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An HIV-1 risk assessment tool for women aged 15-49 in African countries: A machine-learning approach across 15 pooled nationally representative surveys

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BACKGROUND

- Women in Africa disproportionately acquire HIV-1 relative to other global populations. **Understanding which women are most likely to acquire HIV-1 can guide focused prevention, including promotion of pre-exposure prophylaxis (PrEP).**
- The goals of this analysis are: 1) develop a risk assessment tool to identify women most likely to acquire HIV-1 and 2) estimate HIV-1 infections averted with focused PrEP delivery and perfect adherence at 4 sensitivity levels.

METHODS

Data Source

Nationally representative data were collected from 2015-2019 from 15 population-based household surveys:

- *The Fifth South African National HIV Prevalence, Incidence, Behaviour, and Communication Survey (SABSSM-V)*
- *The Nigeria HIV/AIDS Indicator and Impact Survey (NAIIS)*
- *Population-based HIV Impact Assessment surveys (PHIAs)*

Sample and Target Population

- This analysis included 209,012 women aged 15-49 years who tested HIV-1 sero-negative or had recent HIV-1, characterized by HIV limiting antigen avidity enzyme immunoassay, HIV-1 viral load, and detection of antiretroviral drugs in their survey blood samples.
- This represents a population of 118 million women with an estimated 402,000 new annual infections.

	Study Sample	Target Population
Southern Africa	21%	19%
Eastern Africa	31%	34%
West/Central Africa	48%	47%
Total N	**209,012**	**118 million**

Modeling and Evaluation

- Least absolute shrinkage and selection operator regression (LASSO) models were fit with 28 variables to predict recent HIV-1.
- Models were trained on the full population and internally validated using five-fold cross validation.
- Performance was evaluated using area under the receiver-operating-characteristic curve (AUC).
- Potential cases averted and HIV-1 incidence were estimated, assuming perfect PrEP adherence among all women at four sensitivity thresholds: 5%, 33%, 67%, 95%.

Our tool predicted which women aged 15-49 were at highest risk of acquiring HIV-1 in a population of 118 million women in 15 countries.

RESULTS

- AUC was 0.80 (CI: 0.76-0.84) in the full population; cross-validated AUC was 0.79 (CI: 75-0.84) (Figure 2).
- Only two of 26 variables were retained in the model: proportion of adults in their subnational area with viremia and having a partner living outside the home (Figure 3).

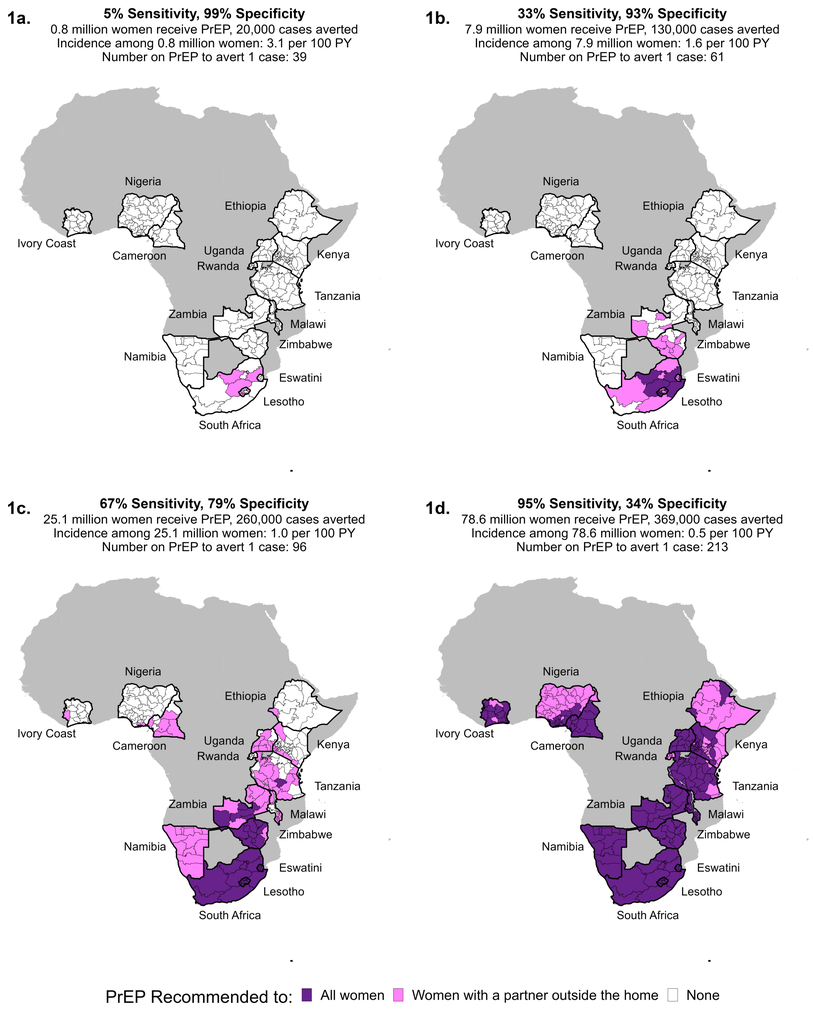

Figure 1. *This series of maps shows the number of women aged 15-49 years for whom PrEP is recommended at four sensitivity-specificity thresholds along the AUC curve depicted in figure 2. In areas shaded in dark purple, PrEP is recommended for all women aged 15-49 years. In areas shaded in light purple, PrEP is recommended for women with a partner outside of the home.*

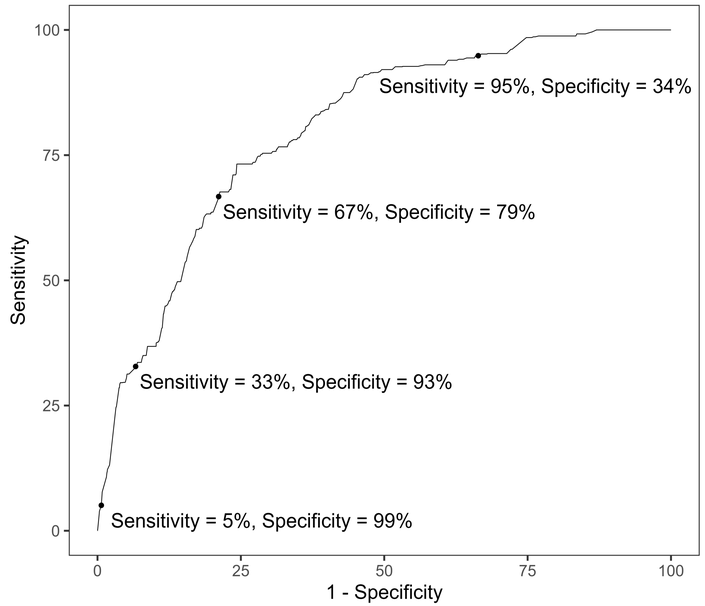

Figure 2. *This figure presents the ROC curve and four different sensitivity-specificity values that correspond to the points on the map. The overall AUC is 0.80 (95% CI: 0.76-0.84).*

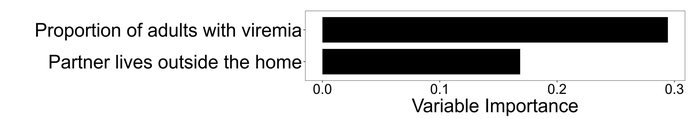

Figure 3. *This figure depicts the relative importance of the two variables that were retained.*

CONCLUSIONS

- Our risk assessment tool retained two variables to identify women most likely to acquire HIV-1: living in a sub-national area with a high proportion of adults with viremia and having a sexual partner living outside the home.
- HIV-1 acquisition is not evenly distributed, with most infections occurring among a small fraction of women.
- This predictive, generalizable, and parsimonious tool has the potential to guide high-impact PrEP delivery.

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