Using statistics to guide response to the HIV epidemic

High Impact Medicine

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Outline

1. Precision public health for HIV
2. Estimating risk group proportions
3. Some broader thoughts on careers

1. Precision public health for HIV

What is precision public health

- In medicine, we want to deliver the right intervention, at the right time
- Precision medicine seeks to do it at the individual-level
- Precision public health seeks to do it at the population-level

*Recognizing that **"one size does not fit all"**, the Strategy prioritizes tailoring of differentiated service packages and service delivery approaches to the **unique needs of people, communities and locations**, using granular data to focus programmes most effectively.*

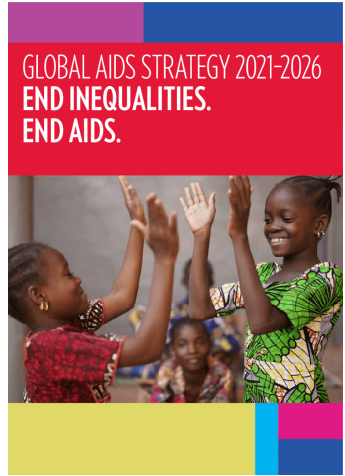


Figure 1: A key feature of the HIV response, both historically and into the future.

How can statistics help?

- Granular estimates of relevant quantities are required
- Disaggregation by geography, sex, age, and behaviour

  - HIV prevalence: proportion of people who are infected
  - HIV incidence: rate of new infections
  - Antiretroviral therapy (ART) coverage: proportion of people living with HIV who take ART

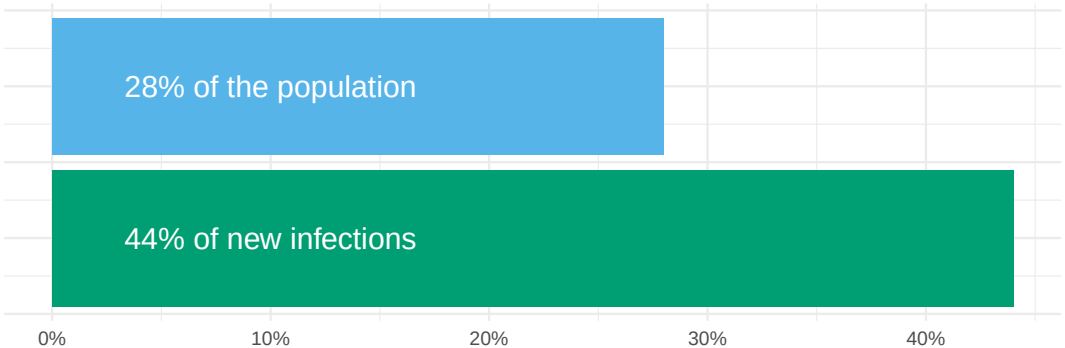
Fast-Track Targets

by 2020	by 2030
90-90-90 Treatment	**95-95-95** Treatment
500 000 New infections among adults	**200 000** New infections among adults
ZERO Discrimination	**ZERO** Discrimination

Figure 2: Example population health goals.

2. Estimating risk group proportions

Adolescent girls and young women (AGYW) 15−29 are



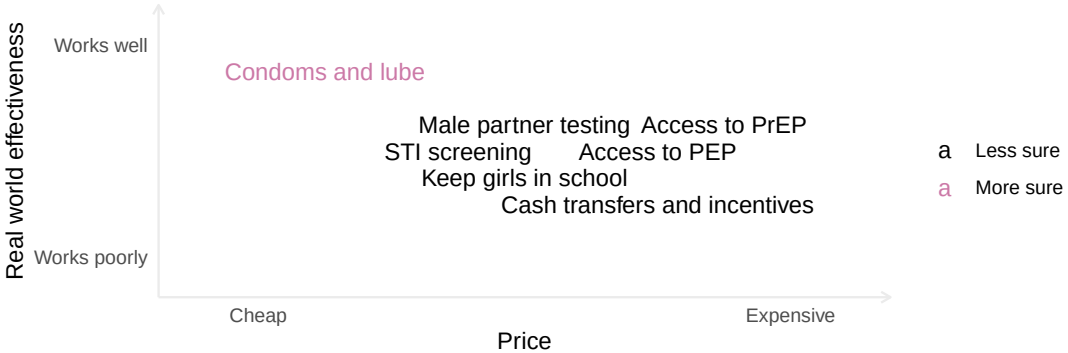
(Across 13 AGYW priority countries in sub−Saharan Africa)

Why?

1. Younger age at first sex
2. Age patterns of sexual mixing
3. Structural vulnerabilities and power imbalances
4. Increased susceptibility to HIV infection

Figure 3: Convergence of marginal utility with equity and human rights.

Insufficient resources to provide all interventions to everyone



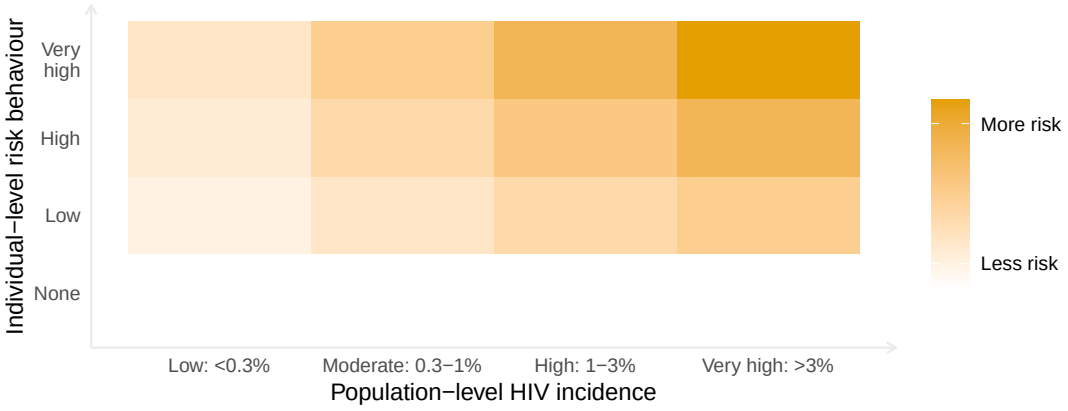
Positions on plot depend on setting and should not be interpreted too precisely.
Some interventions do not only have the effect of reducing HIV incidence.

How to prioritise interventions?

- The most proximal drivers of transmission are

$$\mathbb{P}(\text{transmission}) \propto \text{sexual partnerships} \times \mathbb{P}(\text{each partner can transmit})$$

Important we consider **both** population setting and individual behaviour



Individual-level behavioural risk

Level	Behavioural risk group	Risk ratio
None	Not sexually active	0
Low	One cohabiting partner	1
High	Multiple or non-regular partner(s)	1.72
Very High	Female sex workers	13

The work we've done

- Goal: enable prioritisation of HIV programming for AGYW
- Audience: programme managers, service providers and policy makers
- Plan: estimate district-age-behavioural risk group proportions, HIV prevalences and HIV incidences across 13 high priority countries in sub-Saharan Africa
- Method: a Bayesian spatio-temporal model of survey data

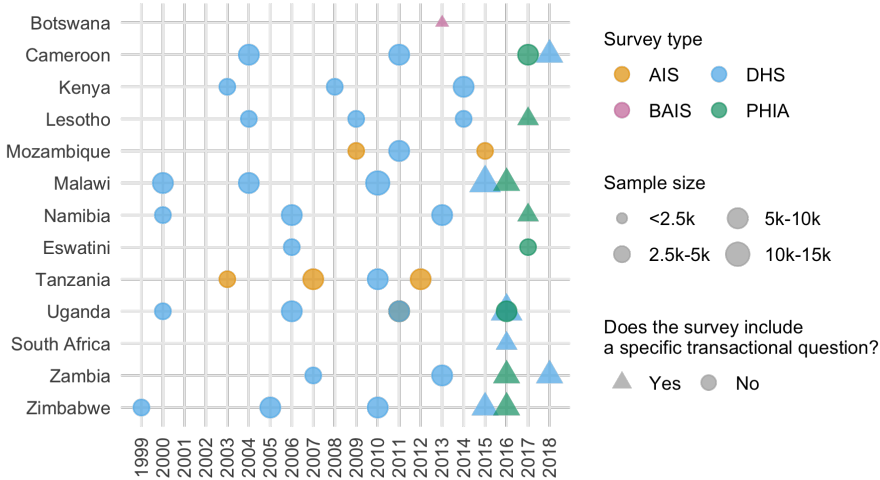


Figure 4: A total of 46 surveys: importantance of good data processing code!

SECTION 7. MARRIAGE AND SEXUAL ACTIVITY

		LAST SEXUAL PARTNER	SECOND-TO-LAST SEXUAL PARTNER	THIRD-TO-LAST SEXUAL PARTNER
715	When was the last time you had sexual intercourse with this person?		DAYS AGO . . 1 WEEKS AGO . . 2 MONTHS AGO . . 3	DAYS AGO . . 1 WEEKS AGO . . 2 MONTHS AGO . . 3
716 (2)	The last time you had sexual intercourse with this person, was a condom used?	YES . . . . 1 NO . . . . 2 (SKIP TO 718)	YES . . . . 1 NO . . . . 2 (SKIP TO 718)	YES . . . . 1 NO . . . . 2 (SKIP TO 718)
717	Was a condom used every time you had sexual intercourse with this person in the last 12 months?	YES . . . . 1 NO 2	YES . . . . 1 NO 2	YES . . . . 1 NO 2
718	What was your relationship to this person with whom you had sexual intercourse? IF BOYFRIEND: Were you living together as if married? IF YES, RECORD '2'. IF NO, RECORD '3'.	HUSBAND . . . . 1 LIVE-IN PARTNER . . . . . 2 BOYFRIEND NOT LIVING WITH RESPONDENT . . . . . 3 CASUAL ACQUAINTANCE . . 4 CLIENT/SEX WORKER . . 5 OTHER ________ 6 (SPECIFY)	HUSBAND . . . . 1 LIVE-IN PARTNER . . . . . 2 BOYFRIEND NOT LIVING WITH RESPONDENT . . . . . 3 CASUAL ACQUAINTANCE . . 4 CLIENT/SEX WORKER . . 5 OTHER ________ 6 (SPECIFY)	HUSBAND . . . . 1 LIVE-IN PARTNER . . . . . 2 BOYFRIEND NOT LIVING WITH RESPONDENT . . . . . 3 CASUAL ACQUAINTANCE . . 4 CLIENT/SEX WORKER . . 5 OTHER ________ 6 (SPECIFY)

Figure 5: Example DHS questionnaire.

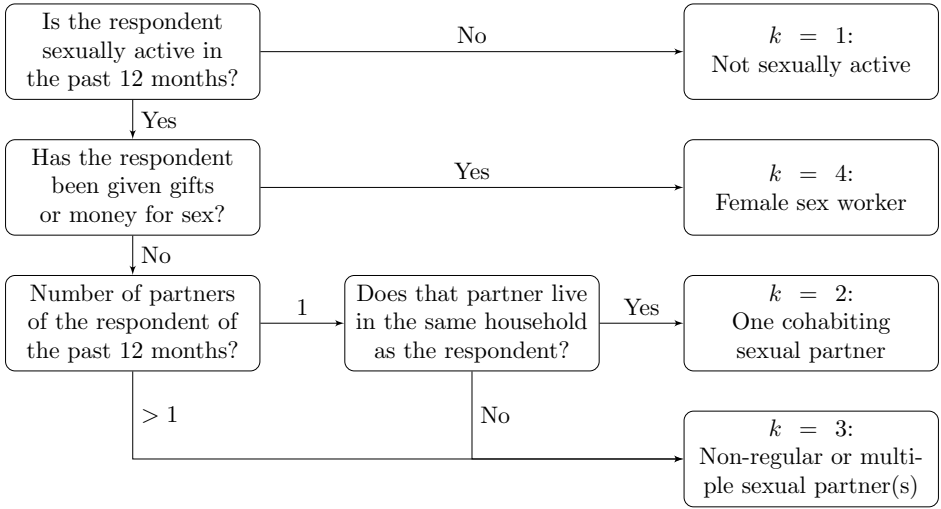


Figure 6: How we allocated survey respondents to risk groups based on the questionnaire.

What do you mean by model?

- Translation of scientific knowledge into a mathematical data generating process. If we wanted to, we could simulate fake data
- Given observed data, we use Bayes theorem to update our beliefs about the parameters of the model

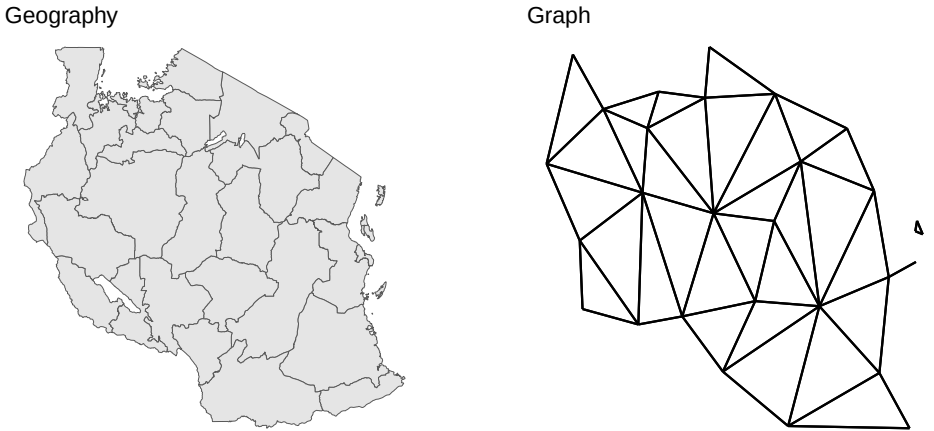


Figure 7: An example of scientific knowledge included in the model is that we assume that neighbouring districts are similar. This is Tobler's first law of geography. The pictured country is Tanzania.

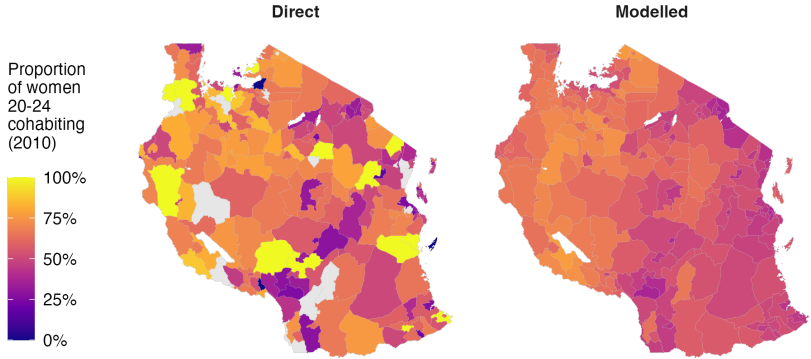


Figure 8: Direct survey estimates are too noisy to work with due to low sample sizes, but our modelled estimates don't have the same issue.

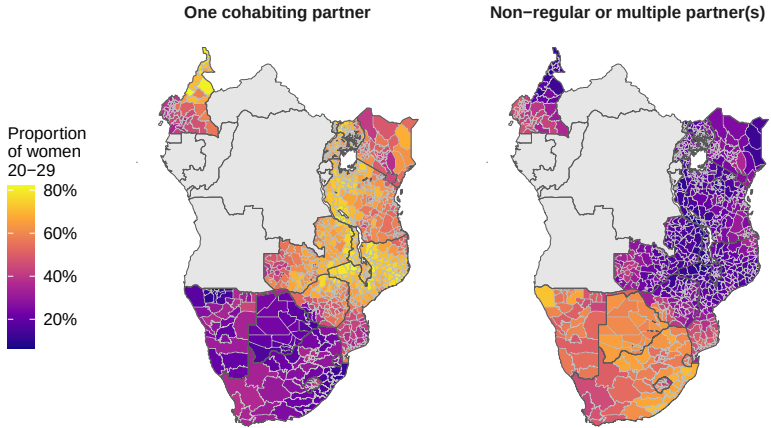


Figure 9: We found a prominent geographic discontinuity between eastern and southen Africa in risk group membership for women 20-29.

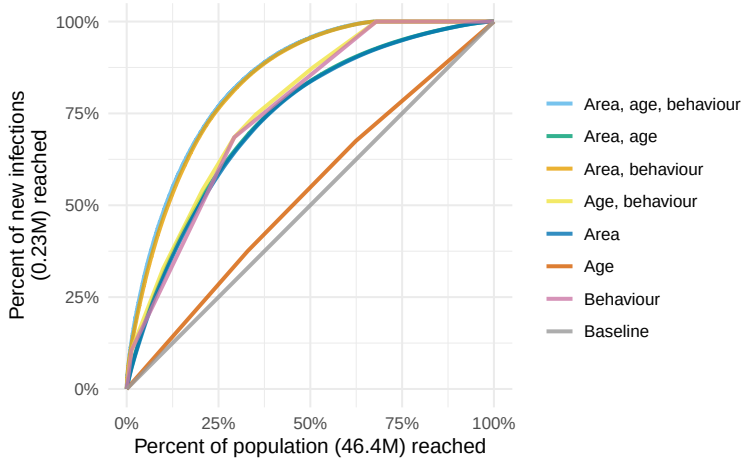


Figure 10: Supposing you prioritised those in the highest incidence strata, what percent of new infections could you find per percent of the population reached?

Where might this work go

- Extension to adults 15-49 and further countries
- Generation of estimates led by country teams as a part of a yearly process
- Virtuous cycle of data ownership, data use, and data quality

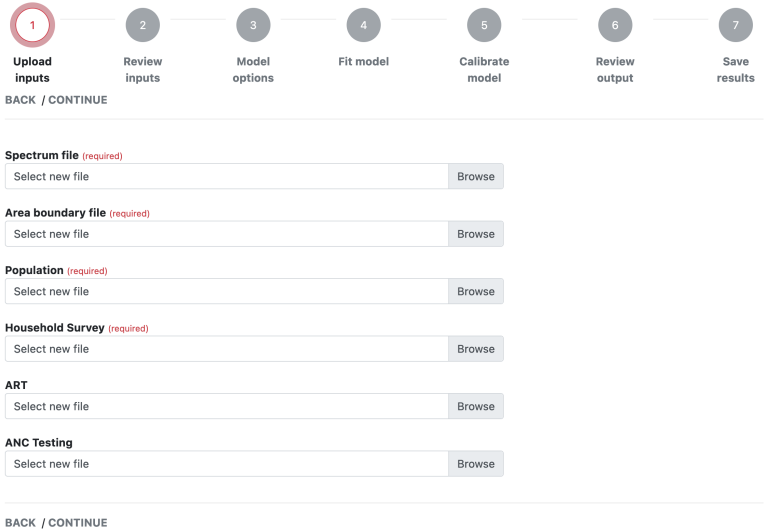


Figure 11: Example of user interface for estimates generation.

3. Some broader thoughts on careers

- Upside: could influence health outcomes for many people
- Downside: part of a (more?) complex theory of change

$$\begin{aligned}\mathbb{P}(\text{impact}) = &\mathbb{P}(\text{relevant people interact with your work}) \\ &\times \mathbb{P}(\text{what you've done is useful}) \\ &\times \mathbb{P}(\text{message correctly conveyed}) \times \cdots \\ &\times \mathbb{P}(\text{intervention technically works}) \\ &\times \mathbb{P}(\text{intervention correctly implemented}) \times \cdots\end{aligned}$$

- How does this balance out?

About me

- Maths undergraduate $\rightarrow$ statistics masters $\rightarrow$ statistics (and machine learning, sort of) PhD
- Involved with Effective Altruism during my masters, and since then I've been interested in impactful applications of statistics

Applied methodology

- Being good (perhaps not great) at a useful enough collection of things
- Feeling like no one cares about the application at methods conferences, and no one cares about the methods at application conferences

Team science

- A lot of disciplines required: Epidemiology, public health, health economics, behavioural science, implementation science, mathematics, statistics, computer science, software engineering
- Academia pushes against this by wanting every contribution to be marginally interesting in each field
- MRC GIDA at Imperial does a good job here, in my opinion

Figure 12: Alternative structures for science.

Thanks for listening!

- More information on my website: athowes.github.io/about
- Feel free to get in contact if I can be useful: ath19@ic.ac.uk
- My PhD is supervised by Seth Flaxman and Jeff Eaton, and the risk group work is in collaboration with Imperial's HIV Inference Group, within the MRC Centre for Global Infectious Disease Analysis, and UNAIDS

MRC Centre for Global Infectious Disease Analysis

Imperial College London

MACHINE LEARNING & GLOBAL HEALTH NETWORK

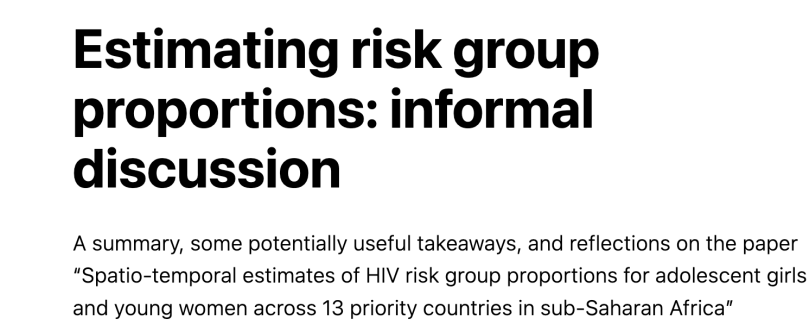


Figure 13: For more (informal!) take a look at the blog post on my website.

Figure 14: For more (formal!) take a look at the paper.