

Using routine programmatic data to measure HIV incidence among pregnant women in Botswana

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Research

Keywords: HIV testing, ANC, HIV seroconversion, pregnancy, PMTCT, Botswana, women

Posted Date: April 2nd, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-19601/v1>

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Version of Record: A version of this preprint was published at Population Health Metrics on March 4th, 2022. See the published version at <https://doi.org/10.1186/s12963-022-00287-2>.

Abstract

Introduction: Pregnant women in sub-Saharan Africa have high risk of HIV acquisition, yet approaches for measuring maternal HIV incidence using routine surveillance systems are undefined. We used programmatic data from routine antenatal care (ANC) HIV testing in Botswana to measure real-world HIV incidence during pregnancy.

Methods: From January 2018 to September 2019, the Botswana Ministry of Health and Wellness implemented an HIV testing program at 139 ANC clinics. The program captured information on testers' age, testing date and result, and antiretroviral treatment (ART) initiation. In our analysis, we excluded individuals who previously tested HIV-positive prior to their first ANC visit. We defined incident HIV infection as testing HIV-positive at an ANC visit after a prior HIV-negative result within ANC.

Results: Overall, 29,570 pregnant women (median age 26 years, IQR 22-31) tested for HIV at ANC clinics: 3% (836) tested HIV-positive at their first recorded ANC visit and 97% tested HIV-negative (28,734). Of those who tested HIV-negative, 28% (7,940/28,734) had a repeat HIV test recorded at ANC. The median time to HIV re-testing was 92 days (IQR 70-112). In total, 17 previously undiagnosed HIV infections were detected (HIV incidence 8 per 1,000 person-years, 95% CI 0.5-1.3). ART initiation among women newly diagnosed with HIV at ANC (853) was 88% (671/762).

Conclusions: In Botswana, real-world HIV incidence among pregnant women at ANC remains above levels of HIV epidemic control (≤ 1 per 1,000 person-years). This study shows how HIV programmatic data can answer timely population-level epidemiological questions and inform ongoing implementation of HIV prevention and treatment programs.

Introduction

In sub-Saharan Africa, a women's risk of acquiring HIV increases during pregnancy and the postpartum period.(1) The increased risk of HIV acquisition during this life stage may be attributable to physiological changes that accompany pregnancy – including immune, hormonal, and vaginal microbiome changes (1–3) – as well as behavioral, cultural, and societal factors – including the difficulty to negotiate condom use or male partners' increased number of sexual contacts during this period (1,4). For these reasons, the World Health Organization (WHO) strongly advocates for primary HIV prevention programs targeting pregnant women in HIV high-burden settings – including repeat testing during antenatal care (ANC) and pre-exposure prophylaxis (PrEP) – to minimize the risk of perinatal HIV transmission.(5,6)

Limited data are available related to incident HIV infection during pregnancy in sub-Saharan Africa. Additionally, existing estimates are often based on costly research studies that may not be representative of general populations of pregnant women because of continued observation and access to superior services and counseling, limiting generalizability outside of research settings.(7) A more generalizable approach would be leveraging existing HIV programmatic data to measure HIV incidence during pregnancy. Over the past decades, health information systems for HIV prevention and treatment programs were strengthened to inform ministries of health, multilateral organizations, and donors, subsequently increasing the volume and accessibility of HIV programmatic data, creating opportunities for real-time analyses and decision making.(8) A recent WHO report on health informatics in Botswana highlights the development and implementation of a robust Monitoring and Evaluation and Health Information Systems.(9)

Botswana has an adult HIV prevalence of 20%,(10) and has achieved high coverage of numerous HIV programs, including universal antiretroviral treatment (ART) and prevention of mother-to-child transmission (PMTCT).(11) In Botswana, it was estimated in 2018 that 91% of people living with HIV knew their status, 92% of these individuals were linked to care, and >95% of these individuals were virally suppressed.(10) ANC attendance among pregnant women in Botswana is high, at 97%, and in 2004 Botswana became the first country in Africa to routinize HIV testing at each ANC visit.(12) Botswana is currently rolling out PrEP delivery for individuals with high HIV risk, including women with partners living with HIV, and planning is underway to distribute HIV self-tests to pregnant women to deliver to their sexual partners.(13) As HIV testing programs for pregnant women continue to be scaled up in Botswana, monitoring population-level effectiveness in the reduction of maternal HIV incidence will become increasingly important.

We utilized programmatic data from HIV testing programs at routine ANC clinics in Botswana to measure the frequency of previously undiagnosed HIV infection and HIV incidence among pregnant women. Understanding whether routine health information systems can be used to monitor incident maternal HIV infections and subsequent linkage to ART is important for informing ongoing implementation of HIV prevention programs targeting pregnant women.(5,6,14)

Methods

HIV testing support

Since 2003, the International Training and Education Center for Health (I-TECH) has been working in collaboration with the Botswana Ministry of Health and Wellness (MOHW). In 2015, I-TECH began working with MOHW to strengthen implementation of routine HIV testing through the provision of training, mentoring, and continuous quality improvement activities as well as the provision of human resources at 148 public health facilities, including 139 with ANC services.⁽¹⁵⁾ This support includes collection of routine programmatic data to assess the accountability, transparency, and impact of HIV testing programs as well as data quality assessments. The testing registries include information on individual tester's age, gender, citizenship, and testing modality: tuberculosis clinic, inpatient, outpatient, ANC clinic, voluntary medical male circumcision, voluntary counseling and testing and index partner testing. Additionally, the registries indicate if individuals that test HIV-positive initiate antiretroviral treatment (ART).

Programmatic data collection

To facilitate monitoring of real-time programmatic implementation, the MOHW (with support from I-TECH) expanded an existing health information system to allow for electronic case-based surveillance of individuals accessing HIV testing services. Site-based HIV testing counselors reported HIV testing data using Open Data Kit electronic forms on handheld devices (tablets). The electronic data forms mirrored variables on paper-based registers for consistency. Data quality checks were inbuilt to increase data reliability and validity. Real-time data were transmitted through a secure mobile network, into the national HIV data warehouse servers. A scaled implementation of the system began in October 2017, with all I-TECH-supported facilities using the system by January 2018.

Data analysis

For our analyses, we limited our sample to women ≥ 15 years of age who underwent HIV testing through ANC care from January 2018 to September 2019. We excluded individuals who previously self-reported testing HIV-positive prior to their first identified ANC visit, enabling us to measure detection of previously undiagnosed HIV infection. Additionally, we excluded women with an indeterminate or missing HIV test result.

We report the number and proportion of women for whom previously undiagnosed HIV infection was detected at their first observed ANC visit. Among women who tested HIV-negative at their first observed ANC visit and had a repeat HIV test at a subsequent visit, we measured time to re-testing and the frequency of HIV seroconversion during ANC follow-up (defined as testing HIV-positive after a prior HIV-negative result within ANC). We only measured follow-up until the first subsequent ANC follow-up visit. For all women who HIV seroconverted, we assumed that seroconversion occurred midway through their observed follow-up period. We calculated the total number of person-years and observed HIV incidence among women HIV testing at ANC clinics. We use bi-variable logistic regression models to measure if age, citizenship, or location of the ANC clinic (i.e., urban vs. rural) were associated with testing HIV-positive or initiating ART.

Results

From January 2018 to September 2019, 29,570 women tested for HIV at 139 ANC clinics, Fig. 1. The median age of women was 26 years (interquartile range [IQR] 22 to 31 years), roughly half (52%, $n = 15,516$) tested at urban (versus rural) ANC clinics, and the majority were citizens of Botswana (95%, $n = 28,215$). At their first observed visit, 3% of women ($n = 836$) had a previously undiagnosed HIV infection detected and 97% of women ($n = 28,734$) tested HIV-negative. Among the women that tested HIV-negative, 28% ($7,940/28,734$) returned for an ANC follow-up visit at one of the 139 clinics and re-tested for HIV. The median time to HIV re-testing at ANC was 92 days (IQR 72 to 112 days). Overall, 17 previously undiagnosed HIV infections were detected over 2,095 person-years of follow-up (HIV incidence rate of 8 per 1,000 person-years, 95% confidence interval [CI] 5–13), Fig. 2. Individuals that HIV seroconverted tended to be young (median age 23 years, IQR 21 to 28 years), citizens of Botswana (94%, $n = 16$), who tested in a mix of rural (53%, $n = 9$) and urban (47%, $n = 8$) ANC clinics. The characteristics of those who HIV seroconverted did not significantly differ from those who remained HIV uninfected. Among all women who tested HIV-positive at ANC clinics ($n = 853$), 88% ($n = 671/762$) initiated ART.

We found significant differences in the age and national citizenship of women who tested HIV-negative versus those who tested HIV-positive during the study, and women who tested HIV-positive and initiated ART versus those who tested HIV-positive and did not initiate ART, Fig. 3. Compared to women who tested HIV-negative at ANC clinics, those who tested HIV-positive were older ($p < 0.001$) and not citizens of Botswana ($p < 0.001$). Compared to women who tested HIV-positive and did not initiate ART, those who tested HIV-positive and did initiate ART were older ($p < 0.001$) and citizens of Botswana ($p < 0.001$). There were no statistically significant differences in the location of the ANC clinics (e.g., urban versus rural) among women who tested HIV-positive versus HIV-negative ($p = 0.14$) and women who tested HIV-positive and did not initiate ART versus those who did ($p = 0.14$).

Discussion

The HIV incidence rate measured among pregnant women in this study is lower than that measured among pregnant women in other sub-Saharan African settings,⁽⁷⁾ but similar to other estimates of HIV incidence among members of the Botswana general population.⁽¹⁶⁾ A systematic review of pregnant women in sub-Saharan African settings measured a pooled HIV incidence rate of 47 per 1,000 person-years.⁽⁷⁾ While this

estimate may be higher than that measured in our study (8 per 1,000 person-years), the review included sub-Saharan African countries that, relative to Botswana, are often in different HIV epidemic stages (17) and generally have achieved fewer HIV programmatic accomplishments (e.g., levels of HIV testing and treatment coverage).(18) Meanwhile, the control arm of a large community randomized trial testing the universal test and treat strategy in Botswana – i.e., the Ya Tsie trial or Botswana Combination Prevention Program (BCPP) – measured from 2013–2018 an HIV incidence (9 per 1,000 person-years) similar to that in our study.(16) Considering the existing levels of population HIV prevalence in Botswana (20%) (10) and the country's many HIV programmatic accomplishments, the measures of HIV incidence in our study and the Ya Tsie trial are high and remain above levels of HIV epidemic control (≤ 1 per 1,000 person-years).(19)

The high levels of HIV incidence among pregnant women, measured using routine programmatic data in this study, suggest that routine HIV testing paired with primary HIV prevention interventions remain critical components of ANC programs in high HIV prevalence settings. Programs for condom distribution (20) and behavioral change interventions,(21) initiation of PrEP,(22,23) or secondary distribution of HIV self-tests (14) paired with HIV testing at ANC clinics may improve the lives of pregnant women and reduce perinatal HIV transmission. Additionally, the data from this study suggests that prioritizing older women and women who are not citizens of Botswana for HIV prevention programs might help further improve women's health and prevent perinatal HIV transmission in Botswana.

This study has a number of strengths. This is the first evaluation to use programmatic data to measure HIV incidence within a HIV high-prevalence setting. Lately, there has been a call to utilize the rich health information systems in low-income, HIV prevalence settings to answer these types of research questions instead of building resource-intensive cohort studies for this purpose.(8) Using programmatic data to inform implementation of HIV prevention efforts is advantageous because the data are readily available (with limited additional costs for analysis) and can be analyzed as programs are ongoing to inform real-time implementation.(8)

This study also has weaknesses that are important to note. For example, limited information were available on the demographics of the women who HIV tested (e.g., education, income) and no details were available on the ANC visit women attended (e.g., their first, second, or third visit), which made difficult to determine how far along women were in their pregnancy. Additionally, data were not available for ANC visits at facilities excluded from this assessment. To best measure previously undiagnosed HIV infection and seroconversion despite these challenges, we limited our sample to women who had not previously tested HIV-positive at their first observed visit, and only measured follow-up until the first time a woman re-tested following a previous HIV-negative diagnosis. If our sample captured numerous women at their last ANC visit, we likely underestimated the prevalence of HIV re-testing in this population. Our sample also only included pregnant women who HIV tested at ANC clinics, and thus our estimates of previously undiagnosed HIV infection and HIV incidence may not be generalizable to pregnant women in this setting that do not engage in ANC. However, few women in Botswana do not engage in ANC.(24)

Conclusions

In Botswana, real-world HIV incidence among pregnant women remains above levels of HIV epidemic control (≤ 1 per 1,000 person-years).(19) This study demonstrates that programmatic data from HIV implementation programs can be used to answer timely population-level epidemiological questions (e.g., HIV incidence among pregnant women), which can inform ongoing implementation of HIV prevention and treatment programs. Detection, especially early detection, of HIV among pregnant women and subsequent linkage to ART is important for both the long-term health of the mother (25) and prevention of perinatal HIV transmission.(26) High ANC attendance in Botswana (24) creates the unique opportunity to link women who test HIV-negative (the vast majority) to HIV prevention interventions, such as PrEP (22,23) or secondary partner distribution of HIV self-tests,(14) to maintain their HIV-negative status. To reach elimination of MTCT, governments in high HIV prevalence settings should consider analyzing existing programmatic data to inform the real-time implementation of HIV prevention and treatment programs. The findings from this study suggest that continued investment in routine HIV testing paired with other HIV prevention interventions during ANC – a unique period in women's lives when they are at increased contact with the health system and increased risk of HIV infection (1) – may help reduce HIV incidence and perinatal HIV transmission in Botswana and other similar settings.

Abbreviations

ANC	Antenatal care
ART	Antiretroviral treatment
BCPP	Botswana Combination Prevention Program
CI	Confidence interval
HIV	Human immunodeficiency virus
HRDC	Human Resource Development Council

HRSA	Health Resources and Services Administration
I-TECH	International Training and Education Center for Health
IRQ	Interquartile range
MOHW	Ministry of Health and Wellness
PEPFAR	President's Emergency Plan for AIDS Relief
PMTCT	Prevention of mother-to-child transmission
PrEP	Pre-exposure prophylaxis
WHO	World Health Organization

Declarations

Ethical approval and consent to participate

This study was approved by the Human Resource Development Council (HRDC) of Botswana. All participants signed written documents of informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publically available because of a data agreement between I-TECH and the Botswana Ministry of Health and Wellness, but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

I-TECH supported HIV testing programs in Botswana with funding from the President's Emergency Plan for AIDS Relief (PEPFAR), through grant number U91HA06801 from the U.S. Department of Health and Human Services, Health Resources and Services Administration (HRSA), HIV/AIDS Bureau's Global Health Systems Branch. KFO was additionally funded by the National Institute for Mental Health (R01-MH110296 and R01-MH113572). The funders had no role in the design of this study, the analysis of results, and the interpretation of findings.

Author contributions

KFO analyzed the data and drafted the paper. All other authors (SM, OB, LT, MG, GPM, EM, MN, LS, RH, JP, JL) helped with data acquisition, interpretation of study findings, and paper revisions. All authors read and approved the final manuscript.

Acknowledgements

We would like to acknowledge all the I-TECH counselors who supported HIV testing at ANC clinics in Botswana, as well as the clinic staff that facilitated data collection and HIV testing.

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Figures

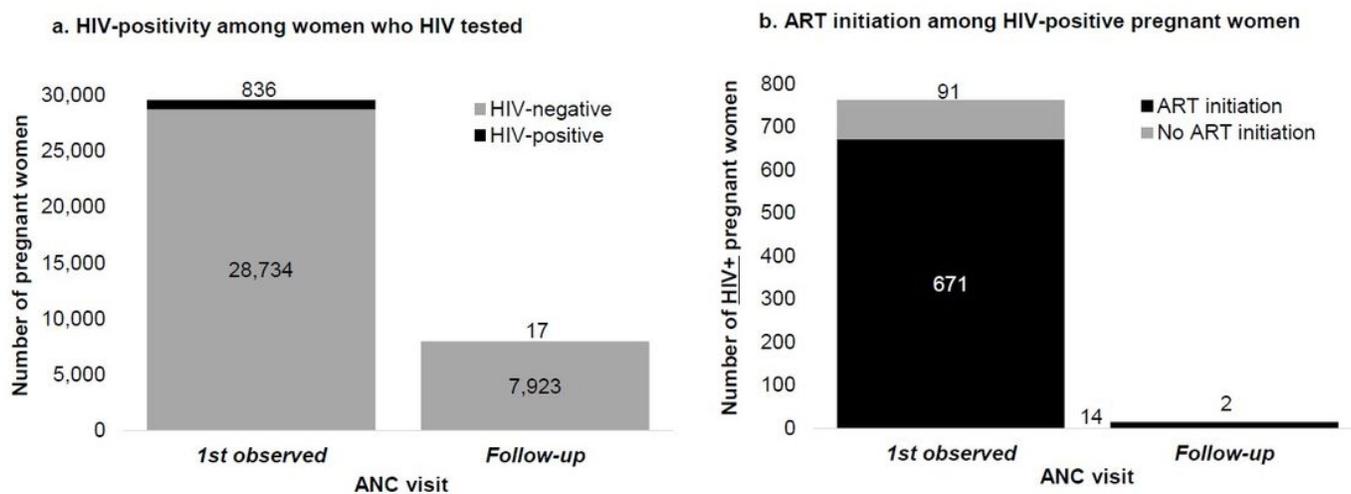


Figure 1

HIV testing outcomes and ART initiation among pregnant women attending ANC in Botswana. At the first observed ANC visit, 343 women were excluded for the following reasons: <15 years (n=285), missing test result (n=22), and previous HIV-positive diagnosis (n=71). Follow-up was only among women who tested HIV-negative at the first observed visit.

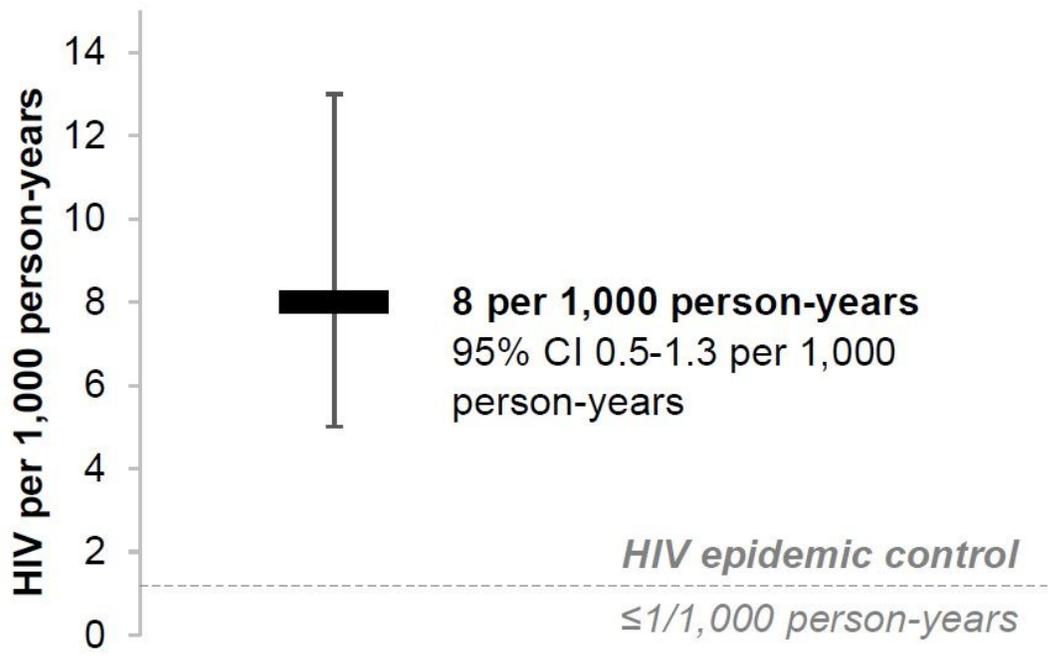


Figure 2

Real-world maternal HIV incidence in Botswana.

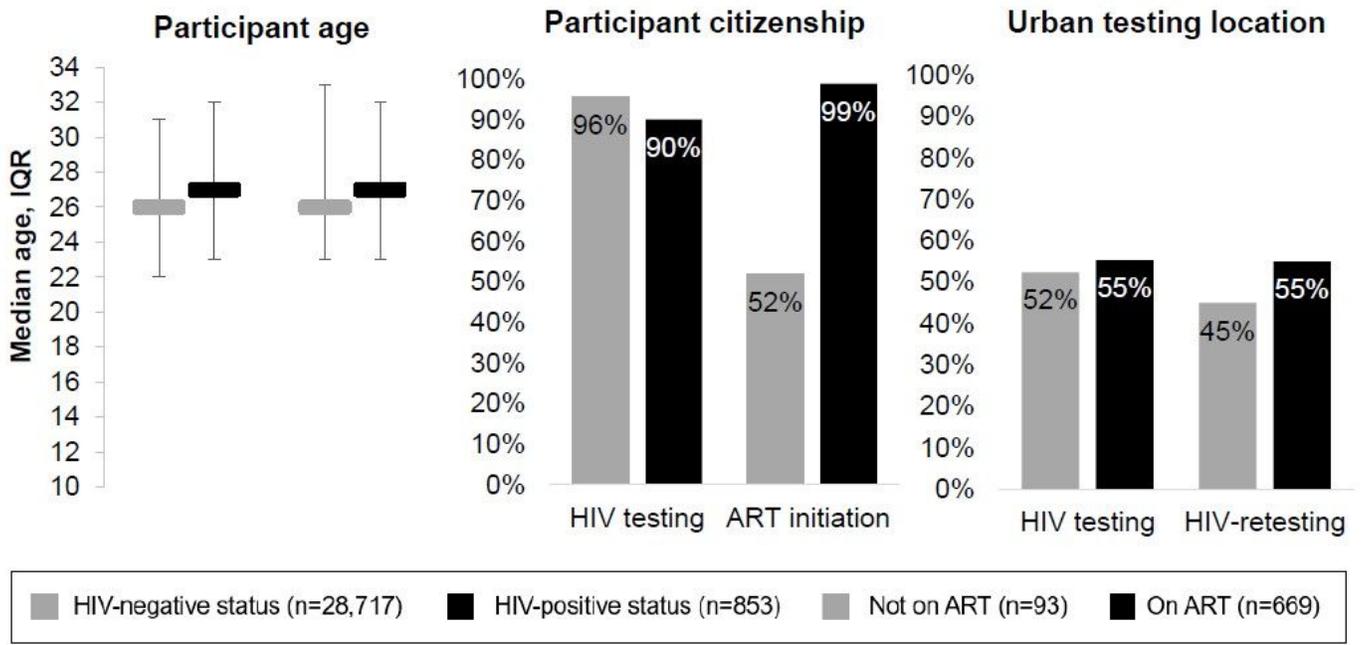


Figure 3

Comparisons in age, citizenship, and ANC clinic location among women with different HIV diagnoses and ART initiation statuses.