Spatio-temporal estimates of HIV risk group proportions for adolescent girls and young women across 13 priority countries in sub-Saharan Africa

MRC Centre for Global Infectious Disease Analysis Seminars

Adam Howes

Imperial College London

May 2022

Background

- In sub-Saharan Africa, adolescent girls and young women (AGYW) aged 15-29 are disproportionately at risk of HIV infection
- This disparity is because of:
  1. Younger age at first sex
  2. Age patterns of sexual mixing
  3. Structural vulnerabilities and power imbalances
  4. Increased susceptibility to HIV infection

Prevention packages

- Prevention
  - Core package
  - Intensified interventions
- It's important to priorisite intensified interventions to those at highest risk

Stratified prevention

The Global AIDS strategy 2021-2016 proposed stratifying HIV prevention for AGYW based upon

1. Population-level HIV incidence
2. Individual-level sexual risk behaviour

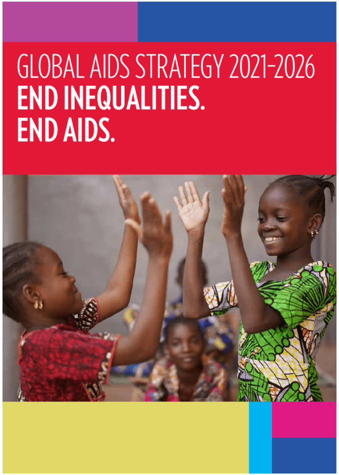


Figure 1: Global AIDS strategy

Scope for our work

Goals

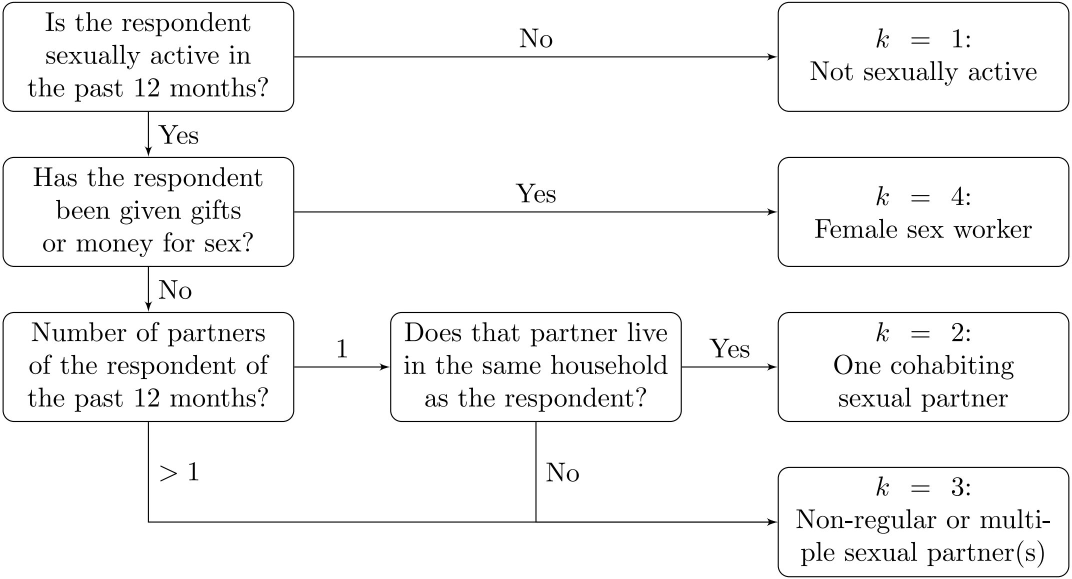
1. Enable implementation of prevention stratified by incidence and behaviour
2. Assess the benefits of such approaches

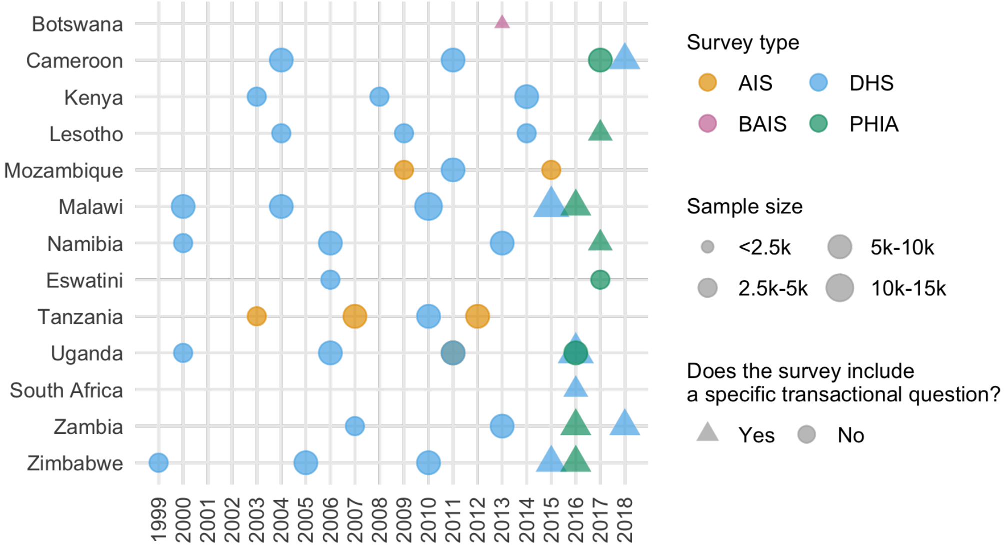
Approach

1. Estimate the proportion of AGYW in four behavioural risk groups at a district level (in 13 countries identified as priority by The Global Fund)
2. Analyze numbers of new infections reached by stratified prevention strategies

Data

- We used sexual behaviour data from AIS, BAIS, DHS and PHIA household surveys to place respondents into four risk groups:
  1. Not sexually active
  2. One cohabiting sexual partner
  3. Non-regular sexual partner(s)
  4. Female sex workers
- District-level HIV incidence, prevalence, population size estimates from the Naomi model (Eaton et al. 2021)
- Risk ratios from ALPHA network analysis (Slaymaker et al. 2020) and UNAIDS analysis led by Keith Sabin


Is the respondent sexually active in the past 12 months?
No
$k = 1$: Not sexually active
Yes
Has the respondent been given gifts or money for sex?
Yes
$k = 4$: Female sex worker
No
Number of partners of the respondent of the past 12 months?
1
Does that partner live in the same household as the respondent?
Yes
$k = 2$: One cohabiting sexual partner
> 1
No
$k = 3$: Non-regular or multiple sexual partner(s)


Botswana
Cameroon
Kenya
Lesotho
Mozambique
Malawi
Namibia
Eswatini
Tanzania
Uganda
South Africa
Zambia
Zimbabwe
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Survey type
AIS
DHS
BAIS
PHIA
Sample size
<2.5k
5k-10k
2.5k-5k
10k-15k
Does the survey include a specific transactional question?
Yes
No

Two-stage model for risk group proportions

Stage 1: $k = 1, 2, 3^+$

- Multinomial logistic regression model for the proportion of AGYW in the $k = 1, 2, 3^+$ risk groups, using all 47 surveys
- Selected model (by CPO) included:
  - Age country effects (IID)
  - Country effects (IID)
  - Correlated spatial effects (ICAR)
  - Correlated temporal effects (AR1)
- Multinomial-Poisson transformation allowed use of R-INLA for inference

Two-stage model for risk group proportions

Stage 2: $k = 3, 4$

- Logistic regression model for the proportion of those in the $k = 3^+ = \{3, 4\}$ risk groups who are in the $k = 4$ risk group, using only the 13 surveys with a specific transactional sex question
- Selected model (by CPO) included:
  - Age country effects (IID)
  - Country effects (IID)
  - Correlated spatial effects (ICAR)
  - Clients of FSW covariates (Hodgins et al. 2022)
- Used R-INLA for inference

Two-stage model for risk group proportions

Combination and FSW adjustment

- Take 1000 samples from each model, then multiply suitably to generate estimates for all four risk groups
- We adjusted the $k = 4$ risk group to match national FSW estimates from Johnston et al. (2022)

$\implies$ Estimates of risk group proportions ρ_{itak} by district, year and age group

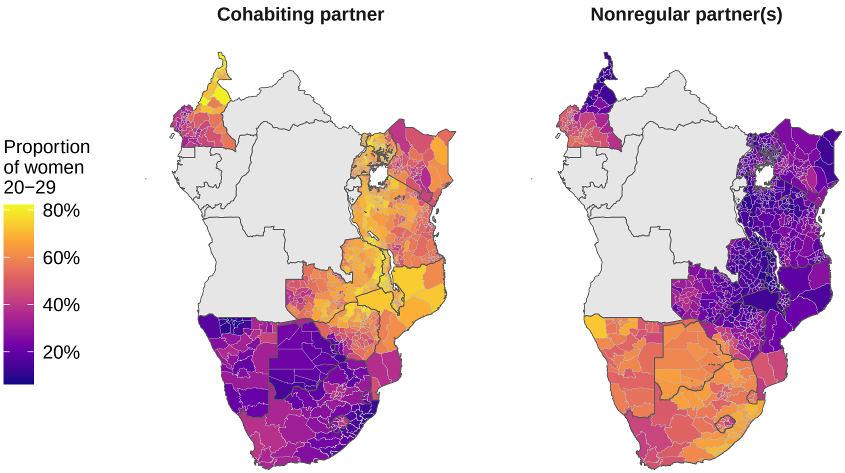


Figure 2: We found a geographic discontinuity in behaviour between Southern and Eastern Africa.

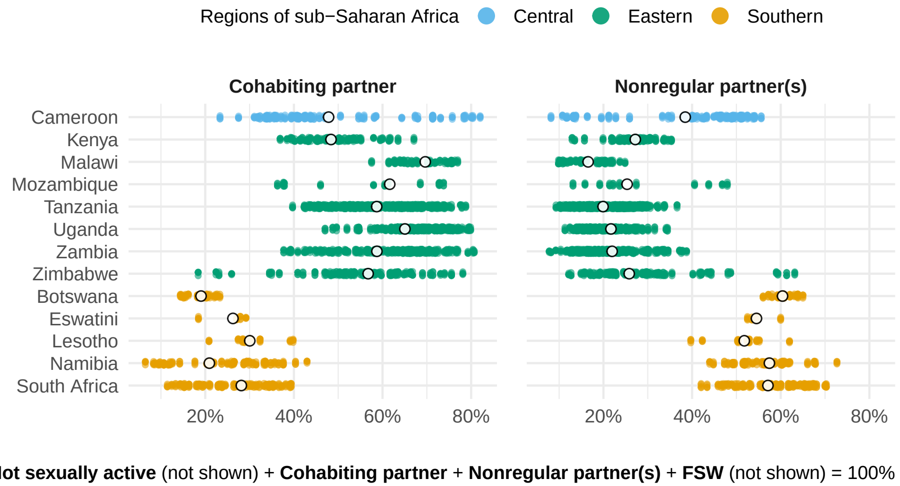


Figure 3: Here is another view of the discontinuity.

Benefits of our modelled risk group estimates

- Integration of all relevant surveys
- Alleivating small-sample sizes by borrowing information
- Estimates where there isn't direct data

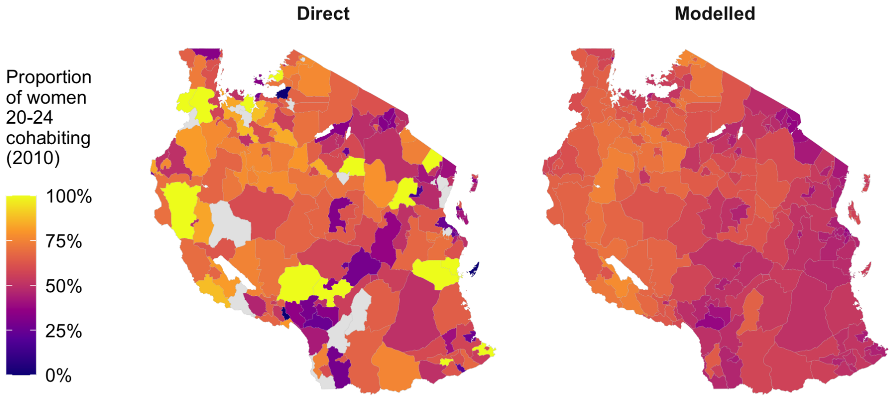


Figure 4: Illustration of the problem with direct survey estimates.

HIV incidence by risk group

- Risk group proportion estimates plus relative risk ratio estimates to disaggregate general population HIV incidence estimates

$$I_{ia} = \sum_k \lambda_{iak} N_{iak}$$
$$= \sum_k \lambda_{ia2} \mathrm{RR}_k N_{iak}.$$

$\implies$ Estimates of HIV incidence λ_{iak} and number of new HIV infections I_{iak} by district, age group and risk group

Prioritisation with risk group information

- Suppose we have all of the information (district, age, and risk group)
- Which are the strata with highest incidence?

area_id	age_group	category	population	incidence
ZMB_2_16	Y015_019	sexpaid12m	30.08	0.20
TZA_4_161rz	Y015_019	sexpaid12m	9.29	0.18
ZAF_2_MAN	Y015_019	sexpaid12m	119.33	0.17
SWZ_1_3	Y015_019	sexpaid12m	74.18	0.17
ZMB_2_21	Y015_019	sexpaid12m	79.16	0.17
ZMB_2_12	Y015_019	sexpaid12m	22.72	0.17

Prioritisation without risk group information

- What about if we lost the risk group information? Now what are the strata with the highest incidence?

area_id	age_group	population	incidence
SWZ_1_2	Y025_029	8395.92	0.03
MOZ_3_0820	Y020_024	6517.29	0.03
MOZ_3_0803	Y020_024	4278.59	0.03
SWZ_1_2	Y020_024	9915.55	0.03
MOZ_3_0816	Y020_024	11857.78	0.03
SWZ_1_3	Y025_029	17643.13	0.03

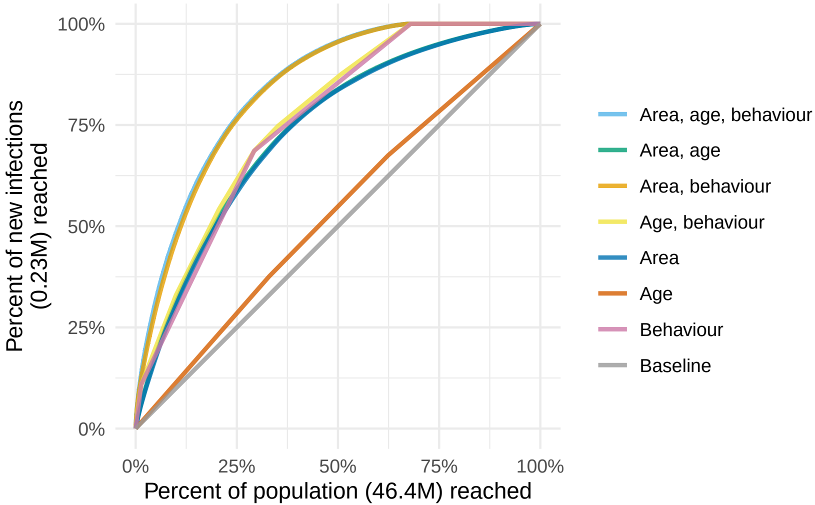


Figure 5: New infections reached prioritising according to different stratifications.

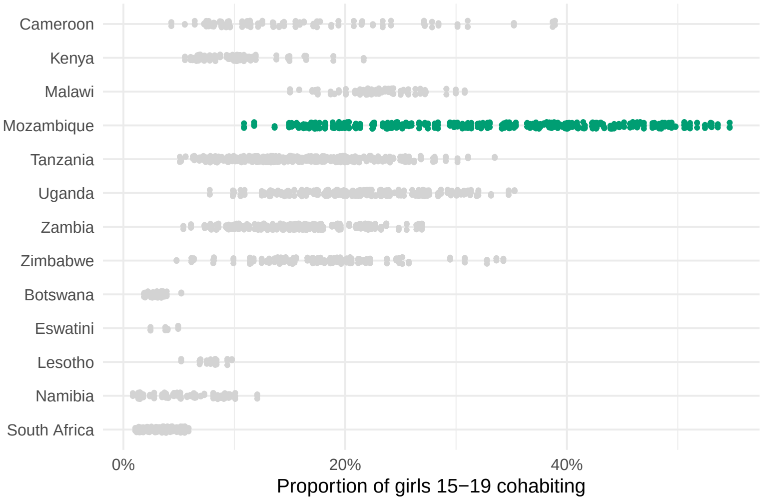


Figure 6: Mozambique stands out.

Limitations

- Simplistic infections reached analysis
- Under-reporting of high risk sexual behaviours
- Risk groups definition justification not clear
- Only focused on AGYW 15-29

Takeaways

- Risk group estimates can help implement the Global AIDS Strategy; tool and user guide currently being prepared!
- Importance of reaching FSW
- Countries have different epidemic profiles

Thanks for listening!

- Joint work with members of the HIV inference group (hiv-inference.org) particularly Katie Risher and Jeff Eaton
- The code for this project is at github.com/athowes/multi-agyw
- You can find me online at athowes.github.io

Bibliography I

Eaton, Jeffrey W., Laura Dwyer-Lindgren, Steve Gutreuter, Megan O'Driscoll, Oliver Stevens, Sumali Bajaj, Rob Ashton, et al. 2021. "Naomi: a new modelling tool for estimating HIV epidemic indicators at the district level in sub-Saharan Africa." *Journal of the International AIDS Society* 24 (S5): e25788.

Hodgins, Caroline, James Stannah, Salome Kuchukhidze, Lycias Zembe, Jeffrey W Eaton, Marie-Claude Boily, and Mathieu Maheu-Giroux. 2022. "Population Sizes, HIV Prevalence, and HIV Prevention Among Men Who Paid for Sex in Sub-Saharan Africa (2000–2020): A Meta-Analysis of 87 Population-Based Surveys." *PLoS Medicine* 19 (1): e1003861.

Bibliography II

Johnston, Lisa, Kinh Van Nguyen, Sudha Balakrishnan, Chibwe Lwamba, Aleya Khalifa, and Keith Sabin. 2022. "Deriving and interpreting population size estimates for adolescent and young key populations at higher risk of HIV transmission: men who have sex with men, female sex workers and transgender women."

Slaymaker, Emma, Kathryn A. Risher, Ramadhani Abdul, Milly Marston, Keith Tomlin, Robert Newton, Anthony Ndyanabo, et al. 2020. "Risk factors for new HIV infections in the general population in sub-Saharan Africa."