Using statistics to guide response to the HIV epidemic

High Impact Medicine

Adam Howes

Imperial College London

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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.*
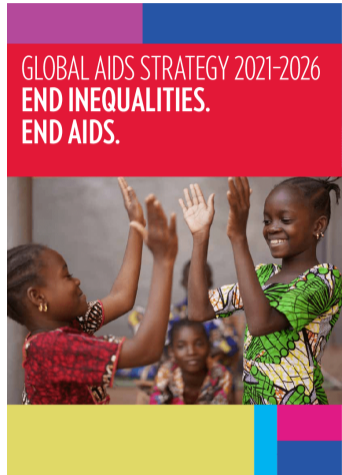

Figure 1: A key feature of the HIV response, both historically and into the future.

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

90-90-90
Treatment

500 000
New infections among adults

ZERO
Discrimination

by 2030

95-95-95
Treatment

200 000
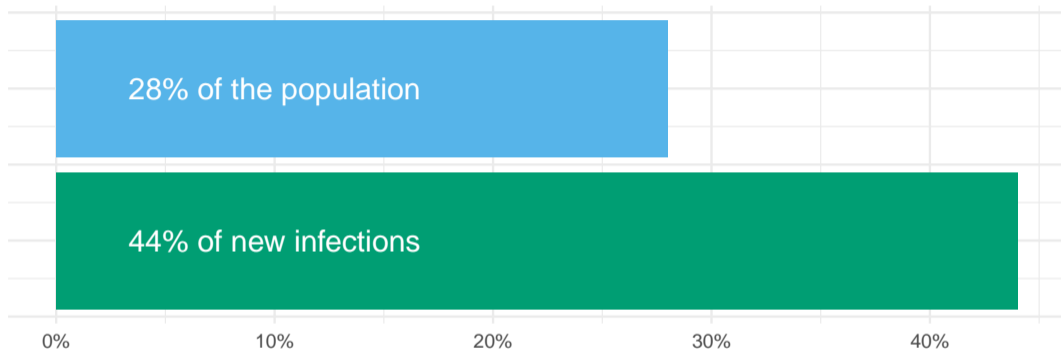New infections among adults

ZERO
Discrimination

Figure 2: Example population health goals.

2. Estimating risk group proportions

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

28% of the population

44% of new infections

0%	10%	20%	30%	40%

(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

Real world effectiveness

Works well

Condoms and lube

Male partner testing Access to PrEP
STI screening   Access to PEP
Keep girls in school
Cash transfers and incentives

a   Less sure
a   More sure

Works poorly

Cheap   Expensive
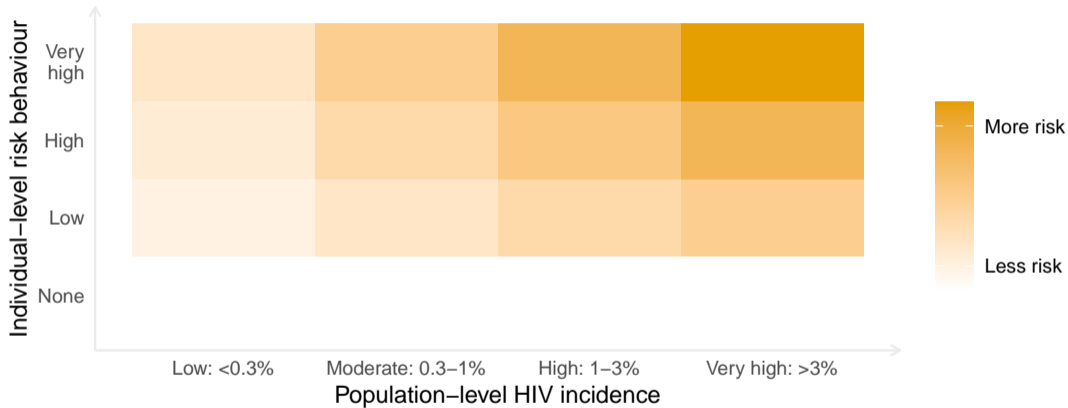
Price

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

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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
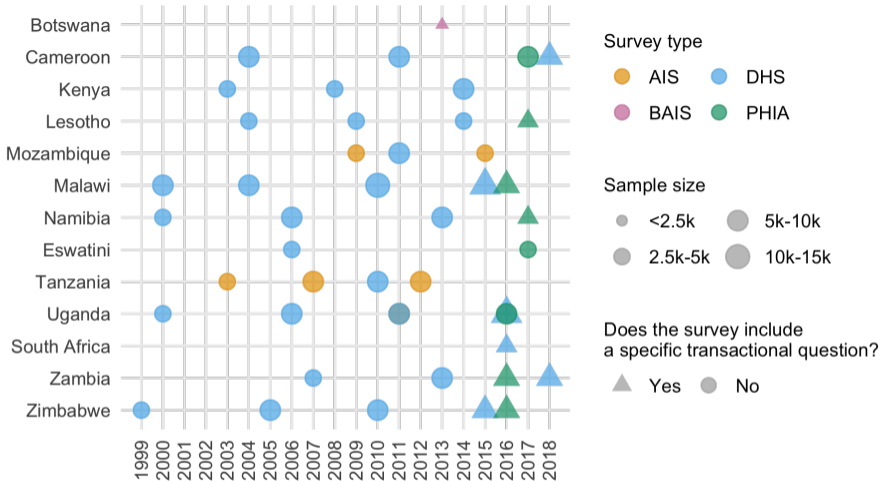- Method: a Bayesian spatio-temporal model of survey data

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

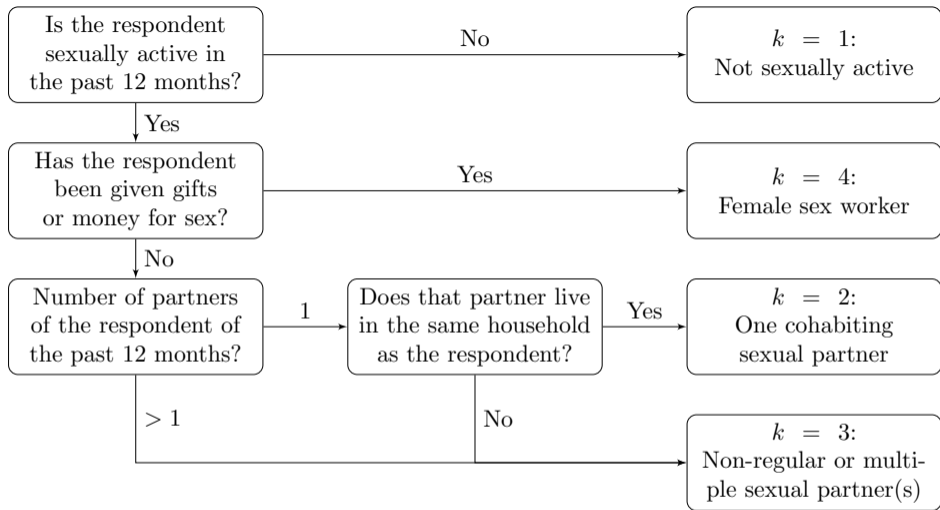|		LAST SEXUAL PARTNER	SECOND-TO-LAST SEXUAL PARTNER	THIRD-TO-LAST SEXUAL PARTNER

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
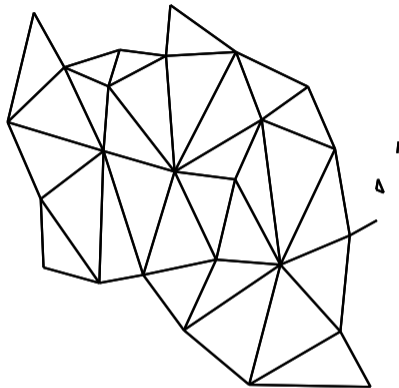
Geography

Graph

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.
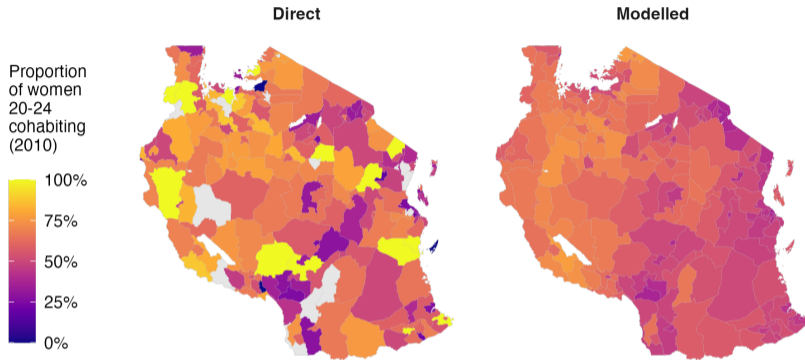
Figure 8: Direct survey estimates are too noisy to work with due to low sample sizes, but our modelled estimates don't have the same issue.
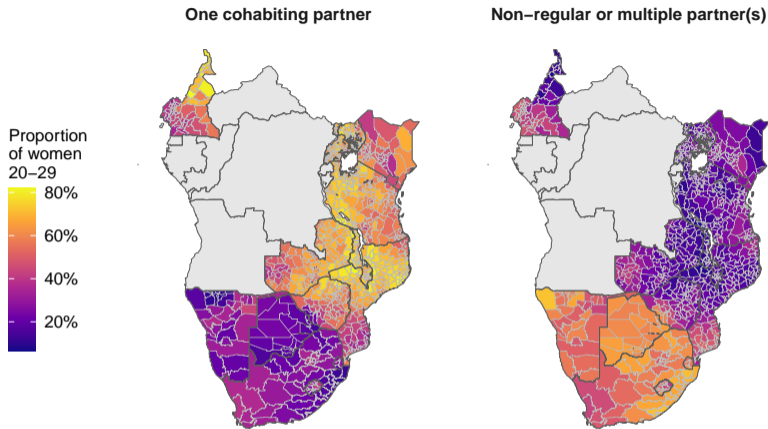
Figure 9: We found a prominent geographic discontinuity between eastern and southen Africa in risk group membership for women 20-29.
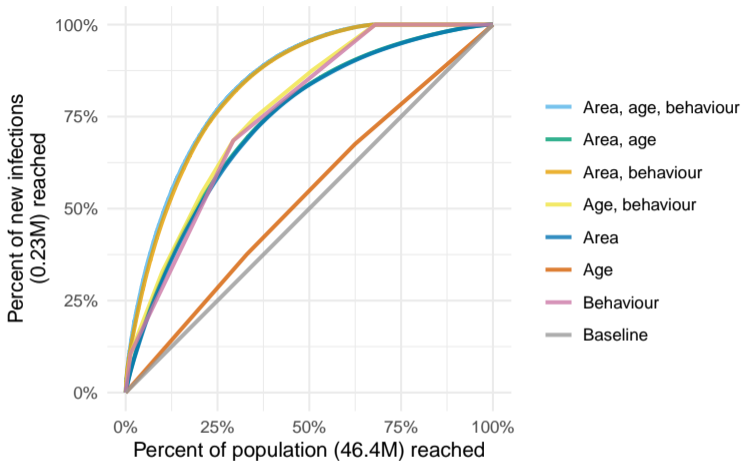
Figure 10: Supposing you prioritised those in the highest incidence strata, what percent of new infections could you find per percent of the population reached?

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

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

- 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

CLEARER THINKING

with Spencer Greenberg

the podcast about ideas that matter

Episode 157: Science is learning from start-ups (with Adam Marblestone)

May 16, 2023

What are focused research organizations? Which kinds of research projects lend themselves to the FRO model? Researchers in academia frequently complain about the incentive structures around funding and publishing; so how do FROs change those dynamics? Why must FROs be time-limited, especially if they're successful? Who's in charge in an FRO? How does "field-building" help to improve science? What effects might large language models have on science?

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

Estimating risk group proportions: informal discussion

A summary, some potentially useful takeaways, and reflections on the paper "Spatio-temporal estimates of HIV risk group proportions for adolescent girls and young women across 13 priority countries in sub-Saharan Africa"

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

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

Adam Howes 🔲, Kathryn A. Risher, Van Kính Nguyen, Oliver Stevens, Katherine M. Jia, Timothy M. Wolock, Rachel T. Esra, Lycias Zembe, Ian Wanyeki, Mary Mahy, Clemens Benedikt, Seth R. Flaxman, Jeffrey W. Eaton

Article	Authors	Metrics	Comments	Media Coverage	Peer Review
⌄					

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