

Successful targeting of HIV prevention using risk behaviour would greatly increase expected new infections preemptively reached.

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

Adam Howes^{1,2}

@adamhowes

ath19@ic.ac.uk

Kathryn A. Risher^{2,3} Van Kinh Nguyen² Oliver Stevens² Katherine M. Jia⁴ Tim M. Wolock^{1,2} Lycias Zembe⁵ Ian Wanyeki⁵ Mary Mahy⁵ Clemens Benedikt⁵ Seth R. Flaxman⁶ Jeffrey W. Eaton²

¹ Department of Mathematics, Imperial College London

² MRC Centre for Global Infectious Disease Analysis, School of Public Health, Imperial College London

³ Department of Medical Social Sciences, Feinberg School of Medicine, Northwestern University

⁴ Harvard T. H. Chan School of Public Health, Harvard University

⁵ Joint United Nations Programme on HIV/AIDS, Geneva, Switzerland

⁶ Department of Computer Science, University of Oxford

Introduction

- Adolescent girls and young women (AGYW) 15-29 face disproportionately high risk of HIV infection, and have been identified as a priority population for prevention efforts
- The UNAIDS Global AIDS Strategy 2021-2026 recommends differentiating services for AGYW geographically based both on individual risk behaviour and epidemic indicators
- We used a spatio-temporal model to estimate the proportion of AGYW in four behavioural risk categories $k = 1 : 4$ in 13 priority countries at a district level in the years 1999-2018

k	Category	Risk ratio
1	Not sexually active	0
2	One cohabiting partner	1
3	Non-regular partner(s)	1.72
4	Female sex workers (FSW)	13

Methods

- We analyzed 47 national household surveys (AIS, BAIS, DHS, PHIA)
- For the categories $k \in \{1, 2, 3^+\}$ we fit a survey-weighted multinomial logistic regression via the multinomial-Poisson transformation

$$y_{ita}^* \sim \text{Poisson}(\kappa_{ita}),$$

$$\log(\kappa_{ita}) = \underbrace{\theta_{ita}}_{\text{Observation (IID)}} + \underbrace{\beta_k}_{\text{Category (IID)}} + \underbrace{\alpha_{ak}}_{\text{Age (IID)}} + \underbrace{\zeta_{ck}}_{\text{Country (IID)}} + \underbrace{\phi_{ik}}_{\text{Spatial (Besag)}} + \underbrace{\gamma_{tk}}_{\text{Temporal (AR1)}}$$

where $p_{ita} = \text{softmax}(\kappa_{ita})_k$

- Using the Poisson formulation facilitated inference using integrated nested Laplace approximation (Rue, Martino, and Chopin 2009) via R-INLA
- To estimate the FSW proportion we used the 13 surveys with a transactional sex question to fit a survey-weighted logistic regression

$$y_{ia4}^* \sim \text{Binomial}(y_{ia3} + y_{ia4}, p_{ia4} / (p_{ia3} + p_{ia4})),$$

$$\text{logit}(p_{ia4} / (p_{ia3} + p_{ia4})) = \beta_0 + \beta_{\text{cfswever}} x_c + \underbrace{\alpha_a}_{\text{Age (IID)}} + \underbrace{\zeta_c}_{\text{Country (IID)}} + \underbrace{\phi_i}_{\text{Spatial (Besag)}}$$

where x_c is the proportion of men in each country who are clients of FSW (Hodgins et al. 2021)

- We aligned our FSW estimates to the national-level UNAIDS Key Populations Atlas (Johnston et al. 2022)
- We estimated incidence and number of expected new infections by risk group using the risk ratios to disaggregate Naomi model (Eaton et al. 2021) general population incidence estimates

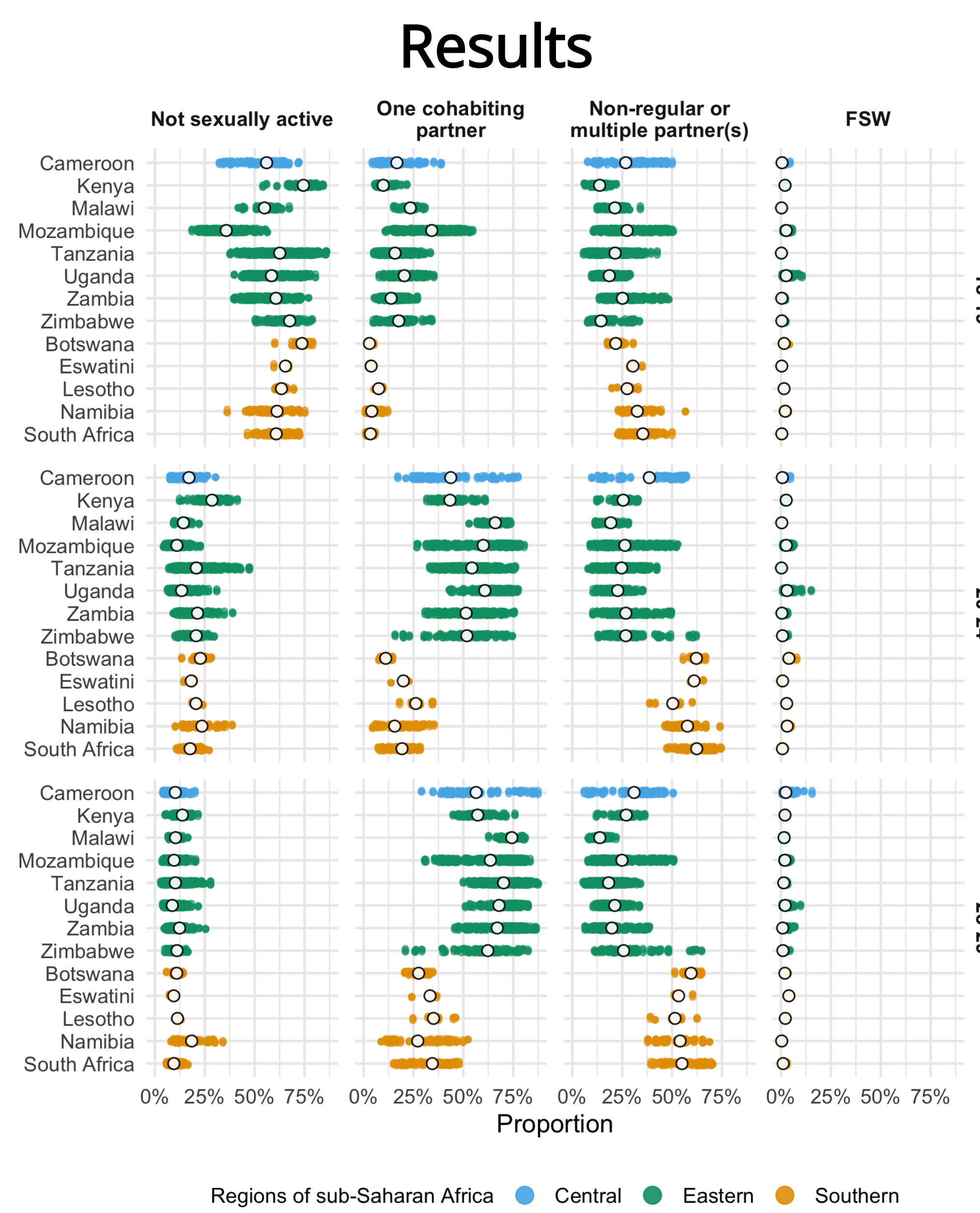


Figure 1: Dotplots showing the posterior mean of our district level estimates (in colour) and national estimates (in white) in 2018.

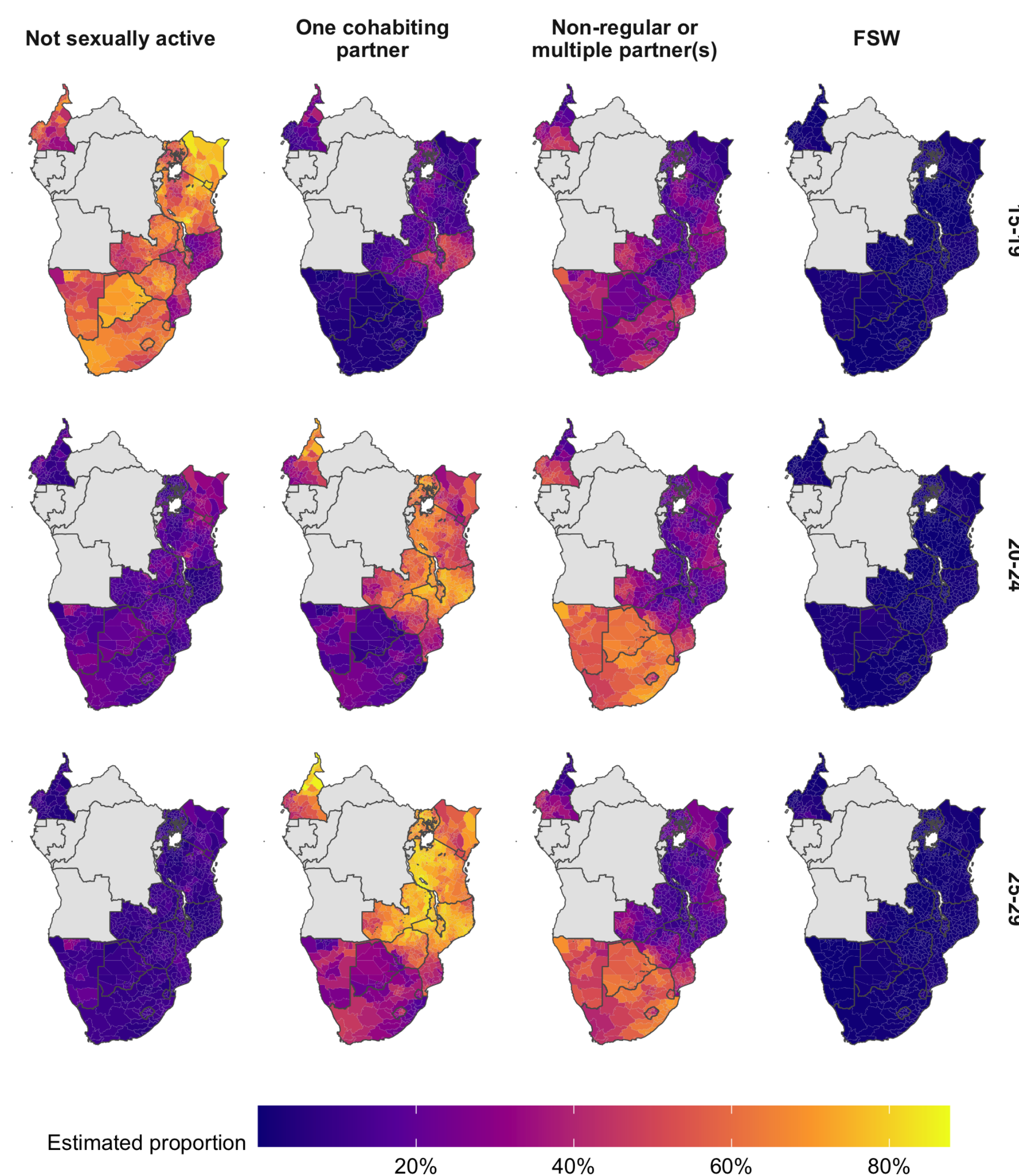


Figure 2: Choropleths showing the posterior mean of our district level estimates in 2018.

- There is significant variation in risk group proportions within and between countries, as well as between age groups (but close to no change over time)

- We found a geographic delineation, with cohabiting more common in the east and non-regular partner(s) more common in the south
- Large numbers of 15-19 in Mozambique have early sexual debut and are already cohabiting

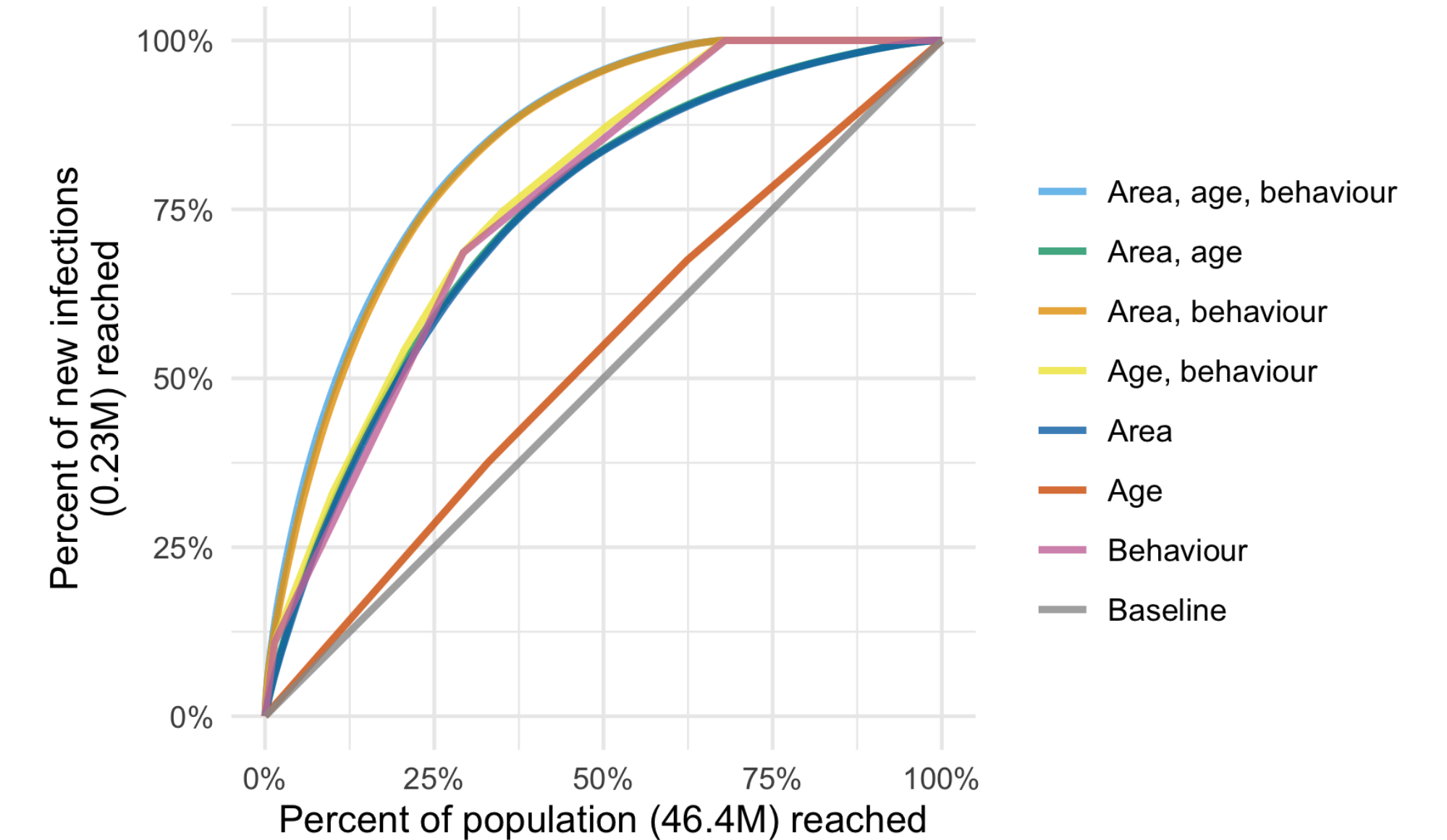


Figure 3: Comparison of targeting strategies

- Using location, age and behavioral risk stratification, 25% of expected new infections can be found by reaching 3% of the population, compared with 8% of the population when behaviour is excluded
- Majority of this benefit comes from reaching FSW, who are 3.5% of the at risk population but 21.0% of all expected new infections

Discussion

- Using a modular approach allowed us to integrate all data from non-conformable surveys
- Spatio-temporal smoothing can be used to overcome high variance from the small sample sizes that result when further stratifying districts
- Individual behaviour is a key determinant of risk and providing prevention services on the basis of behavior would allow many more expected new infections to be reached, especially among FSW

Limitations

- No assessment of practicalities or costs of risk stratification approaches, or efficacy of available interventions
- No adjustment for reporting bias
- Risk category definitions could be disputed
 - What constitutes sex work?
 - Is within-group risk heterogeneity small enough?

Future work

- Inclusion of more surveys e.g. VACS
- Extension to general population: men and women 15-49

Funding AH was supported by the EPSRC and Bill & Melinda Gates Foundation. This research was supported by the MRC Centre for Global Infectious Disease Analysis.

References

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. 2021. "HIV prevalence, population sizes, and HIV prevention among men who paid for sex in sub-Saharan Africa: a meta-analysis of 82 population-based surveys (2000-2020)." *Journal of the International AIDS Society* 24 (S5): e25788.

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." *Journal of the International AIDS Society* 24 (S5): e25788.

Rue, Håvard, Sara Martino, and Nicolas Chopin. 2009. "Approximate Bayesian inference for latent Gaussian models by using integrated nested Laplace approximations." *Journal of the Royal Statistical Society: Series B (Statistical Methodology)* 71 (2): 319-92.