	34
2010	-	-	1.09	41
2011	-	-	1.02	46
2012	-	-	1.03	45

ANC data sources: Mozambique 2012 GARPR

National DHS or AIS data source: Mozambique AIS 2009

Namibia

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	0.49	-
1991	-	-	0.72	-
1992	-	-	1.02	-
1993	-	-	1.39	-
1994	-	-	1.78	-
1995	-	-	2.15	-
1996	-	-	2.44	-
1997	-	-	2.64	-
1998	-	-	2.70	-
1999	-	-	2.64	-
2000	-	-	2.50	-
2001	-	-	2.29	-
2002	-	-	2.03	-
2003	-	-	1.78	-
2004	15.2	-	1.53	22
2005	-	-	1.31	62
2006	14.2	-	1.12	64
2007	-	-	0.96	88
2008	10.6	-	0.88	-
2009	-	-	0.81	78
2010	10.3	-	0.78	90
2011	-	-	0.82	>95
2012	-	-	0.81	90

ANC data source: Namibia UNGASS Report 2010

	Incidence rate/100 person years	Time frame of study	Study/Trial population	Region
Aulagnier et al., PLoS One 2011	2.4	2007-2009	Adult general population	Windhoek

ALPHA network study

Nigeria

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	0.22	-
1991	-	-	0.26	-
1992	-	-	0.30	-
1993	-	-	0.34	-
1994	-	-	0.39	-
1995	-	-	0.43	-
1996	-	-	0.48	-
1997	-	-	0.51	-
1998	-	-	0.53	-
1999	-	-	0.56	-
2000	-	-	0.55	-
2001	6.0	-	0.54	-
2002	-	-	0.51	-
2003	5.3	-	0.49	-
2004	-	-	0.45	2
2005	4.3	-	0.40	6
2006	-	-	0.37	13
2007	-	-	0.34	26
2008	4.2	-	0.31	-
2009	-	-	0.28	25
2010	4.1	-	0.27	27
2011	-	-	0.26	30
2012	-	-	0.23	32

ANC data source: 2010 Nigeria National HIV Sero-prevalence Sentinel Survey

Rwanda

	Prevalence among females 15-24 (%)		Spectrum estimates		Indicator 1.6 - HIV prevalence in young people 15-24 (%)
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)	
1990	-	-	0.92	-	-
1991	-	-	0.96	-	-
1992	-	-	0.87	-	-
1993	-	-	0.76	-	-
1994	-	-	0.67	-	-
1995	-	-	0.60	-	-
1996	-	-	0.57	-	-
1997	-	-	0.51	-	-
1998	-	-	0.45	-	-
1999	-	-	0.39	-	-
2000	-	-	0.34	-	-
2001	-	-	0.27	-	-
2002	-	-	0.25	-	-
2003	-	-	0.23	-	-
2004	-	-	0.22	10	-
2005	-	1.5	0.21	29	-
2006	-	-	0.18	52	-
2007	-	-	0.17	71	3.5
2008	-	-	0.18	-	-
2009	-	-	0.16	77	3.7
2010	-	1.5	0.13	84	-
2011	-	-	0.13	82	1.86
2012	-	-	0.13	87	-

National DHS or AIS data sources: Rwanda DHS 2005 and 2010/2011

Study reference	Incidence rate/100 person years	Time frame of study	Study/Trial population	Region
Braunstein et al., Sex Transm Dis 2011	3.5 (2006-2007), 2.1 (2007-2008)	2006-2008	Female sex workers	-

South Africa

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	0.15	-
1991	-	-	0.30	-
1992	-	-	0.55	-
1993	-	-	0.93	-
1994	-	-	1.41	-
1995	-	-	1.93	-
1996	-	-	2.40	-
1997	-	-	2.72	-
1998	-	-	2.85	-
1999	-	-	2.81	-
2000	-	-	2.67	-
2001	23.1	-	2.49	-
2002	23.5	-	2.26	-
2003	24.8	-	2.09	-
2004	25.1	-	1.96	4
2005	24.9	16.9	1.85	15
2006	22.4	-	1.79	21
2007	22.1	-	1.73	28
2008	21.7	13.9	1.72	-
2009	21.7	-	1.75	42
2010	21.8	-	1.78	57
2011	20.5	-	1.72	66
2012	-	-	1.37	80

ANC data sources: The 2011 National Antenatal Sentinel HIV & Syphilis Prevalence Survey in South Africa, The 2010 National Antenatal Sentinel HIV & Syphilis Prevalence Survey in South Africa

National DHS or AIS data sources: South African National HIV Prevalence, HIV Incidence, Behaviour and Communication Survey 2005 and 2008

South Africa

Study reference	Prevalance in young females (%)	Incidence rate/100 person years	Time frame of study	Study/Trial population	Region
Coleman et al., J Acquir Immune Defic Syndr Hum Retrovirol 1997	6.3 (1992), 9.7 (1993), 14 (1995)		1992-1995	Women from antenatal clinics	Hlabisa, Durban
Auvert et al., PLoS Med 2005		2.11	2002-2004	Young men (18-24) in circumcision trial	Orange Farm and surrounding areas
Jewkes et al., BMJ 2008		4.07	2003-2004	Young adults (15-26) in intervention trial (control)	Eastern Cape
Mavedzenge et al., J Acquir Immune Defic Syndr 2011		6.75	2003-2005	Women in prevention trial	Durban
Mavedzenge et al., J Acquir Immune Defic Syndr 2011		3.33	2003-2005	Women in prevention trial	Johannesburg
Ramjee et al., J Acquir Immune Defic Syndr 2008	39.2 (18-25)	5	2003-2005	Women in preparatory study for microbicide trial	Durban
Ramjee et al., J Acquir Immune Defic Syndr 2008	36.8 (18-25)	6	2003-2005	Women in preparatory study for microbicide trial	Hlabisa
Rice et al., BMC Public Health 2007	30.3 (ANC), 15.2 (general population)		2005	Women from antenatal clinics and in general population	Hlabisa
Moodley et al., AIDS 2009		10.7	2006-2007	Pregnant women	Mpumalanga, Eastern Cape and Free State
Abdool et al., AIDS 2011		3.82	2005-2009	Women in microbicide study (control)	Durban
Abdool et al., AIDS 2011		11.5	2005-2009	Women in microbicide study (control)	Hlabisa
Nel et al., PLoS One 2012		14.8	2007-2009	Non pregrant women (18-35)	Ladysmith
Nel et al., PLoS One 2012		6.3	2007-2009	Non pregrant women (18-35)	Edendale
Nel et al., PLoS One 2012		7.2	2007-2009	Non pregrant women (18-35)	Pinetown
Abdool et al., Science 2010		9.1	2007-2010	Women in microbicide trial (placebo)	KwaZulu-Natal
Van Damme, NEJM 2012		3.4	2009-2011	PrEP among women 18-35 (control)	Bloemfontein
Van Damme, NEJM 2012		6	2009-2011	PrEP among women 18-35 (control)	Praetoria
Gómez-Olivé et al. AIDS Care 2013	18.40		2010-2011	Adult general population	Ehlanseni

ALPHA network study

South African National HIV Incidence, Prevalence, and Behaviour Survey, 2012, Data and Estimates

			HIV Incidence (%)		
	Survey Year or Inter-Survey Period	**Age Group and Demographic**		**95% Confidence Interval (Low)**	**95% Confidence Interval (High)**
Modeled	**2002–2005**	**Total 15–49**	2.20	0.90	4.00
		Males 15-49	1.20	0.10	3.00
		Females 15-49	3.20	1.80	5.00
		Total 15–24	2.80	1.70	4.20
		Males 15-24	0.60	0.10	1.60
		Females 15-24	5.30	3.60	7.10
	2005–2008	**Total 15–49**	1.90	0.80	3.30
		Males 15-49	1.60	0.60	3.00
		Females 15-49	2.20	1.00	3.60
		Total 15–24	2.30	1.20	3.50
		Males 15-24	1.40	0.50	2.30
		Females 15-24	3.50	2.10	4.90
	2008–2012	**Total 15–49**	1.90	0.80	3.10
		Males 15-49	1.60	0.60	2.70
		Females 15-49	2.10	1.00	3.40
		Total 15–24	1.50	0.80	2.30
		Males 15-24	1.00	0.40	1.60
		Females 15-24	2.10	1.20	3.10
Direct Measurement	**2012**	**Total 15–49**	1.72	1.38	2.06
		Males 15-49	1.21	0.97	1.45
		Females 15-49	2.28	1.84	2.74
		Total 15–24	1.49	1.21	1.88
		Males 15-24	0.55	0.45	0.65
		Females 15-24	2.54	2.04	3.04

Swaziland

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	0.54	-
1991	-	-	1.16	-
1992	-	-	2.12	-
1993	-	-	3.27	-
1994	-	-	4.30	-
1995	-	-	4.92	-
1996	-	-	5.07	-
1997	-	-	4.84	-
1998	-	-	4.45	-
1999	-	-	4.07	-
2000	35.4	-	3.75	-
2001	-	-	3.48	-
2002	39.4	-	3.36	-
2003	-	-	3.27	-
2004	39.4	-	3.29	14
2005	-	-	3.21	27
2006	34.6	-	3.03	35
2007	-	22.7	2.85	42
2008	38.1	-	2.74	-
2009	-	-	2.57	64
2010	34.7	-	2.50	73
2011	34.0	-	2.47	83
2012	-	-	2.04	82

ANC data source: Swaziland Country Report on Monitoring the Political Declaration on HIV/AIDS 2012

National DHS and AIS data source: Swaziland DHS 2006-2007

Tanzania

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	1.25	-
1991	-	-	1.33	-
1992	-	-	1.34	-
1993	-	-	1.29	-
1994	-	-	1.21	-
1995	-	-	1.08	-
1996	-	-	0.97	-
1997	-	-	0.87	-
1998	-	-	0.76	-
1999	-	-	0.71	-
2000	-	-	0.64	-
2001	-	-	0.59	-
2002	-	-	0.55	-
2003	-	-	0.53	-
2004	7.4	4.0	0.50	<1
2005	-	-	0.48	5
2006	6.8	-	0.46	14
2007	-	-	0.42	31
2008	5.3	3.6	0.40	-
2009	-	-	0.38	32
2010	-	-	0.34	38
2011	-	-	0.34	40
2012	-	-	0.32	61

ANC data sources: Tanzania Surveillance of HIV and Syphilis Infections Among Antenatal Clinic Attendees 2003/4, 2005/06, 2008

National DHS and AIS data sources: Tanzania AIS 2003-2004, Tanzania AIS/Malaria Indicator Survey 2007-2008 and 2011-2012

Tanzania

	Prevalence among females 15-24 (%)	Incidence rate/100 person years	Time frame of study	Study/Trial population	Region
Boerma et al., Sex Transm Dis 2003	5.32		1996-1997	Adult general population	Kisesa
Wambura et al., J Acquir Immune Defic Syndr 2007		.81 (1994-1997) 1.24 (1996-2000) 1.13 (1999-2004)	1994-2003	Adult general population	Kisesa
Bloom et al., Sex Transm Infect 2002	5.4 (1994-1995)	0.84 Females (1996-1997), 0.73 Males (1996-1997)	1994-1995, 1996-1997	Adult general population	Kisesa
Ramjee et al., J Acquir Immune Defic Syndr 2008	11 (Baseline Prevalence 18-25)	1.3	2003-2005	Women in preparatory study for microbicide trial	Moshi
Geis et al., J Acquir Immune Defic Syndr 2011		1.35	2002-2006	Adult general population	Mbeya
Watson-Jones et al., NEJM 2008		4.12	2004-2006	HSV-2+ women from STD treatment trial (placebo)	North-western Tanzania
Munseri et al., BMC Public Health 2013		0.85	2007-2008	Police officers	Dar es Salaam
Kapiga et al., PLoS One, 2013		3.7	2008-2010	Women working in food and recreational facilities	Northern Tanzania

ALPHA network study

Uganda

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	2.71	-
1991	-	-	2.06	-
1992	-	-	1.48	-
1993	-	-	1.01	-
1994	-	-	0.73	-
1995	-	-	0.55	-
1996	-	-	0.44	-
1997	-	-	0.47	-
1998	-	-	0.51	-
1999	-	-	0.55	-
2000	-	-	0.62	-
2001	-	-	0.64	-
2002	-	-	0.67	-
2003	-	-	0.73	-
2004	-	-	0.75	12
2005	-	4.3	0.79	21
2006	-	-	0.84	27
2007	-	-	0.90	33
2008	-	-	0.90	-
2009	-	-	0.89	41
2010	-	-	0.87	45
2011	-	4.9	0.83	54
2012	-	-	0.77	64

National DHS and AIS data sources: Uganda HIV/AIDS Sero-behavioural survey 2004-2005, Uganda AIS 2011

Uganda

Study reference	Prevalence among females 15-24 (%)	Incidence rate/100 person years	Time frame of study	Study/Trial population	Region
Ahmed et al., AIDS 2001		1.71	1994-1998	Community HIV prevention trial	Rakai
Mulder et al., BMJ 1995	Ages 13-24: 9.9 (1989), 7.3 (1994)	0.73 (1989-1991), 0.71 (1992-1994)	1989-1994	Adult general population	Masaka
Wawer et al., AIDS 1997	Adults 15-24: 20.6 (1990), 16.45 (1992)	2.1 (1990-1991), 2 (1991-1992)	1990-1992	Adult general population	Rakai
Kengeya-Kayondo et al., Int J Epidemiol 1996		0.82 (1990), 0.69 (1991), 0.57 (1992), 0.89 (1993), 0.45 (1994)	1990-1994	Adult general population	Masaka
Arroyo et al., J Acquir Immune Defic Syndr 2006		Ages 14-90: 1.27	1999-2002	Adult general population	Rakai
Brown et al., AIDS 2007		1.6	1999-2004	Women 18-35	Kampala
Gray et al., Lancet 2007		1.33	2004-2006	Control men in circumcision trial	Rakai
Tobian et al., AIDS 2009		1.09	2004-2006	Men undergoing circumcision	Rakai
Ruzagira et al., PLoS ONE 2011	Ages 18-24: 10.3 (2004)	1.04	2004-2007	Adult general population	Masaka
Guwatudde et al., PLoS ONE 2009	Adults 15-24: 5.8	0.77	2006-2007	Adult general population	Kayunga
Seeley et al., Sex Transm Dis 2012		4.9	2009- 2011	Fishing communities	Lake Victoria
Baeten et al., NEJM 2012		2.07	2008-2011	PrEP in discordant couples (placebo group)	Jinja, Kabwoh, Kampala, Mbale, Tororo

ALPHA network study

Zambia

	Prevalence among females 15-24 (%)		Spectrum estimates		Indicator 1.6 - HIV prevalence in young people 15-24 (%)
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)	
1990	-	-	2.50	-	-
1991	-	-	2.53	-	-
1992	-	-	2.59	-	-
1993	-	-	2.51	-	-
1994	-	-	2.43	-	-
1995	-	-	2.33	-	-
1996	-	-	2.23	-	-
1997	-	-	2.10	-	-
1998	-	-	1.98	-	-
1999	-	-	1.88	-	-
2000	-	-	1.79	-	-
2001	-	-	1.75	-	-
2002	16.3	11.1	1.66	-	-
2003	-	-	1.59	-	-
2004	11.5	-	1.49	7	-
2005	-	-	1.38	16	-
2006	14.6	-	1.35	26	-
2007	15.6	8.5	1.27	46	16.8
2008	-	-	1.15	-	-
2009	-	-	1.02	81	13.8
2010	-	-	0.99	72	-
2011	-	-	0.96	82	-
2012	-	-	0.79	79	-

ANC data sources: Zambia UNGASS Report 2008, Zambia Country Report: Monitoring the Declaration of Commitment on HIV and AIDS and the Universal Access 2010, ANC Sentinel Surveillance of HIV/Syphilis trends in Zambia 1994-2002
National DHS and AIS data sources: Zambia DHS 2001-2002 and 2007

Zambia

Study reference	Incidence rate/100 person years	Time frame of study	Study/Trial population	Region
Abdool et al., AIDS 2011	3.57	2005-2009	Women in microbicide study (control)	Lusaka

Zimbabwe

	Prevalence among females 15-24 (%)		Spectrum estimates	
	National Antenatal Sentinel Surveillance Surveys	National Demographic and Health or AIDS Impact Surveys	Incidence in adults 15-49 (%)	Antiretroviral coverage (%)
1990	-	-	4.03	-
1991	-	-	4.89	-
1992	-	-	5.49	-
1993	-	-	5.84	-
1994	-	-	5.78	-
1995	-	-	5.47	-
1996	-	-	4.86	-
1997	-	-	4.16	-
1998	-	-	3.48	-
1999	-	-	2.87	-
2000	29.0	-	2.38	-
2001	25.2	-	1.98	-
2002	20.8	-	1.72	-
2003	-	-	1.56	-
2004	17.4	-	1.45	1
2005	-	-	1.35	4
2006	12.5	10.9	1.31	11
2007	-	-	1.29	18
2008	-	-	1.28	-
2009	11.6	-	1.25	37
2010	-	-	1.22	54
2011	-	7.3	1.16	77
2012	-	-	0.96	79

ANC data sources: Zimbabwe UNGASS Report 2008, Zimbabwe GARPR 2012

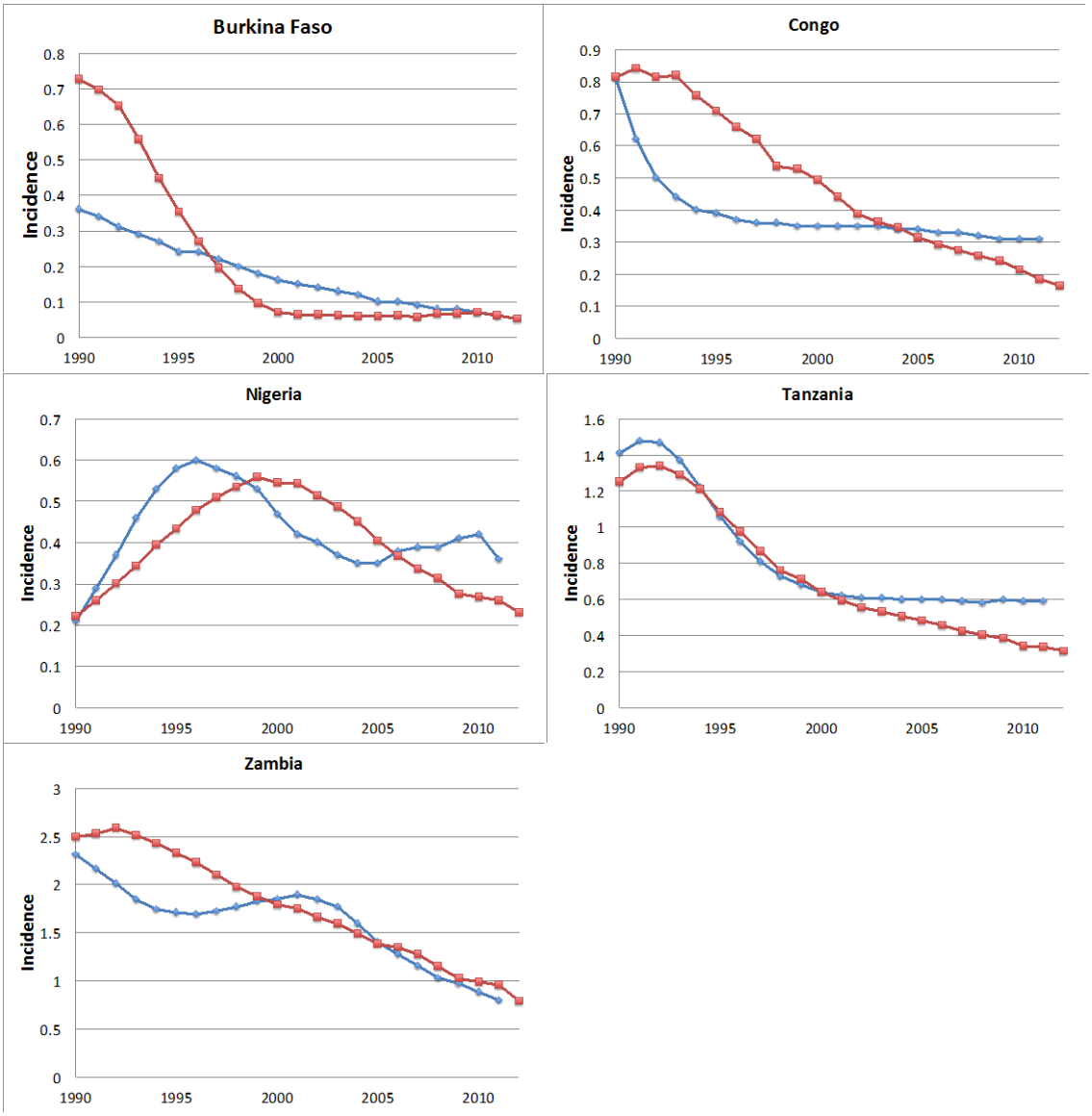
National DHS or AIS data sources: Zimbabwe DHS 2005-2006 and 2010-2011

Study reference	Prevalence among females 15-24 (%)	Incidence rate/100 person years	Time frame of study	Study/Trial population	Region
Gregson et al., AIDS 1997	Ages 15-29: 21.8		1993-1994	Adult general population	Manicaland
Boerma et al., Sex Transm Dis 2003	11.67		1998-2000	Adult general population	Manicaland
Kumwenda et al., Sex Transm Dis 2006		4.78	1999-2001	Women attending postnatal or family planning clinics	Harare
Brown et al., AIDS 2007		4.1	1999-2004	Women (18-35)	Harare and Chitungwiza
Marsh et al., J Int AIDS Soc 2011			1998-2005	Women from antenatal clinics and in general population	Manicaland
Corbett et al., AIDS 2007		1.2	2002-2004	Employees from businesses included in VCT study	Harare
Mavedzenge et al., J Acquir Immune Defic Syndr 2011		2.72	2003-2005	Women in prevention trial	Harare
Abdool et al., AIDS 2011		2.71	2005-2009	Women in microbicide study (control)	Harare
Abdool et al., AIDS 2011		3.29	2005-2009	Women in microbicide study (control)	Chitungwiza

ALPHA network study

ANNEX 2: Changes to Spectrum data curves from 2012 to 2013

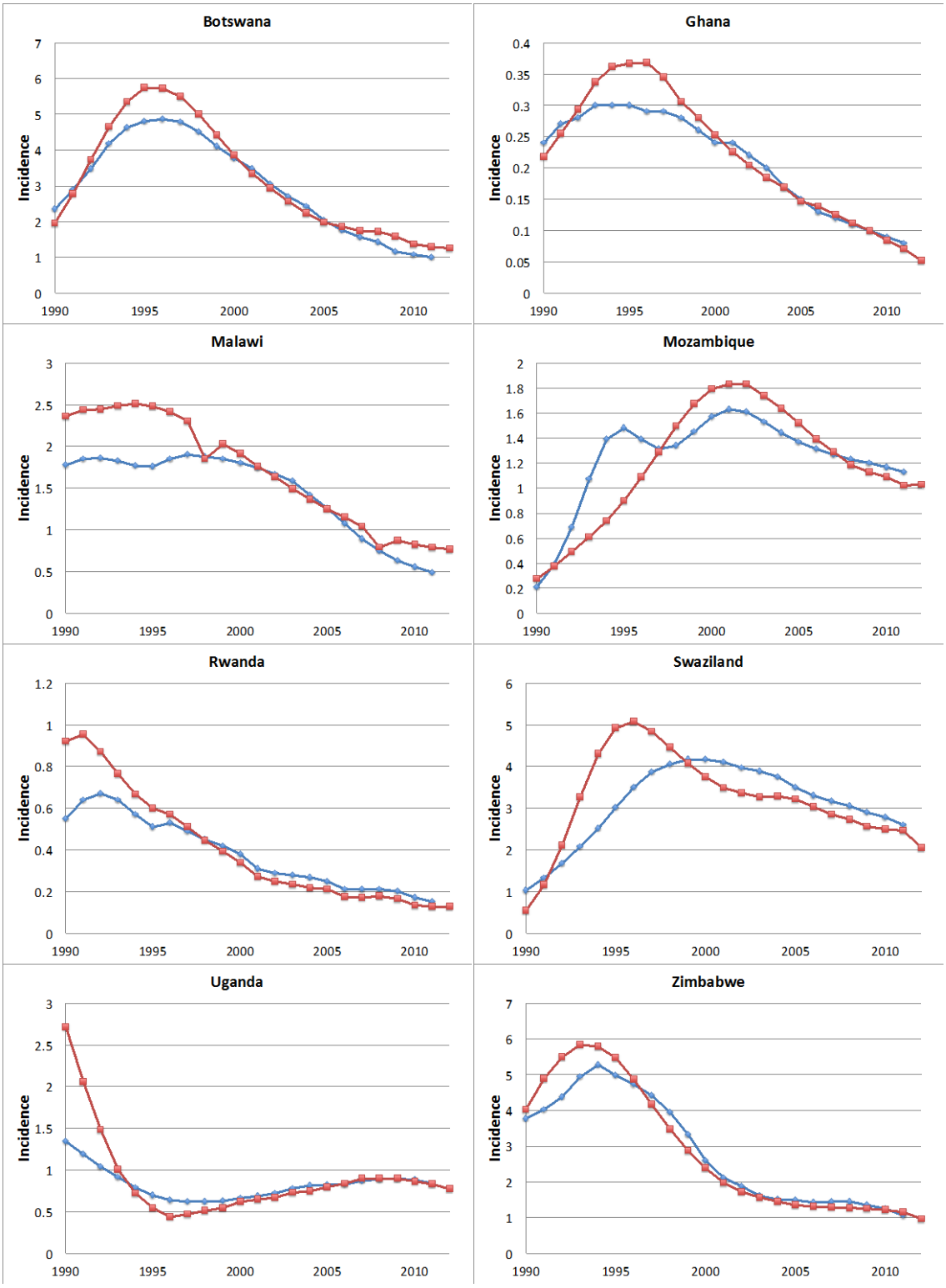
2013 Spectrum data changes shape of curve



Incidence (%), adults 15-49 (source: UNAIDS Global Report on HIV/AIDS, 2012)

Incidence (%), adults 15-49 (source: UNAIDS Global Report on HIV/AIDS, 2013)

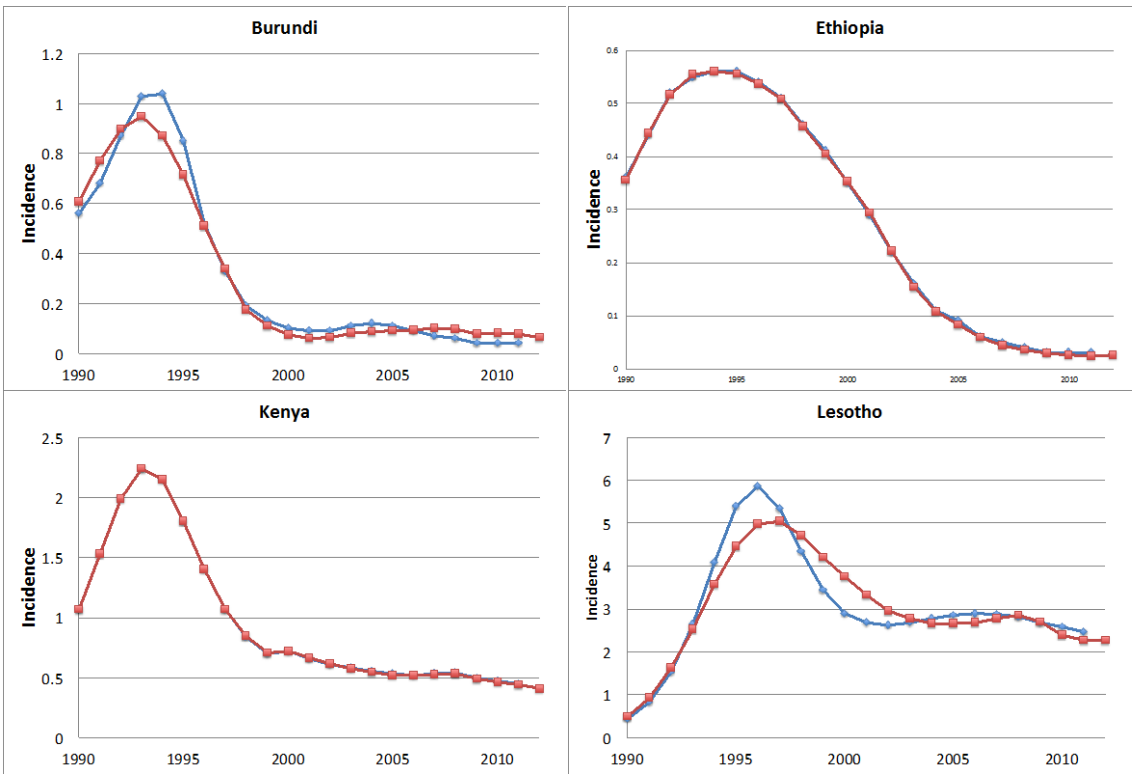
2013 Spectrum estimates generate higher incidence peaks



Incidence (%), adults 15-49 (source: UNAIDS Global Report on HIV/AIDS, 2012)

Incidence (%), adults 15-49 (source: UNAIDS Global Report on HIV/AIDS, 2013)

Very little difference between 2012 and 2013 Spectrum data:



Incidence (%), adults 15-49 (source: UNAIDS Global Report on HIV/AIDS, 2012)

Incidence (%), adults 15-49 (source: UNAIDS Global Report on HIV/AIDS, 2013)

REFERENCES

Abdool Karim, Quarraisha, Salim S. Abdool Karim, Janet A. Frohlich, Anneke C. Grobler, Cheryl Baxter, Leila E. Mansoor, Ayesha B. M. Kharsany, Sengeziwe Sibeko, Koleka P. Mlisana, Zaheen Omar, Tanuja N. Gengiah, Silvia Maarschalk, Natasha Arulappan, Mukelisiwe Mlotshwa, Lynn Morris, Douglas Taylor, and on behalf of the CAPRISA 004 Trial Group. 2010. 'Effectiveness and Safety of Tenofovir Gel, an Antiretroviral Microbicide, for the Prevention of HIV Infection in Women', *Science*, 329: 1168-74.

Abdool Karim, S. S., B. A. Richardson, G. Ramjee, I. F. Hoffman, Z. M. Chirenje, T. Taha, M. Kapina, L. Maslankowski, A. Coletti, A. Profy, T. R. Moench, E. Piwowar-Manning, B. Masse, S. L. Hillier, L. Soto-Torres, and H. I. V. Prevention Trials Network 035 Study Team. 2011. 'Safety and effectiveness of BufferGel and 0.5% PRO2000 gel for the prevention of HIV infection in women', *AIDS*, 25: 957-66.

Ahmed, S., T. Lutalo, M. Wawer, D. Serwadda, N. K. Sewankambo, F. Nalugoda, F. Makumbi, F. Wabwire-Mangen, N. Kiwanuka, G. Kigozi, M. Kiddugavu, and R. Gray. 2001. 'HIV incidence and sexually transmitted disease prevalence associated with condom use: a population study in Rakai, Uganda', *AIDS*, 15: 2171-9.

Arroyo, M. A., W. B. Sateren, D. Serwadda, R. H. Gray, M. J. Wawer, N. K. Sewankambo, N. Kiwanuka, G. Kigozi, F. Wabwire-Mangen, M. Eller, L. A. Eller, D. L. Birx, M. L. Robb, and F. E. McCutchan. 2006. 'Higher HIV-1 incidence and genetic complexity along main roads in Rakai District, Uganda', *J Acquir Immune Defic Syndr*, 43: 440-5.

Assembly, United Nations General. 2012. "Report of the Secretary-General: United to End AIDS: Achieving the Targets of the 2011 Political Declaration." In.

Aulagnier, M., W. Janssens, I. De Beer, G. van Rooy, E. Gaeb, C. Hesp, J. van der Gaag, and T. F. Rinke de Wit. 2011. 'Incidence of HIV in Windhoek, Namibia: demographic and socio-economic associations', *PLoS One*, 6: e25860.

Auvert, B., D. Taljaard, E. Lagarde, J. Sobngwi-Tambekou, R. Sitta, and A. Puren. 2005. 'Randomized, controlled intervention trial of male circumcision for reduction of HIV infection risk: the ANRS 1265 Trial', *PLoS Med*, 2: e298.

Baeten, J. M., D. Donnell, P. Ndase, N. R. Mugo, J. D. Campbell, J. Wangisi, J. W. Tappero, E. A. Bukusi, C. R. Cohen, E. Katabira, A. Ronald, E. Tumwesigye, E. Were, K. H. Fife, J. Kiarie, C. Farquhar, G. John-Stewart, A. Kakia, J. Odoyo, A. Mucunguzi, E. Nakku-Joloba, R. Twesigye, K. Ngure, C. Apaka, H. Tamooh, F. Gabona, A. Mujugira, D. Panteleeff, K. K. Thomas, L. Kidoguchi, M. Krows, J. Revall, S. Morrison, H. Haugen, M. Emmanuel-Ogier, L. Ondrejcek, R. W. Coombs, L. Frenkel, C. Hendrix, N. N. Bumpus, D. Bangsberg, J. E. Haberer, W. S. Stevens, J. R. Lingappa, C. Celum, and E. P. Study Team Partners Pr. 2012. 'Antiretroviral prophylaxis for HIV prevention in heterosexual men and women', *N Engl J Med*, 367: 399-410.

Bao, L., J. A. Salomon, T. Brown, A. E. Raftery, and D. R. Hogan. 2012. 'Modelling national HIV/AIDS epidemics: revised approach in the UNAIDS Estimation and Projection Package 2011', *Sex Transm Infect*, 88 Suppl 2: i3-10.

Barnighausen, T., V. Hosegood, I. M. Timaeus, and M. L. Newell. 2007. 'The socioeconomic determinants of HIV incidence: evidence from a longitudinal, population-based study in rural South Africa', *AIDS*, 21 Suppl 7: S29-38.
Barnighausen, T., F. Tanser, Z. Gqwede, C. Mbizana, K. Herbst, and M. L. Newell. 2008. 'High HIV incidence in a community with high HIV prevalence in rural South Africa: findings from a prospective population-based study', *AIDS*, 22: 139-44.
Bloom, S. S., M. Urassa, R. Isingo, J. Ng'weshemi, and J. T. Boerma. 2002. 'Community effects on the risk of HIV infection in rural Tanzania', *Sex Transm Infect*, 78: 261-6.
Boerma, J. T., S. Gregson, C. Nyamukapa, and M. Urassa. 2003. 'Understanding the uneven spread of HIV within Africa: comparative study of biologic, behavioral, and contextual factors in rural populations in Tanzania and Zimbabwe', *Sex Transm Dis*, 30: 779-87.
Braunstein, S. L., C. M. Ingabire, E. Kestelyn, A. U. Uwizera, L. Mwamarangwe, J. Ntirushwa, D. Nash, N. J. Veldhuijzen, A. Nel, J. Vyankandondera, and J. H. van de Wijgert. 2011. 'High human immunodeficiency virus incidence in a cohort of Rwandan female sex workers', *Sex Transm Dis*, 38: 385-94.
Brown, J. M., A. Wald, A. Hubbard, K. Rungruengthanakit, T. Chipato, S. Rugpao, F. Mmiro, D. D. Celentano, R. S. Salata, C. S. Morrison, B. A. Richardson, and N. S. Padian. 2007. 'Incident and prevalent herpes simplex virus type 2 infection increases risk of HIV acquisition among women in Uganda and Zimbabwe', *AIDS*, 21: 1515-23.
Brown, T., L. Bao, A. E. Raftery, J. A. Salomon, R. F. Baggaley, J. Stover, and P. Gerland. 2010. 'Modelling HIV epidemics in the antiretroviral era: the UNAIDS Estimation and Projection package 2009', *Sex Transm Infect*, 86 Suppl 2: ii3-10.
Brubaker, S. G., E. A. Bukusi, J. Odoyo, J. Achando, A. Okumu, and C. R. Cohen. 2011. 'Pregnancy and HIV transmission among HIV-discordant couples in a clinical trial in Kisumu, Kenya', *HIV Med*, 12: 316-21.
Burundi, Republique du. 2010. "Mise En Oeuvre De La Declaration D'Engagement Sur Le VIH/SIDA " In.
Central Bureau of Statistics (CBS) [Kenya], Ministry of Health (MOH) [Kenya], and ORC Macro. 2003. 'Kenya Demographic and Health Survey 2003'.
Central Statistical Agency [Ethiopia], and ICF International. 2012. "Ethiopia Demographic and Health Survey 2011 " In.
Central Statistical Agency [Ethiopia], and ORC Macro. 2006. "Ethiopia Demographic and Health Survey 2005." In.
Central Statistical Office (CSO) [Swaziland], and Macro International Inc. 2008. "Swaziland Demographic and Health Survey 2006-07." In.
Central Statistical Office (CSO) [Zimbabwe], and Macro International Inc. 2007. 'Zimbabwe Demographic and Health Survey 2005-06'.
Centre National de la Statistique et des Études Économiques (CNSEE). 2009. "Enquête de Séroprévalence et sur les Indicateurs du Sida du Congo ESISC-I." In.
Chege, W., S. L. Pals, E. McLellan-Lemal, S. Shinde, M. Nyambura, F. O. Otieno, D. A. Gust, R. T. Chen, and T. Thomas. 2012. 'Baseline findings of an HIV incidence

cohort study to prepare for future HIV prevention clinical trials in Kisumu, Kenya', *J Infect Dev Ctries*, 6: 870-80.

Cohen, M. S., Y. Q. Chen, M. McCauley, T. Gamble, M. C. Hosseinipour, N. Kumarasamy, J. G. Hakim, J. Kumwenda, B. Grinsztejn, J. H. Pilotto, S. V. Godbole, S. Mehendale, S. Chariyalertsak, B. R. Santos, K. H. Mayer, I. F. Hoffman, S. H. Eshleman, E. Piwowar-Manning, L. Wang, J. Makhema, L. A. Mills, G. de Bruyn, I. Sanne, J. Eron, J. Gallant, D. Havlir, S. Swindells, H. Ribaudo, V. Elharrar, D. Burns, T. E. Taha, K. Nielsen-Saines, D. Celentano, M. Essex, T. R. Fleming, and Hptn Study Team. 2011. 'Prevention of HIV-1 infection with early antiretroviral therapy', *N Engl J Med*, 365: 493-505.

Coleman, R. L., and D. Wilkinson. 1997. 'Increasing HIV prevalence in a rural district of South Africa from 1992 through 1995', *J Acquir Immune Defic Syndr Hum Retrovirol*, 16: 50-3.

Commission, Ghana AIDS. 2007. "2007 HIV Sentinel Survey Report." In.

———. 2008. "National Report on the Progress of the United Nations General Assembly Special Session (UNGASS) Declaration of Commitment on HIV and AIDS " In.

———. 2012. 'Ghana Country AIDS Progress Report'.

Corbett, E. L., B. Makamure, Y. B. Cheung, E. Dauya, R. Matambo, T. Bandason, S. S. Munyati, P. R. Mason, A. E. Butterworth, and R. J. Hayes. 2007. 'HIV incidence during a cluster-randomized trial of two strategies providing voluntary counselling and testing at the workplace, Zimbabwe', *AIDS*, 21: 483-9.

Crampin, A. C., J. R. Glynn, B. M. Ngwira, F. D. Mwaungulu, J. M. Ponnighaus, D. K. Warndorff, and P. E. Fine. 2003. 'Trends and measurement of HIV prevalence in northern Malawi', *AIDS*, 17: 1817-25.

Crampin, A. C., A. Jahn, M. Kondowe, B. M. Ngwira, J. Hemmings, J. R. Glynn, S. Floyd, P. E. Fine, and B. Zaba. 2008. 'Use of antenatal clinic surveillance to assess the effect of sexual behavior on HIV prevalence in young women in Karonga district, Malawi', *J Acquir Immune Defic Syndr*, 48: 196-202.

Eaton, J. W., G. P. Garnett, F. R. Takavarasha, P. R. Mason, L. Robertson, C. M. Schumacher, C. A. Nyamukapa, and S. Gregson. 2013. 'Increasing adolescent HIV prevalence in Eastern Zimbabwe--evidence of long-term survivors of mother-to-child transmission?', *PLoS One*, 8: e70447.

Eaton, J. W., L. F. Johnson, J. A. Salomon, T. Barnighausen, E. Bendavid, A. Bershteyn, D. E. Bloom, V. Cambiano, C. Fraser, J. A. Hontelez, S. Humair, D. J. Klein, E. F. Long, A. N. Phillips, C. Pretorius, J. Stover, E. A. Wenger, B. G. Williams, and T. B. Hallett. 2012. 'HIV treatment as prevention: systematic comparison of mathematical models of the potential impact of antiretroviral therapy on HIV incidence in South Africa', *PLoS Med*, 9: e1001245.

Eshleman, S. H., J. P. Hughes, O. Laeyendecker, J. Wang, R. Brookmeyer, L. Johnson-Lewis, C. E. Mullis, J. Hackett, Jr., A. S. Vallari, J. Justman, and S. Hodder. 2013. 'Use of a multifaceted approach to analyze HIV incidence in a cohort study of women in the United States: HIV Prevention Trials Network 064 Study', *J Infect Dis*, 207: 223-31.

Federal Ministry of Health Department of Public Health National AIDS/STI Control Programme. 2010. "Technical Report on the 2010 National HIV Sentinel Survey Among Pregnant
Women Attending Antenatal Clinics in Nigeria." In.
Finances, Institut National de la Statistique et de la Démographie (INSD) Ministère de l'Économie et des. 2004. "Burkina Faso - Enquête Démographique et de Santé 2003." In.
———. 2012. "Enquête Démographique et de Santé et à Indicateurs Multiples (EDSBF-MICS IV)." In.
Geis, S., L. Maboko, E. Saathoff, O. Hoffmann, C. Geldmacher, D. Mmbando, E. Samky, N. L. Michael, D. L. Birx, M. L. Robb, and M. Hoelscher. 2011. 'Risk factors for HIV-1 infection in a longitudinal, prospective cohort of adults from the Mbeya Region, Tanzania', *J Acquir Immune Defic Syndr*, 56: 453-9.
Ghana Statistical Service (GSS), Noguchi Memorial Institute for Medical Research (NMIMR), and ORC Macro. 2004. "Ghana Demographic and Health Survey 2003 " In.
Gomez-Olive, F. X., N. Angotti, B. Houle, K. Klipstein-Grobusch, C. Kabudula, J. Menken, J. Williams, S. Tollman, and S. J. Clark. 2013. 'Prevalence of HIV among those 15 and older in rural South Africa', *AIDS Care*, 25: 1122-8.
Government of Botswana Central Statistics Office. 2005. "BOTSWANA AIDS IMPACT SURVEY II 2004." In.
Government of Botswana, Ministry of Health. 2012. "2011 Botswana Second Generation HIV/AIDS Antenatal Sentinel Surveillance Technical Report " In.
Government of Botswana Ministry of Health. 2011. "2009 Botswana Second Generation HIV/AIDS Antenatal Sentinel Surveillance Technical Repor." In.
Gray, R. H., G. Kigozi, D. Serwadda, F. Makumbi, S. Watya, F. Nalugoda, N. Kiwanuka, L. H. Moulton, M. A. Chaudhary, M. Z. Chen, N. K. Sewankambo, F. Wabwire-Mangen, M. C. Bacon, C. F. Williams, P. Opendi, S. J. Reynolds, O. Laeyendecker, T. C. Quinn, and M. J. Wawer. 2007. 'Male circumcision for HIV prevention in men in Rakai, Uganda: a randomised trial', *Lancet*, 369: 657-66.
Gregson, S., R. M. Anderson, J. Ndlovu, T. Zhuwau, and S. K. Chandiwana. 1997. 'Recent upturn in mortality in rural Zimbabwe: evidence for an early demographic impact of HIV-1 infection?', *AIDS*, 11: 1269-80.
Guwatudde, D., F. Wabwire-Mangen, L. A. Eller, M. Eller, F. McCutchan, H. Kibuuka, M. Millard, N. Sewankambo, D. Serwadda, N. Michael, M. Robb, and Team Kayunga Cohort Research. 2009. 'Relatively low HIV infection rates in rural Uganda, but with high potential for a rise: a cohort study in Kayunga District, Uganda', *PLoS One*, 4: e4145.
Hallett, T. B., J. Stover, V. Mishra, P. D. Ghys, S. Gregson, and T. Boerma. 2010. 'Estimates of HIV incidence from household-based prevalence surveys', *AIDS*, 24: 147-52.
Hallett, T. B., B. Zaba, J. Todd, B. Lopman, W. Mwita, S. Biraro, S. Gregson, J. T. Boerma, and Alpha Network. 2008. 'Estimating incidence from prevalence in generalised HIV epidemics: methods and validation', *PLoS Med*, 5: e80.

Hargrove, J. W., J. H. Humphrey, K. Mutasa, B. S. Parekh, J. S. McDougal, R. Ntozini, H. Chidawanyika, L. H. Moulton, B. Ward, K. Nathoo, P. J. Iliff, and E. Kopp. 2008. 'Improved HIV-1 incidence estimates using the BED capture enzyme immunoassay', *AIDS*, 22: 511-8.

Health, National Department of. 2011. "The National Antenatal Sentinel HIV and Syphilis Prevalence Survey, South Africa, 2010." In.

———. 2012. "The National Antenatal Sentinel HIV and Syphilis Prevalence Survey, South

Africa, 2011." In.

Hladik, W., I. Shabbir, A. Jelaludin, A. Woldu, M. Tsehaynesh, and W. Tadesse. 2006. 'HIV/AIDS in Ethiopia: where is the epidemic heading?', *Sex Transm Infect*, 82 Suppl 1: i32-5.

Hogan, D. R., and J. A. Salomon. 2012. 'Spline-based modelling of trends in the force of HIV infection, with application to the UNAIDS Estimation and Projection Package', *Sex Transm Infect*, 88 Suppl 2: i52-7.

Hygiene, London School of Tropical Medicine and. 'The ALPHA Network'. http://www.lshtm.ac.uk/eph/dph/research/alpha/index.html.

Institut National de la Statistique du Rwanda (INSR), and ORC Macro. 2006. "Rwanda Demographic and Health Survey 2005." In.

Institute, Federal Ministry of Health/Ethiopian Health and Nutrition Research. 2011. "Report on the 2009 Round Antenatal Care Sentinel HIV Surveillance in Ethiopia." In.

Instituto Nacional de Saúde (INS), Instituto Nacional de Estatística (INE), e ICF Macro. 2010. "Inquérito Nacional de Prevalência, Riscos Comportamentais e Informação sobre o HIV e SIDA em Moçambique 2009." In.

Jewkes, R., M. Nduna, J. Levin, N. Jama, K. Dunkle, A. Puren, and N. Duvvury. 2008. 'Impact of stepping stones on incidence of HIV and HSV-2 and sexual behaviour in rural South Africa: cluster randomised controlled trial', *BMJ*, 337: a506.

Johnson, L. F., T. B. Hallett, T. M. Rehle, and R. E. Dorrington. 2012. 'The effect of changes in condom usage and antiretroviral treatment coverage on human immunodeficiency virus incidence in South Africa: a model-based analysis', *J R Soc Interface*, 9: 1544-54.

Justman, Jessica, T Ellman, D Donnell, Y Duong, J Reed, G Bicego, P Ehrenkranz, L Wang, N Bock, and R Nkambule. 2013. "Population HIV Viral Load Estimate in Swaziland: Assessing ART Program Effectiveness and Transmission Potential." In *20th Conference on Retroviruses and Opportunistic Infections*. Atlanta, Georgia, United States.

Kapiga, S. H., F. M. Ewings, T. Ao, J. Chilongani, A. Mongi, K. Baisley, S. Francis, A. Andreasen, R. Hashim, D. Watson-Jones, J. Changalucha, and R. Hayes. 2013. 'The epidemiology of HIV and HSV-2 infections among women participating in microbicide and vaccine feasibility studies in Northern Tanzania', *PLoS One*, 8: e68825.

Karita, E., M. Price, E. Hunter, E. Chomba, S. Allen, L. Fei, A. Kamali, E. J. Sanders, O. Anzala, M. Katende, N. Ketter, Iavi Collaborative Seroprevalence, and Team Incidence Study. 2007. 'Investigating the utility of the HIV-1 BED capture enzyme

immunoassay using cross-sectional and longitudinal seroconverter specimens from Africa', *AIDS*, 21: 403-8.

Kayibanda, J. F., M. Alary, R. Bitera, A. Kabeja, R. Hinda, L. Munyakazi, B. Chitou, and J. P. Gatarayiha. 2011. 'HIV Prevalence Comparison Between Antenatal Sentinel Surveillance and Demographic and Health Survey in Rwanda', *Open AIDS J*, 5: 29-36.

Kayirangwa, E., J. Hanson, L. Munyakazi, and A. Kabeja. 2006. 'Current trends in Rwanda's HIV/AIDS epidemic', *Sex Transm Infect*, 82 Suppl 1: i27-31.

Keating, M. A., G. Hamela, W. C. Miller, A. Moses, I. F. Hoffman, and M. C. Hosseinipour. 2012. 'High HIV incidence and sexual behavior change among pregnant women in Lilongwe, Malawi: implications for the risk of HIV acquisition', *PLoS One*, 7: e39109.

Kengeya-Kayondo, J. F., A. Kamali, A. J. Nunn, A. Ruberantwari, H. U. Wagner, and D. W. Mulder. 1996. 'Incidence of HIV-1 infection in adults and socio-demographic characteristics of seroconverters in a rural population in Uganda: 1990-1994', *Int J Epidemiol*, 25: 1077-82.

Kenya National Bureau of Statistics (KNBS), and ICF Macro. 2010. "Kenya Demographic and Health Survey 2008-09 " In.

Kilmarx, P. H., and T. Mutasa-Apollo. 2013. 'Patching a leaky pipe: the cascade of HIV care', *Curr Opin HIV AIDS*, 8: 59-64.

Kingdom of Swaziland Ministry of Health. 2012. "Swaziland HIV Incidence Measurement Survey (SHIMS) - First Findings Report." In.

Kranzer, K., S. D. Lawn, L. F. Johnson, L. G. Bekker, and R. Wood. 2013. 'Community viral load and CD4 count distribution among people living with HIV in a South African Township: implications for treatment as prevention', *J Acquir Immune Defic Syndr*, 63: 498-505.

Kumwenda, N., I. Hoffman, M. Chirenje, C. Kelly, A. Coletti, A. Ristow, F. Martinson, J. Brown, D. Chilongozi, B. Richardson, Z. Rosenberg, N. Padian, and T. Taha. 2006. 'HIV incidence among women of reproductive age in Malawi and Zimbabwe', *Sex Transm Dis*, 33: 646-51.

Laeyendecker, O., R. Brookmeyer, M. M. Cousins, C. E. Mullis, J. Konikoff, D. Donnell, C. Celum, S. P. Buchbinder, G. R. Seage, 3rd, G. D. Kirk, S. H. Mehta, J. Astemborski, L. P. Jacobson, J. B. Margolick, J. Brown, T. C. Quinn, and S. H. Eshleman. 2013. 'HIV incidence determination in the United States: a multiassay approach', *J Infect Dis*, 207: 232-9.

Lopman, B., C. Nyamukapa, P. Mushati, Z. Mupambireyi, P. Mason, G. P. Garnett, and S. Gregson. 2008. 'HIV incidence in 3 years of follow-up of a Zimbabwe cohort--1998-2000 to 2001-03: contributions of proximate and underlying determinants to transmission', *Int J Epidemiol*, 37: 88-105.

Mahy, M., J. M. Garcia-Calleja, and K. A. Marsh. 2012. 'Trends in HIV prevalence among young people in generalised epidemics: implications for monitoring the HIV epidemic', *Sex Transm Infect*, 88 Suppl 2: i65-75.

Marsh, K. A., C. A. Nyamukapa, C. A. Donnelly, J. M. Garcia-Calleja, P. Mushati, G. P. Garnett, E. Mpandaguta, N. C. Grassly, and S. Gregson. 2011. 'Monitoring trends

in HIV prevalence among young people, aged 15 to 24 years, in Manicaland, Zimbabwe', *J Int AIDS Soc*, 14: 27.
Martin, Jeff. 2009. "Rate and Cumulative Incidence." In.
Mavedzenge, S. N., H. A. Weiss, E. T. Montgomery, K. Blanchard, G. de Bruyn, G. Ramjee, T. Chipato, N. S. Padian, and A. Van Der Straten. 2011. 'Determinants of differential HIV incidence among women in three southern African locations', *J Acquir Immune Defic Syndr*, 58: 89-99.
McDougal, J. S., B. S. Parekh, M. L. Peterson, B. M. Branson, T. Dobbs, M. Ackers, and M. Gurwith. 2006. 'Comparison of HIV type 1 incidence observed during longitudinal follow-up with incidence estimated by cross-sectional analysis using the BED capture enzyme immunoassay', *AIDS Res Hum Retroviruses*, 22: 945-52.
Ministry of Health and Social Welfare (MOHSW) [Lesotho], and ICF Macro. 2010. 'Lesotho Demographic and Health Survey 2009 '.
Ministry of Health and Social Welfare (MOHSW) [Lesotho], Bureau of Statistics (BOS) [Lesotho], and ORC Macro. 2005. "Lesotho Demographic and Health Survey 2004." In.
Ministry of Health National AIDS Council. 2008. 'Zambia Country Report Multi-sectoral AIDS Response Monitoring and Evaluation Biennial Report 2006-2007 '.
———. 2010. 'Zambia Country Report: Monitoring the Declaration of Commitment on HIV and AIDS and the Universal Access 2010'.
Montana, L. S., V. Mishra, and R. Hong. 2008. 'Comparison of HIV prevalence estimates from antenatal care surveillance and population-based surveys in Sub-Saharan Africa', *Sex Transm Infect*, 84 Suppl 1: i78-i84.
Moodley, D., T. M. Esterhuizen, T. Pather, V. Chetty, and L. Ngaleka. 2009. 'High HIV incidence during pregnancy: compelling reason for repeat HIV testing', *AIDS*, 23: 1255-9.
Mulder, D., A. Nunn, A. Kamali, and J. Kengeya-Kayondo. 1995. 'Decreasing HIV-1 seroprevalence in young adults in a rural Ugandan cohort', *BMJ*, 311: 833-6.
Munseri, P. J., M. Bakari, M. Janabi, E. Aris, S. Aboud, B. Hejdeman, and E. Sandstrom. 2013. 'Declining HIV-1 prevalence and incidence among Police Officers -- a potential cohort for HIV vaccine trials, in Dar es Salaam, Tanzania', *BMC Public Health*, 13: 722.
National AIDS and STD Control Programme (NASCOP) Ministry of Health. 2006. "Sentinel Surveillance of HIV & STDS in Kenya Report 2006 " In.
National AIDS and STI Control Programme, Kenya Ministry of Health. 2013. "Kenya AIDS Indicator Survey 2012 Preliminary Report." In.
National AIDS Council. 2012. "Zimbabwe Global AIDS Response Progress Report 2012 " In.
National Bureau of Statistics. 2005. 'Tanzania HIV/AIDS Indicator Survey 2003-2004'.
National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda], and ICF International. 2012. "Rwanda Demographic and Health Survey 2010." In.
National Statistical Office (NSO), and ICF Macro. 2011. "Malawi Demographic and Health Survey 2010." In.

National Statistical Office (NSO) [Malawi], and ORC Macro. 2005. 'Malawi Demographic and Health Survey 2004'.

Nel, A., Z. Mabude, J. Smit, P. Kotze, D. Arbuckle, J. Wu, N. van Niekerk, and J. van de Wijgert. 2012. 'HIV incidence remains high in KwaZulu-Natal, South Africa: evidence from three districts', *PLoS One*, 7: e35278.

Peterson, L., K. Nanda, B. K. Opoku, W. K. Ampofo, M. Owusu-Amoako, A. Y. Boakye, W. Rountree, A. Troxler, R. Dominik, R. Roddy, and L. Dorflinger. 2007. 'SAVVY (C31G) gel for prevention of HIV infection in women: a Phase 3, double-blind, randomized, placebo-controlled trial in Ghana', *PLoS One*, 2: e1312.

Program, National AIDS and STI Control. 2010. "Sentinel surveillance for HIV and Syphilis Among Pregnant Women, 2010." In.

Ramjee, G., S. Kapiga, S. Weiss, L. Peterson, C. Leburg, C. Kelly, B. Masse, and Hptn Study Team. 2008. 'The value of site preparedness studies for future implementation of phase 2/IIb/III HIV prevention trials: experience from the HPTN 055 study', *J Acquir Immune Defic Syndr*, 47: 93-100.

Rehle, T. M., T. B. Hallett, O. Shisana, V. Pillay-van Wyk, K. Zuma, H. Carrara, and S. Jooste. 2010. 'A decline in new HIV infections in South Africa: estimating HIV incidence from three national HIV surveys in 2002, 2005 and 2008', *PLoS One*, 5: e11094.

Republic of Namibia Ministry of Health and Social Services. 2010. "United Nations General Assembly Special Session (UNGASS) Country Report " In.

Rice, B. D., J. Batzing-Feigenbaum, V. Hosegood, F. Tanser, C. Hill, T. Barnighausen, K. Herbst, T. Welz, and M. L. Newell. 2007. 'Population and antenatal-based HIV prevalence estimates in a high contracepting female population in rural South Africa', *BMC Public Health*, 7: 160.

Ruzagira, E., S. Wandiembe, A. Abaasa, J. Levin, A. Bwanika, U. Bahemuka, M. A. Price, and A. Kamali. 2011. 'Prevalence and incidence of HIV in a rural community-based HIV vaccine preparedness cohort in Masaka, Uganda', *PLoS One*, 6: e20684.

Seeley, J., J. Nakiyingi-Miiro, A. Kamali, J. Mpendo, G. Asiki, A. Abaasa, J. De Bont, L. Nielsen, P. Kaleebu, and Chivtum Study Team. 2012. 'High HIV incidence and socio-behavioral risk patterns in fishing communities on the shores of Lake Victoria, Uganda', *Sex Transm Dis*, 39: 433-9.

Shisana, O , T Rehle, LC Simbayi, K Zuma, S Jooste, V Pillay-van-Wyk, N Mbelle, J Van Zyl, W Parker, NP Zungu, S Pezi, and SABSSM III Implementation Team. 2009. "South African national HIV prevalence, incidence, behaviour and communication survey 2008: A turning tide among teenagers? ." In.

Shisana, O, T Rehle, Simbayi LC, K Zuma, S Jooste, Zungu N, D Labadarios, and D Onoya. 2014. "South African National HIV Prevalence, Incidence and Behaviour Survey, 2012." In. Cape Town.

Shisana, O, T Rehle, LC Simbayi, W Parker, K Zuma, A Bhana, C Connolly, S Jooste, and V Pillay. 2005. "South African national HIV prevalence, HIV incidence, behaviour and communication survey, 2005." In.

SIDA, Comité National de Lutte contre le. 2008a. "Rapport De Situation Nationale Pour La Republique Du Congo À L'Intention De L'UNGASS " In.

———. 2008b. 'Republique Centrafricaine Rapport De Situation National À Lintention De L'UNGASS Janvier 2006-Décembre 2007 '.
———. 2010. 'Republique Centrafricaine Rapport De Situation National À Lintention De L'ungass 2010'.
———. 2012a. "2012 Rapport d'Activite au Niveau du Pays Republique Centrafricaine." In.
———. 2012b. "Rapport D'Activites Sur La Riposte Au SIDA Du Burkina Faso 2012." In.
SIDA, Conselho Nacional de Combate ao. 2012c. "2012 Global AIDS Response Progress Report Mozambique." In.
Sida, Institut National de Santé Publique (INSP) Ministère de la Santé Publique et de la Lutte contre le. 2012d. "Enquête Démographique et de Santé Burundi 2010 " In.
SIDA, SEP/Comité National de Lutte contre le. 2011. "Burundi Bilan des Realisation du Plan d'Action National de Lutte contre le SIDA 2011." In.
Southern African Development Community. 2009. "SADC HIV and AIDS Strategic Framework." In.
Swedish International Development Cooperation Agency. 2002. "ANC Sentinel Surveillance of HIV/Syphilis trends in Zambia 1994-2002." In.
Tanser, F., T. Barnighausen, E. Grapsa, J. Zaidi, and M. L. Newell. 2013. 'High coverage of ART associated with decline in risk of HIV acquisition in rural KwaZulu-Natal, South Africa', *Science*, 339: 966-71.
Tanzania Commission for AIDS (TACAIDS), Zanzibar AIDS Commission (ZAC), National Bureau of Statistics (NBS), Office of the Chief Government Statistician (OCGS), and Macro International Inc. 2008. 'Tanzania HIV/AIDS and Malaria Indicator Survey 2007-08'.
Tanzania Commission for AIDS (TACAIDS), Zanzibar AIDS Commission (ZAC), National Bureau of Statistics (NBS), Office of the Chief Government Statistician (OCGS), and ICF International. 2013. 'Tanzania HIV/AIDS and Malaria Indicator Survey 2011-12.'.
The Republic of Malawi Ministry of Health. 2008. "HIV and Syphilis Sero–Survey and National HIV Prevalence and AIDS Estimates Report for 2007 " In.
Tobian, A. A., V. Ssempijja, G. Kigozi, A. E. Oliver, D. Serwadda, F. Makumbi, F. K. Nalugoda, B. Iga, S. J. Reynolds, M. J. Wawer, T. C. Quinn, and R. H. Gray. 2009. 'Incident HIV and herpes simplex virus type 2 infection among men in Rakai, Uganda', *AIDS*, 23: 1589-94.
Todd, J, S Biraro, LA Shafer, T Lutalo, A Ndyanabo, JB Bwanika, R Isingo, W Mwita, A Wringe, Mushati P, B Lopman, T Hallett, T Bärnighausen, M Nyirenda, V Hosegood, M Marston, and B Żaba. 2008. "Diverse Age Patterns of HIV Incidence Rates in Africa." In *XVII conference of International AIDS Society*. Mexico.
Transmissibles, Conseil National De Lutte Contre Le Sida Et Les Infections Sexuellement. 2008. "Rapport UNGASS 2008 Du Burkina Faso." In.
'Treatment as prevention for HIV'. 2011. *Lancet Infect Dis*, 11: 651.
UNAIDS. 2012a. "Fact Sheet: Fact sheet: Adolescents, young people and HIV " In.
———. 2012b. "Swaziland Country Report on Monitoring the Political Declaration on HIV and AIDS." In.
———. 2013a. "Core Slides: Global Summary of the AIDS Epidemic." In.

———. 2013b. "Methodology – Understanding the HIV estimates." In.
UNAIDS Reference Group on Estimates, Modelling and Projections. 2012. "Technical Refinements for Spectrum 2013: December 2012." In. Geneva, Switzerland.
United Republic of Tanzania Ministry of Health, National AIDS Control Programme. 2006. "Tanzania Surveillance of HIV and Syphilis Infections Among Antenatal Clinic Attendees 2005/06." In.
United Republic of Tanzania Ministry of Health National AIDS Control Programme. 2005. "Tanzania Surveillance of HIV and Syphilis Infections Among Antenatal Clinic Attendees 2003/04." In.
———. 2010. 'Tanzania Surveillance of HIV and Syphilis Infections Among Antenatal Clinic Attendees 2008'.
Van Damme, Lut, Amy Corneli, Khatija Ahmed, Kawango Agot, Johan Lombaard, Saidi Kapiga, Mookho Malahleha, Fredrick Owino, Rachel Manongi, Jacob Onyango, Lucky Temu, Modie Constance Monedi, Paul Mak'Oketch, Mankalimeng Makanda, Ilse Reblin, Shumani Elsie Makatu, Lisa Saylor, Haddie Kiernan, Stella Kirkendale, Christina Wong, Robert Grant, Angela Kashuba, Kavita Nanda, Justin Mandala, Katrien Fransen, Jennifer Deese, Tania Crucitti, Timothy D. Mastro, and Douglas Taylor. 2012. 'Preexposure Prophylaxis for HIV Infection among African Women', *New England Journal of Medicine*, 367: 411-22.
Wambura, M., M. Urassa, R. Isingo, M. Ndege, M. Marston, E. Slaymaker, J. Mngara, J. Changalucha, T. J. Boerma, and B. Zaba. 2007. 'HIV prevalence and incidence in rural Tanzania: results from 10 years of follow-up in an open-cohort study', *J Acquir Immune Defic Syndr*, 46: 616-23.
Watson-Jones, D., H. A. Weiss, M. Rusizoka, J. Changalucha, K. Baisley, K. Mugeye, C. Tanton, D. Ross, D. Everett, T. Clayton, R. Balira, L. Knight, I. Hambleton, J. Le Goff, L. Belec, R. Hayes, H. S. V. trial team, Steering, and Committees Data Monitoring. 2008. 'Effect of herpes simplex suppression on incidence of HIV among women in Tanzania', *N Engl J Med*, 358: 1560-71.
Wawer, M. J., D. Serwadda, R. H. Gray, N. K. Sewankambo, C. Li, F. Nalugoda, T. Lutalo, and J. K. Konde-Lule. 1997. 'Trends in HIV-1 prevalence may not reflect trends in incidence in mature epidemics: data from the Rakai population-based cohort, Uganda', *AIDS*, 11: 1023-30.
Welfare, Ministry of Health and Social. 2008. 'ANC HIV and Syphilis Sentinel Surveillance Synopisis 2003, 2005 and 2007 '.
WHO. 2006. 'Antiretroviral therapy for HIV infection in adults and adolescents Recommendations for a public health approach (2006 revision)'.
———. 2010. "Antiretroviral therapy for HIV infection in adults and adolescents Recommendations for a public health approach: 2010 revision." In.
———. 2013. "Consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection." In.
WHO, and UNAIDS. 2013. "WHO/UNAIDS Technical Update on HIV incidence assays for surveillance and epidemic monitoring." In.
WHO, UNAIDS, and CDC. 2003. "Guidelines for Conducting HIV Sentinel Serosurveys among Pregnant Women and Other Groups." In.

WHO Regional Office for Africa. 2008. "HIV and AIDS Epidemiological Surveillance Report for the WHO African Region 2007 Update." In.

Zaidi, J., E. Grapsa, F. Tanser, M. L. Newell, and T. Barnighausen. 2013. 'Dramatic increase in HIV prevalence after scale-up of antiretroviral treatment', *AIDS*, 27: 2301-5.

Zimbabwe National Monitoring and Evaluation Taskforce. 2008. "United Nationals General Assembly (UNGASS) Report on HIV and AIDS " In.

Zimbabwe National Statistics Agency (ZIMSTAT), and ICF International. 2012. "Zimbabwe Demographic and Health Survey 2010-11." In.