A multinomial spatio-temporal model for sexual risk behaviour with application to adolescent girls and young women in 13 sub-Saharan African countries

HIV Inference Lab Group Meeting

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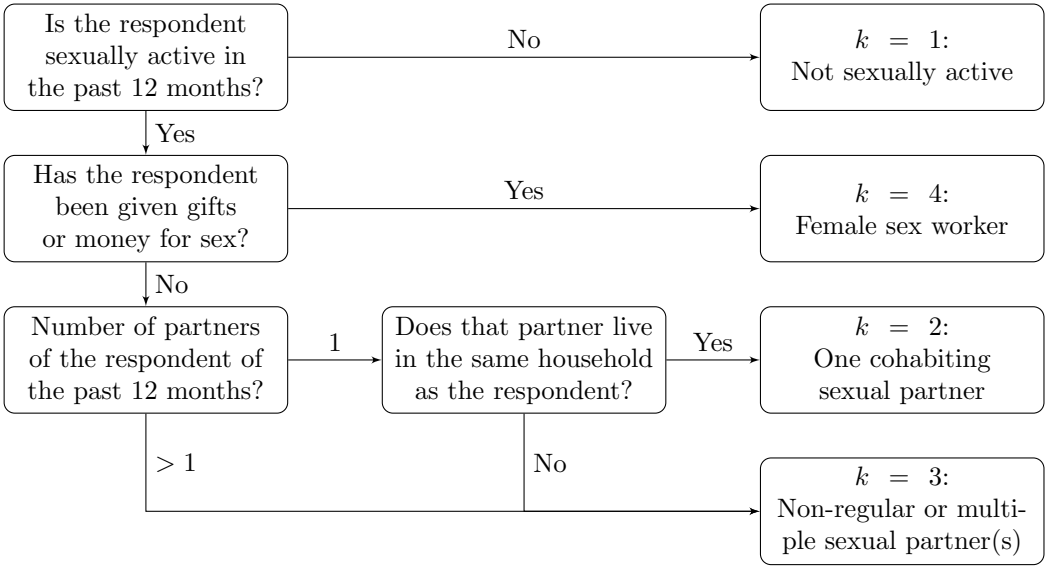
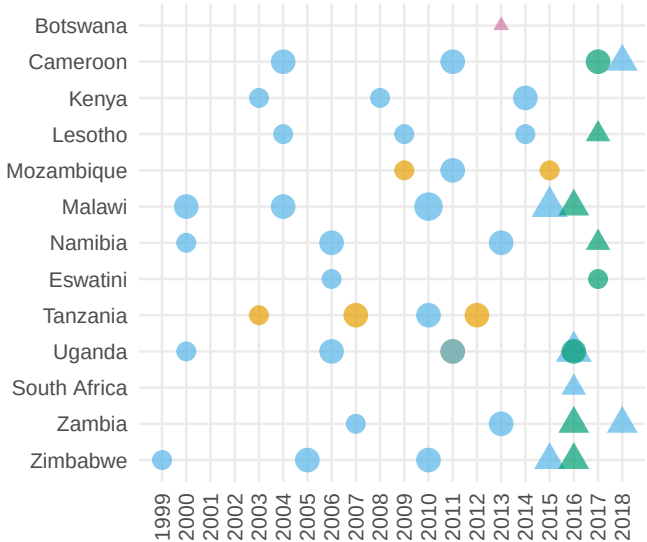
Category	Description	Risk ratio	Notes
None	Not sexually active	0	Ignores incidence from e.g. drug injection (assumed to be negligible).
Low	One cohabiting sexual partner	1	Baseline category.
High	Non-regular sexual partner(s)	1.72	From ALPHA network pooled analysis. Supported by Jia et al.
Very high	Young women from key populations	13	Sabin et al.

Table 1: HIV risk categories and risk ratios.


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

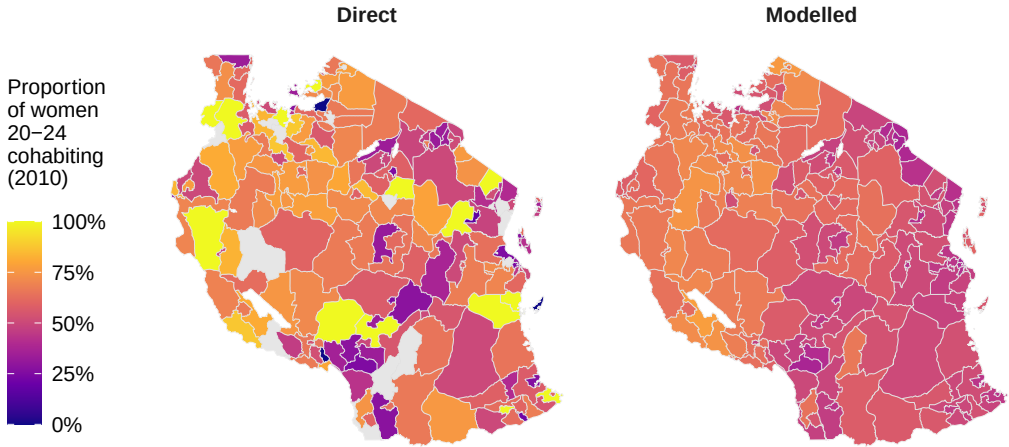
Statistical model

Fit 13 models of the form:

$$y^{\star}_{itak} \sim \text{xPoisson}(\lambda_{itak}) \tag{1}$$

$$\log(\lambda_{itak}) = \beta_k + \alpha_{ak} + \phi_{ik} + \gamma_{tk} + \delta_{itk} + \theta_{ita}. \tag{2}$$

Model ID	Spatial structure	Temporal structure	Spatio-temporal interaction
1	None	None	✗
2	IID	None	✗
3	Besag	None	✗
4	None	IID	✗
5	IID	IID	✗
5x	IID	IID	✓
6	Besag	IID	✗
6x	Besag	IID	✓
7	None	AR1	✗
8	IID	AR1	✗
8x	IID	AR1	✓
9	Besag	AR1	✗
9x	Besag	AR1	✓


Direct
Modelled
Proportion of women 20−24 cohabiting (2010)
100%
75%
50%
25%
0%

Benefits of smoothing

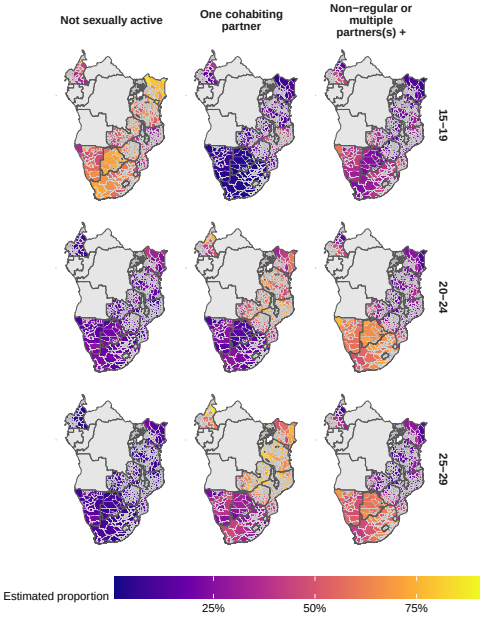
1. Get estimates even where there isn't direct data

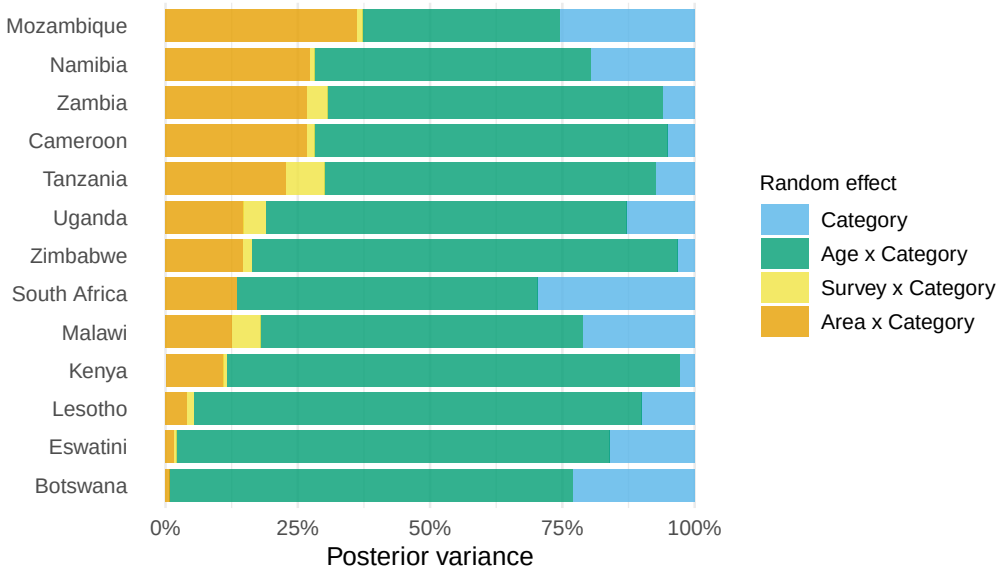
- Some people think of this as "making up data"
- In some sense all estimates are "made up" though
- Uncertainty should be higher in regions with infilling
- Perhaps we do a bad job communicating uncertainty, or it's just hard

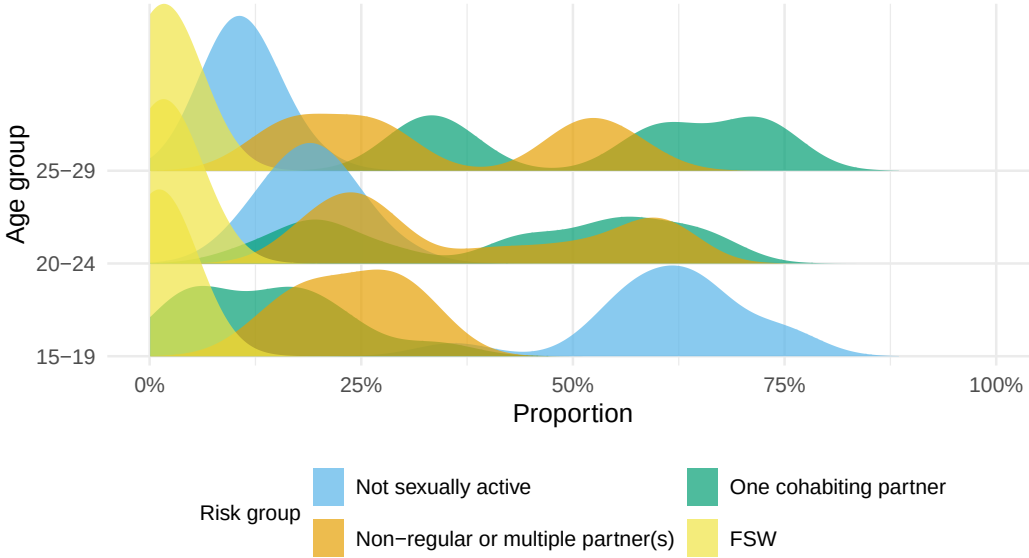
Benefits of smoothing

2. Borrow information across space, surveys, categories

- Space-category effects, survey-category effects, space-survey-category effects (using Kronecker products)
- Fun to think about what models might be reasonable for this and whether structured category effects might be interesting
  - e.g. some model for misclassification of individuals into categories could give a kind of structured category effect (currently it's IID always)
- Wonder to what extent we're oversmoothing
  - e.g. might expect to see discontunities in the data (e.g. urban centers) which we're smoothing away


Not sexually active
One cohabiting partner
Non−regular or multiple partners(s) +
15–19
20–24
25–29
Estimated proportion
25%
50%
75%


Mozambique
Namibia
Zambia
Cameroon
Tanzania
Uganda
Zimbabwe
South Africa
Malawi
Kenya
Lesotho
Eswatini
Botswana
0%
25%
50%
75%
100%
Posterior variance
Random effect
Category
Age x Category
Survey x Category
Area x Category


Age group
25–29
20–24
15–19
0%
25%
50%
75%
100%
Proportion
Risk group
Not sexually active
Non−regular or multiple partner(s)
One cohabiting partner
FSW

Next steps

- Feedback on paper from people who know more about country contexts
- Connect more to policy. For example by replicating Katie's "number of new infections by risk group" spreadsheet
- Add logistic regression model for proportion of non-regular partner(s) who are KP