Rose's 'prevention paradox' and HIV

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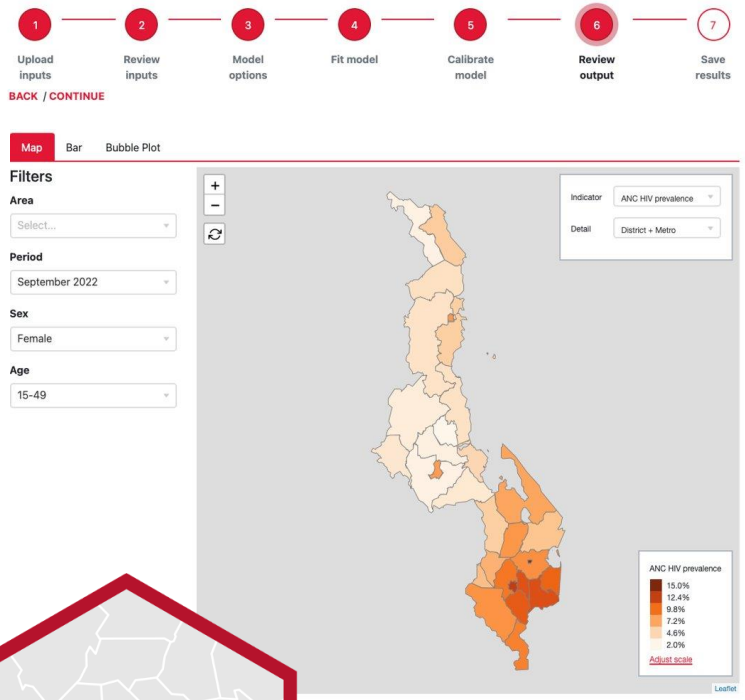
Key messages

Efficient and highly targeted delivery of HIV prevention in contemporary high-burden settings is difficult—for two main reasons:

1. **Transmission dynamics:** In generalized epidemic settings with declining new infections, it is very difficult to predict who will acquire infection
   - Large population with **low-to-moderate, but non-zero, exposure**
   - Low transmission probability per exposure (for HIV: approx. 1 per 1000)
   - → *Classic example of Geoffrey Rose's 'Prevention Paradox'*

2. **Inadequate data:** We do not have very good contemporary data about *who is acquiring HIV infection* in high-burden African settings
   - *We have *mostly* stopped collecting current information about this*

Models and tools used by African MoHs for strategic information to plan HIV programmes

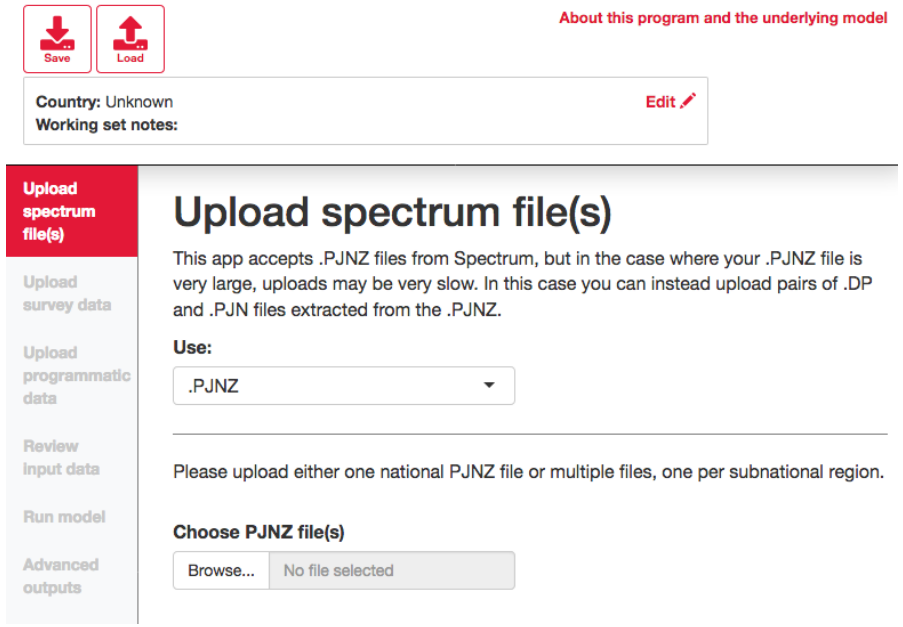


Naomi

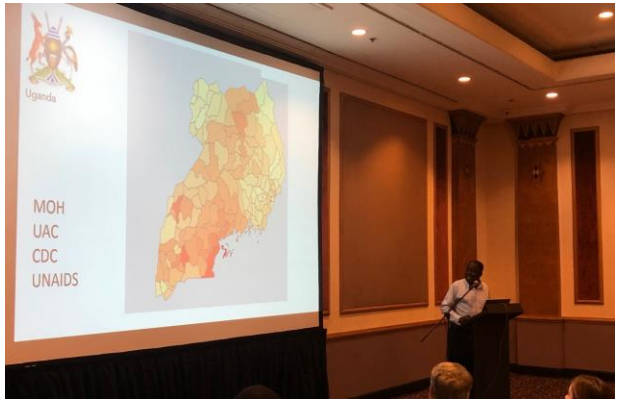
naomi.unaids.org

https://naomi.unaids.org

Shiny 90

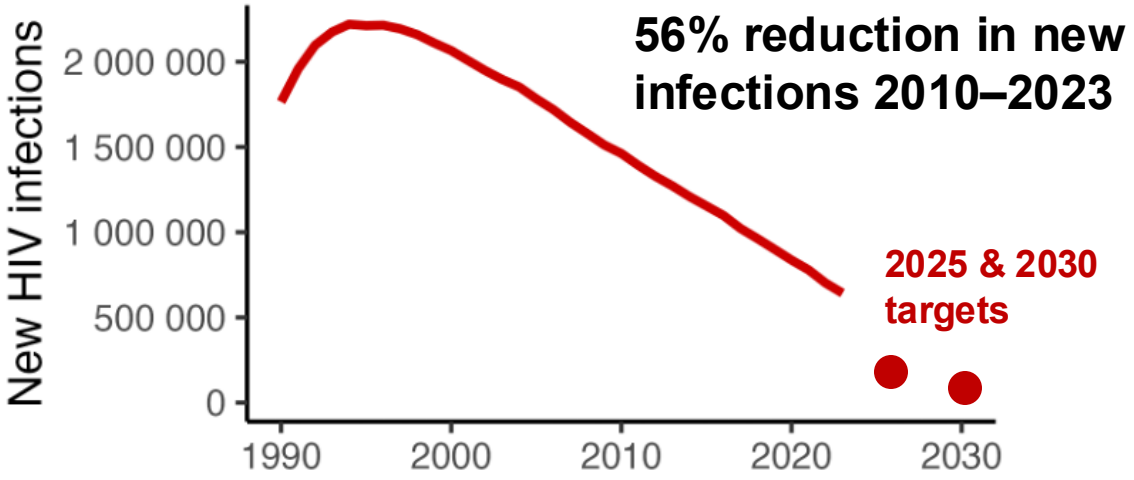


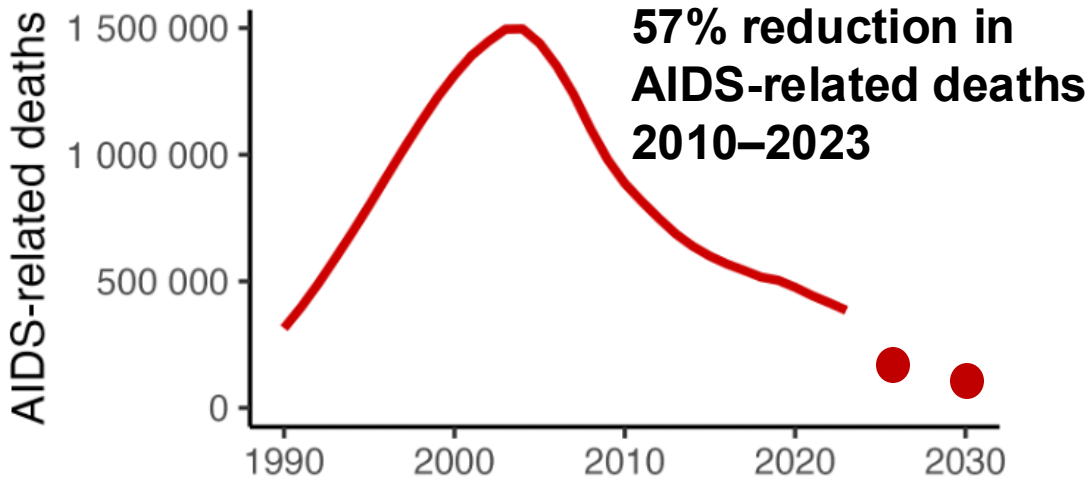
https://shiny90.unaids.org



UNAIDS

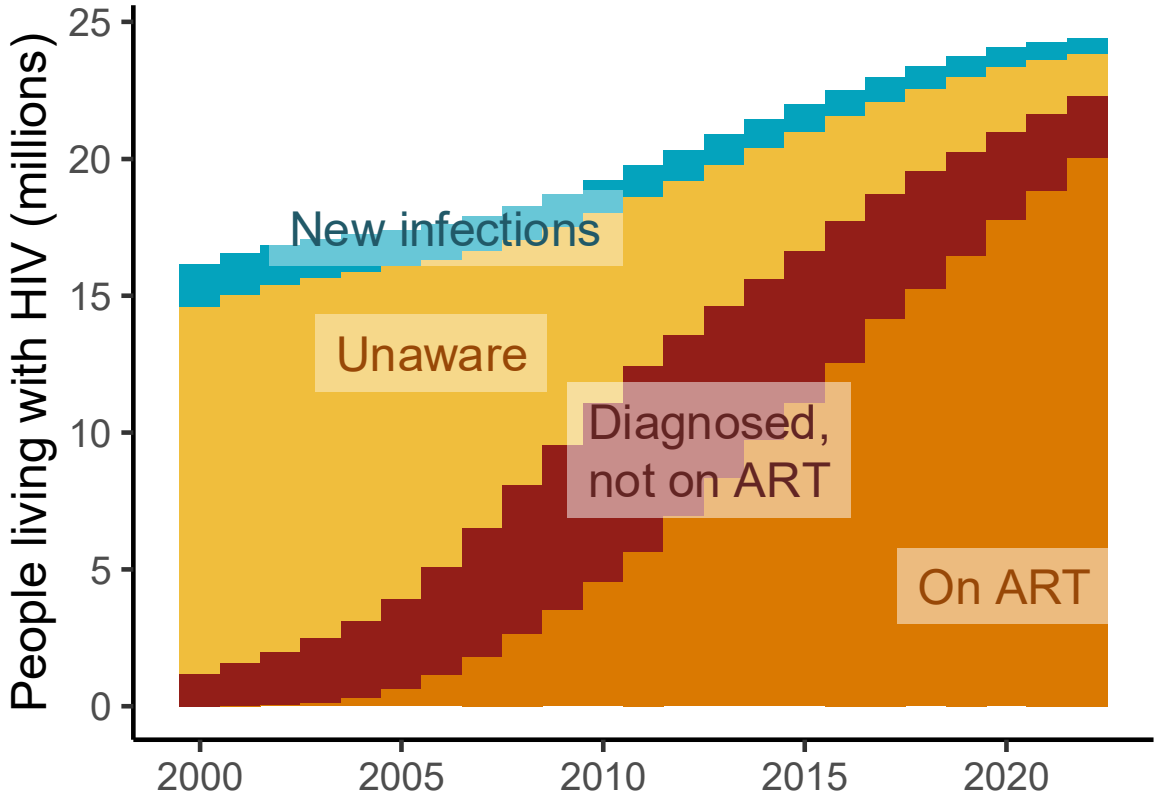
HIV Trends in East, West, Central, and Southern Africa





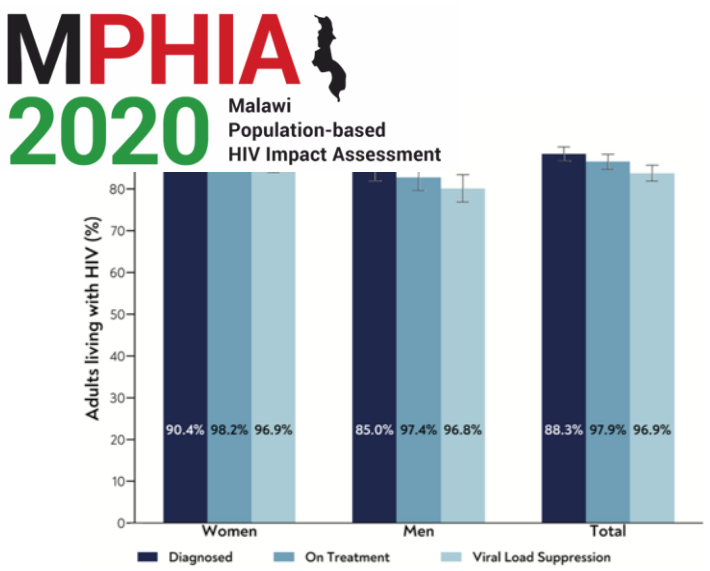
Source: UNAIDS 2024 epidemiological estimates.

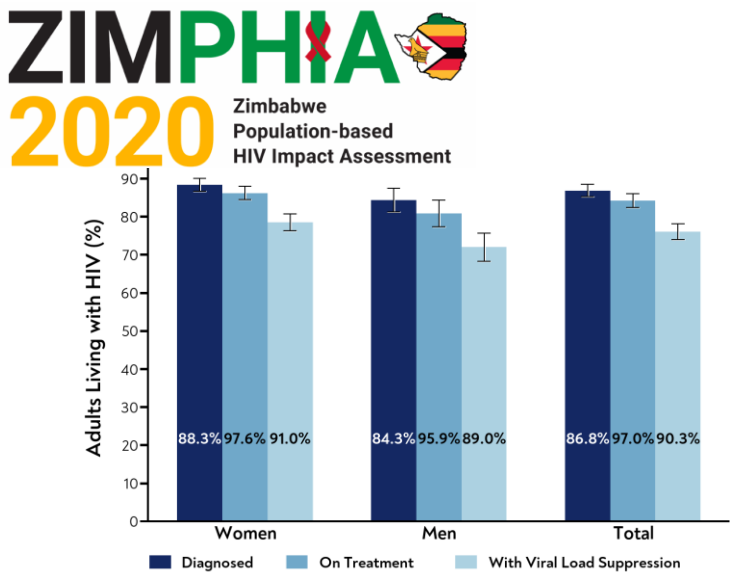
Adults living with HIV: Sub-Saharan African countries, 2000-2022

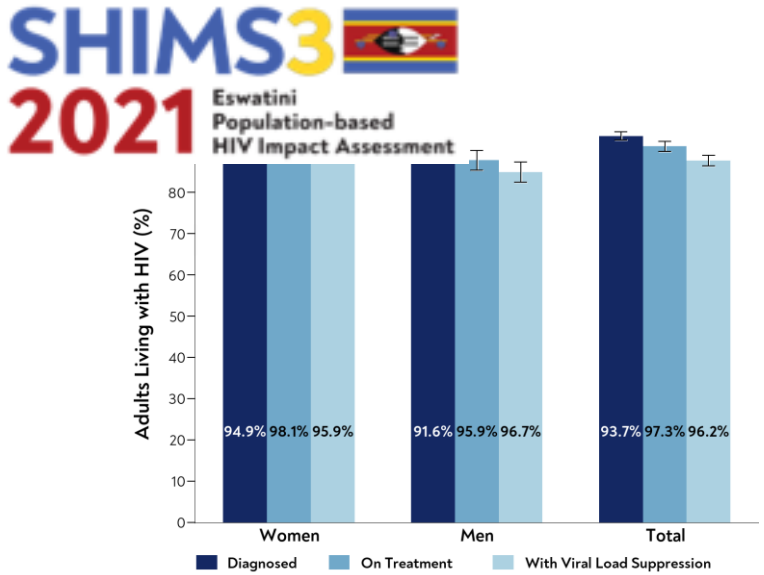


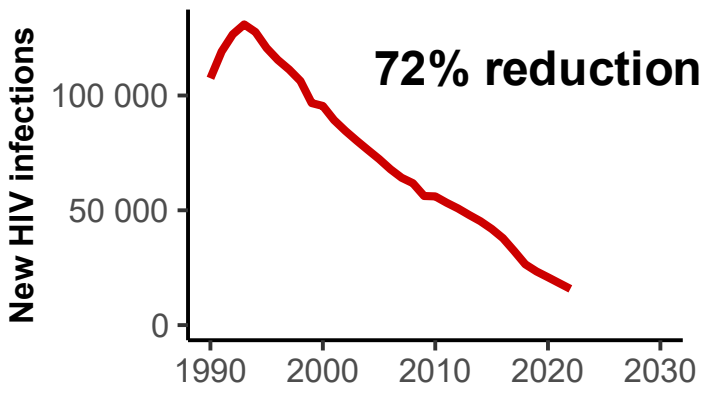
Source: UNAIDS 2023 epidemiological estimates.

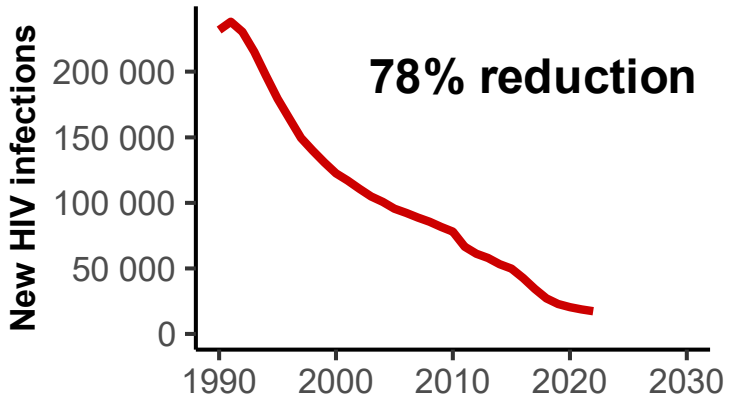
Countries attaining 95-95-95: 2030 targets in reach

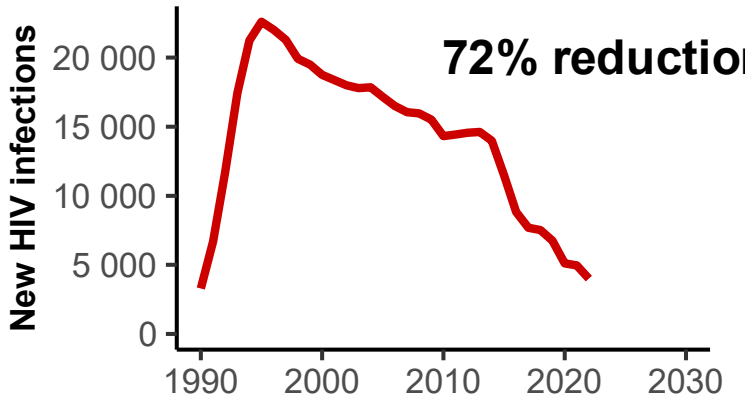












Source: PHIA surveys and UNAIDS 2023 epidemiological estimates.

Deploying an expanding HIV prevention menu

Broad-based HIV prevention to maximise scale and impact


HIV treatment for people living with HIV/U=U


Male & female condoms


Voluntary medical male circumcision


PEP


Syringe exchange programs

Opioid substitution therapy

Focused HIV prevention that meets specific needs of defined populations

Highly efficacious but resource intensive to deliver


Daily oral PrEP


Injectable cabotegravir/ lenacapavir


Dapivirine vaginal ring

Icons from AVAC: The HIV Prevention Pipeline [Infographic]
https://avac.org/resource/infographic/the-hiv-prevention-pipeline/

AVAC
Advocacy. Access. Equity.

ARV-based prevention—some simple math

Lifelong antiretroviral treatment (among HIV+):

- Cost: $70-100 pppy
  - ~$40 drugs
  - $30-60 delivery & monitoring
- 1 infection averted **per 13 people receiving treatment** (per year) + life extended 1 year
- ~$1300 per infection averted
- *Cost scales ~people with HIV → decreases as epidemic decreases*

Pre-Exposure Prophylaxis (among HIV-):

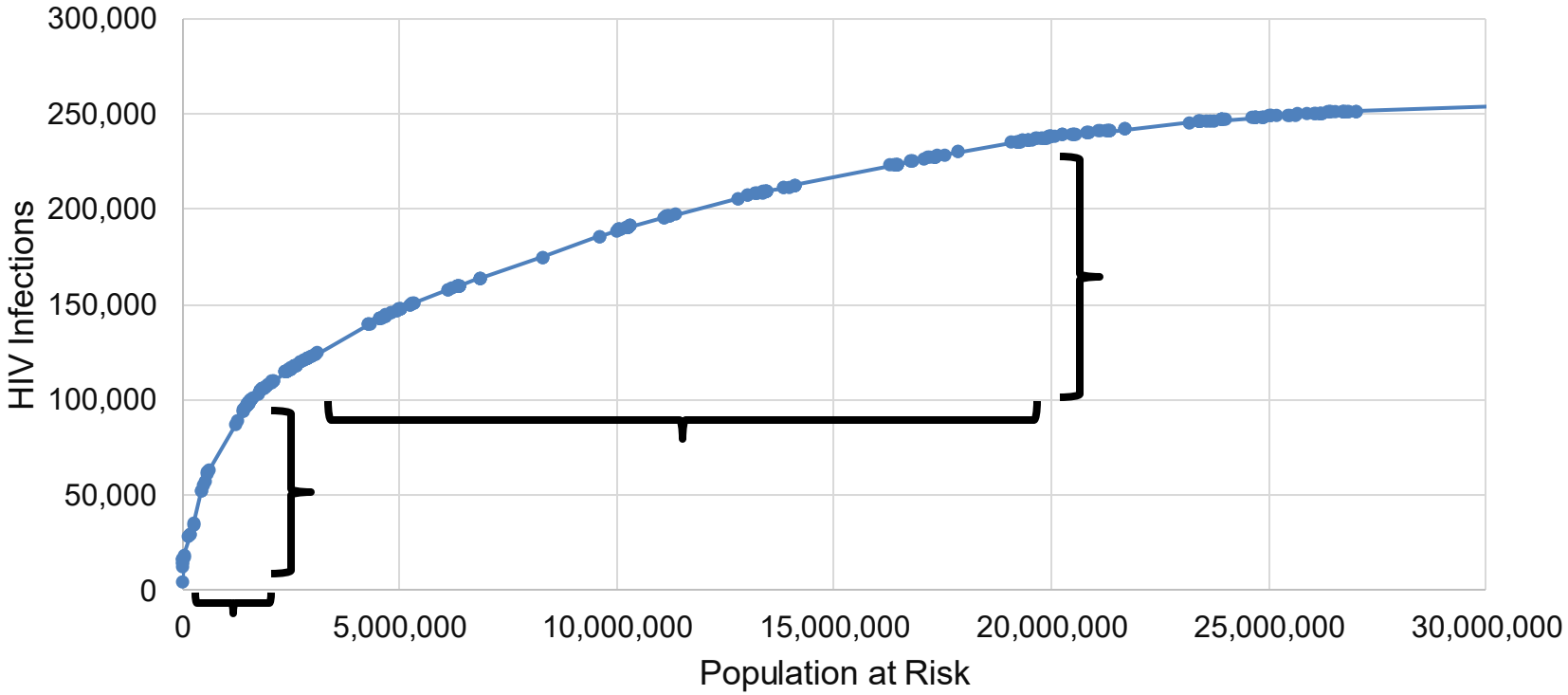
- Cost: $60-80 pppy
  - ~$40 drugs (oral or inject.)
- *Impact depends on incidence risk among those who uptake*
- 1 infection averted **per 40-250 people receiving prevention** (per year)
- ~$2500-15,000 per infection averted

Country	Total annual health spending per capita (US$)	Government health spending per capita (US$)
Kenya	$85	$38
Uganda	$45	$10
Rwanda	$53	$25
Tanzania	$36	$11
Malawi	$41	$5
Mozambique	$53	$14
Zambia	$80	$32
Zimbabwe	$63	$20
Botswana	$490	$369
Namibia	$397	$232
Lesotho	$123	$57
Eswatini	$296	$127
South Africa	$537	$331

- Median **$80** total annual health expenditure; $32 from domestic government funds

Geoffrey Rose's 'Prevention Paradox'

Prevention paradox: situation where the majority of cases of a disease come from a population at low or moderate risk of that disease, and only a minority of cases come from the high-risk population

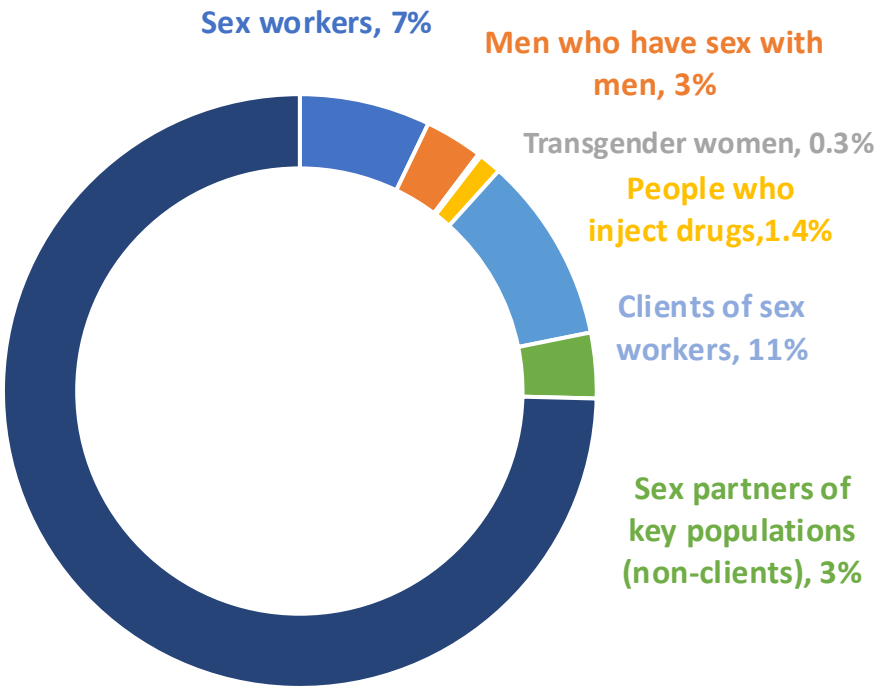


Avenir Health

(John Stover; Goals model applied to country and population risk group)

Reaching populations with effective prevention

Western, Central, Eastern, and Southern Africa, 2024



- **Extremely disproportionate HIV vulnerability among key populations**
  - 25% of infections among key populations and their partners

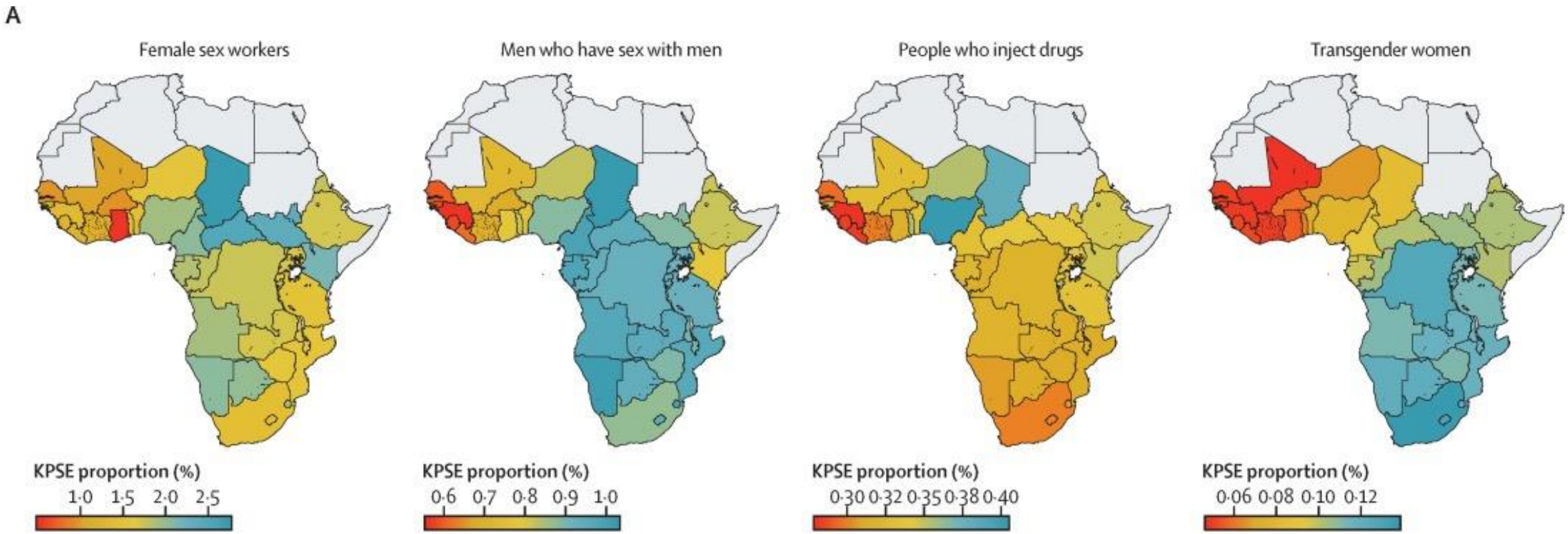
Source: UNAIDS 2025 epidemiological estimates
Updated from: Korenromp *et al.* JAIDS 2024; https://doi.org/10.1097/QAI.0000000000003340

UNAIDS

Population size, HIV prevalence, and antiretroviral therapy coverage among key populations in sub-Saharan Africa: collation and synthesis of survey data, 2010–23

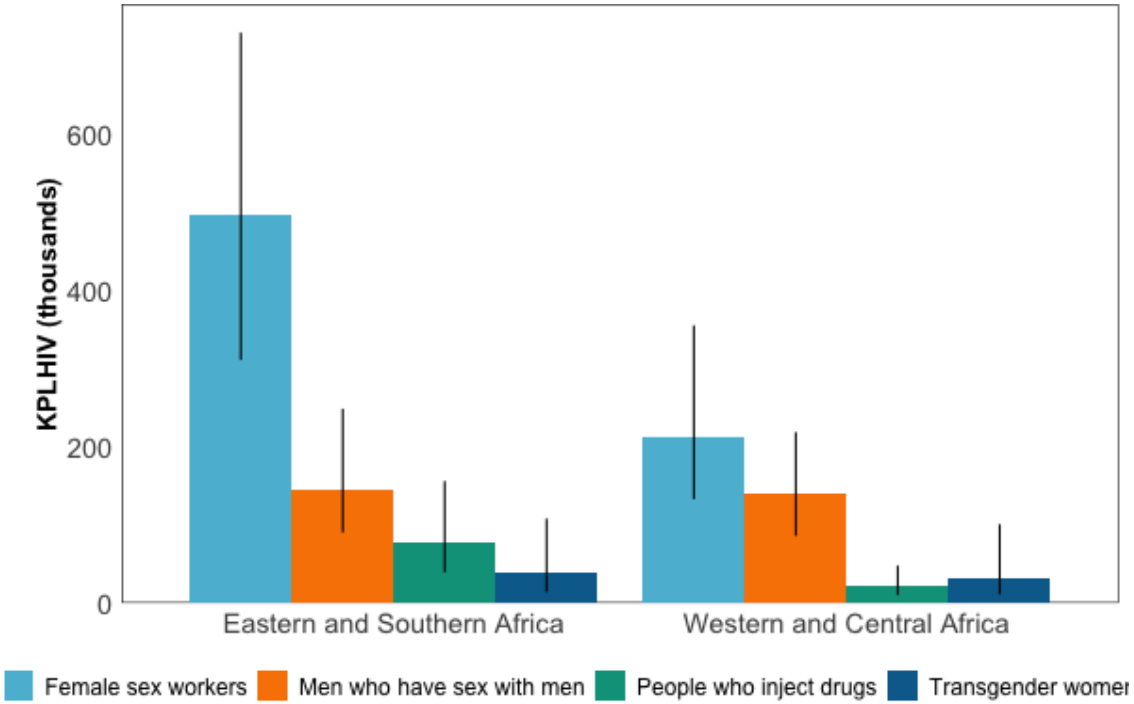
Stevens et al.

Lancet Glob Health 2024; 12: e1408–12



Stevens *et al.* Lancet Global Health 2024; https://doi.org/10.1016/s2214-109x(24)00236-5

Key populations are disproportionately affected by HIV in all countries in sub-Saharan Africa



Collation and synthesis key population size, HIV prevalence, and ART coverage survey data, 2010-2023

Female sex workers, men who have sex with men, people who inject drugs, and transgender women are

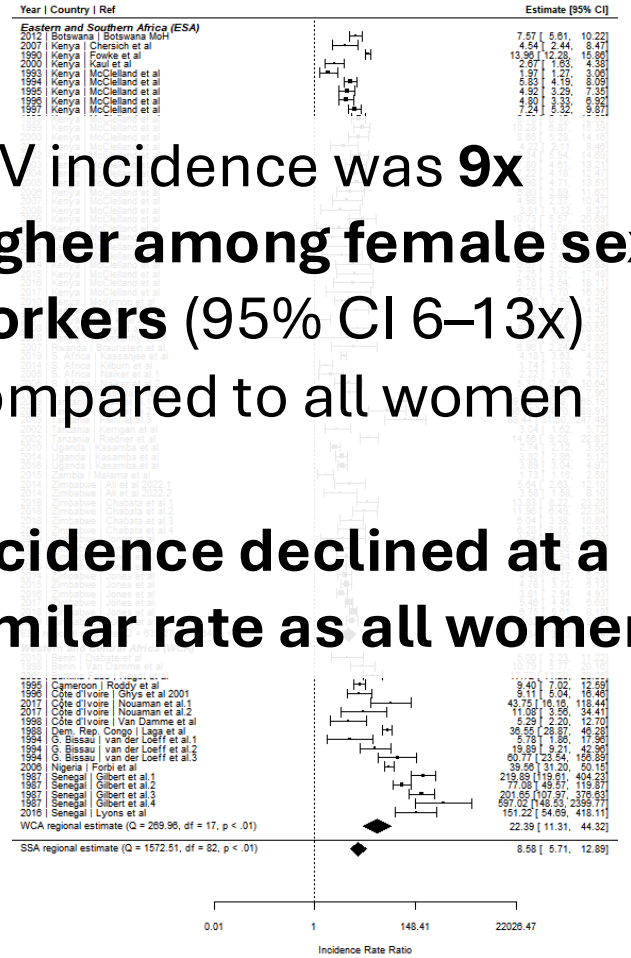
1.3% of adults **(95% CI 0.9-1.7%)** in sub-Saharan Africa

But comprise

- **5.0%** (3.6-7.0%) **of PLHIV in in Eastern and Southern Africa** and
- **12.0%** (8.4-17.4%) **of PLHIV in Western and Central Africa**

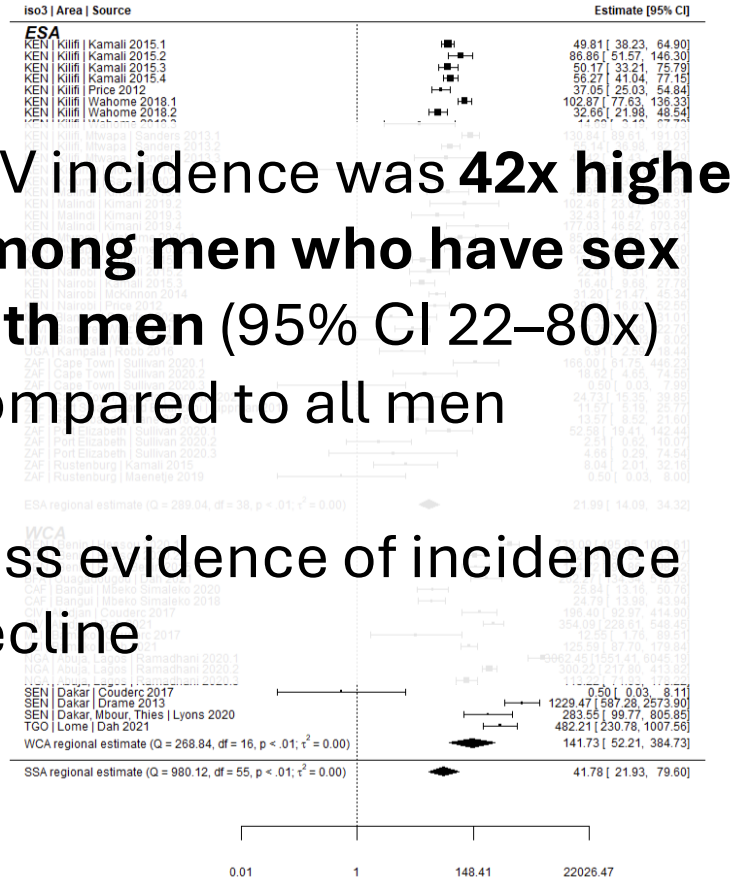
Stevens *et al.* Lancet Global Health 2024; https://doi.org/10.1016/s2214-109x(24)00236-5

Key populations experience disproportionately high HIV incidence



HIV incidence was **9x higher among female sex workers** (95% CI 6–13x) compared to all women

Incidence declined at a similar rate as all women



HIV incidence was **42x higher among men who have sex with men** (95% CI 22–80x) compared to all men

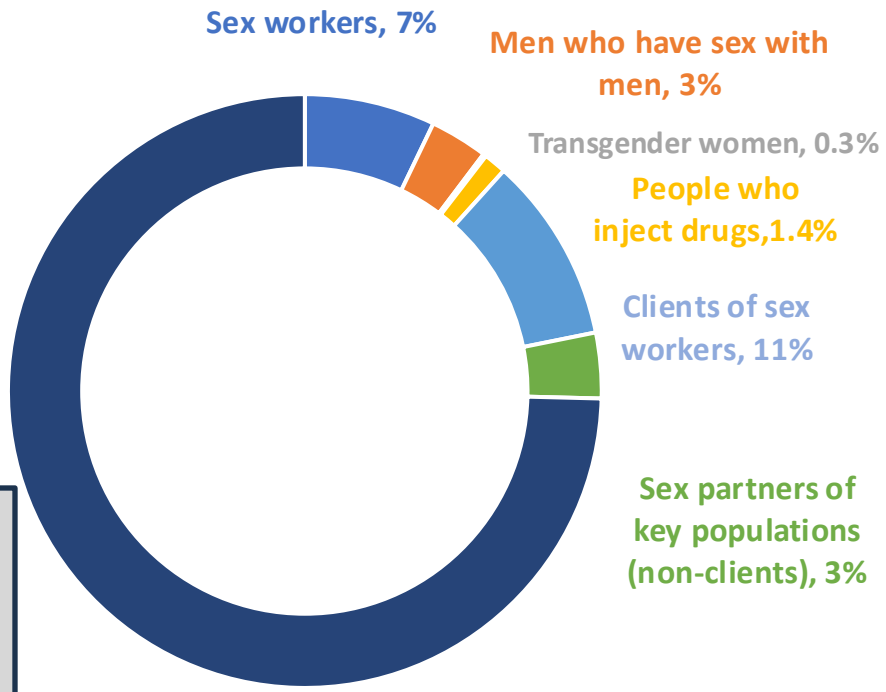
Less evidence of incidence decline

Jones and Anderson *et al.* Lancet Global Health 2024; https://doi.org/10.1016/s2214-109x(24)00227-4

Stannah *et al.* Lancet HIV 2023; https://doi.org/10.1016/s2352-3018(23)00111-x
Stevens *et al.* JAIDS 2024; https://doi.org/10.1097/qai.0000000000003321

Reaching populations with effective prevention

Western, Central, Eastern, and Southern Africa, 2024



74% among remaining population

- **Extremely disproportionate HIV vulnerability among key populations**
  - 25% of infections among key populations and their partners
- **But large numbers of ongoing new infections among all population groups**

Source: UNAIDS 2025 epidemiological estimates
Updated from: Korenromp *et al.* JAIDS 2024; https://doi.org/10.1097/QAI.0000000000003340

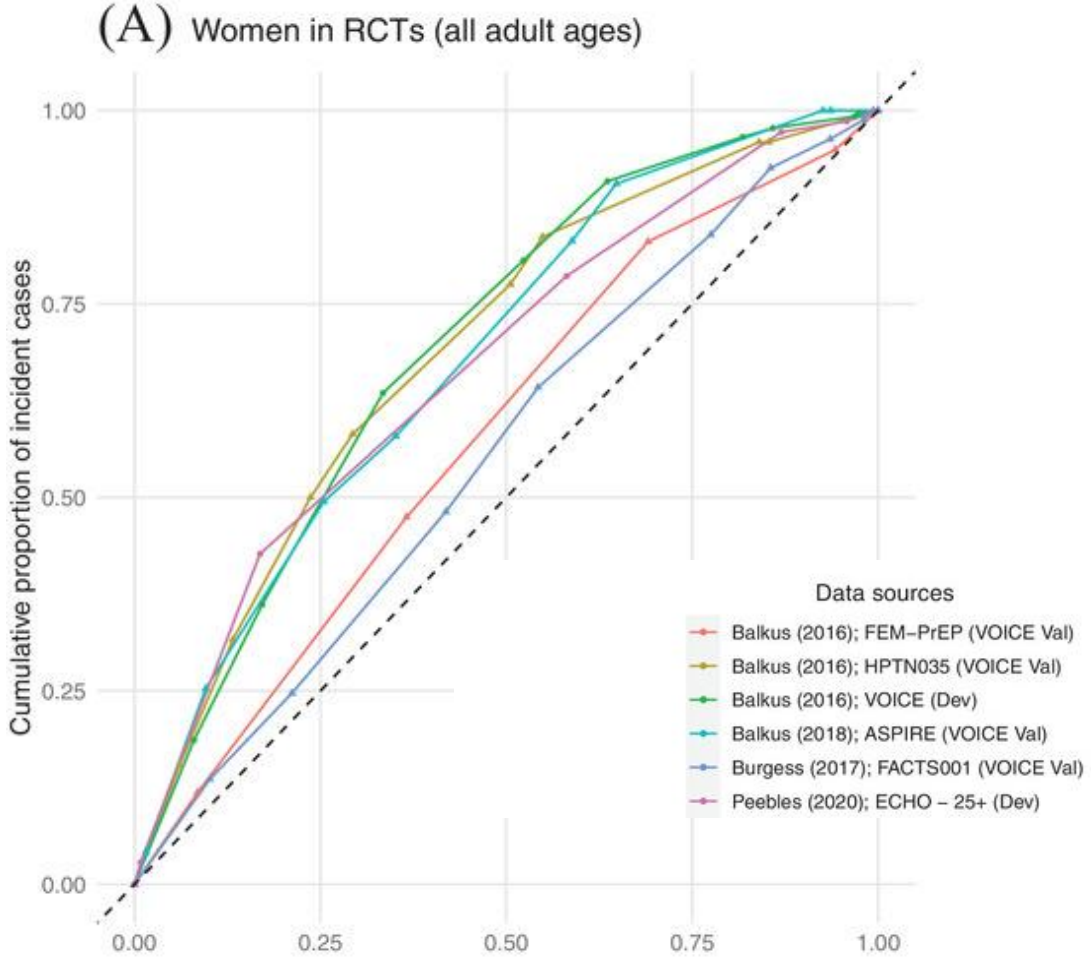
UNAIDS

No 'silver bullets' for narrowly targeted HIV prevention → require strategies that protect large populations with moderate HIV risk

Systematic review of HIV 'risk score' tools:

- Consistent predictors of HIV incidence:
  - Non-cohabiting with primary partner, young age, curable STI, HSV-2, multiple partners

- But only low-to-moderate ability to differentiate those who subsequently acquired HIV *(systematic review)*



Jia *et al. J Int AIDS Soc* 2022; 25:e25861
https://doi.org/10.1002/jia2.25861

No 'silver bullets' for narrowly targeted HIV prevention → require strategies that protect large populations with moderate HIV risk

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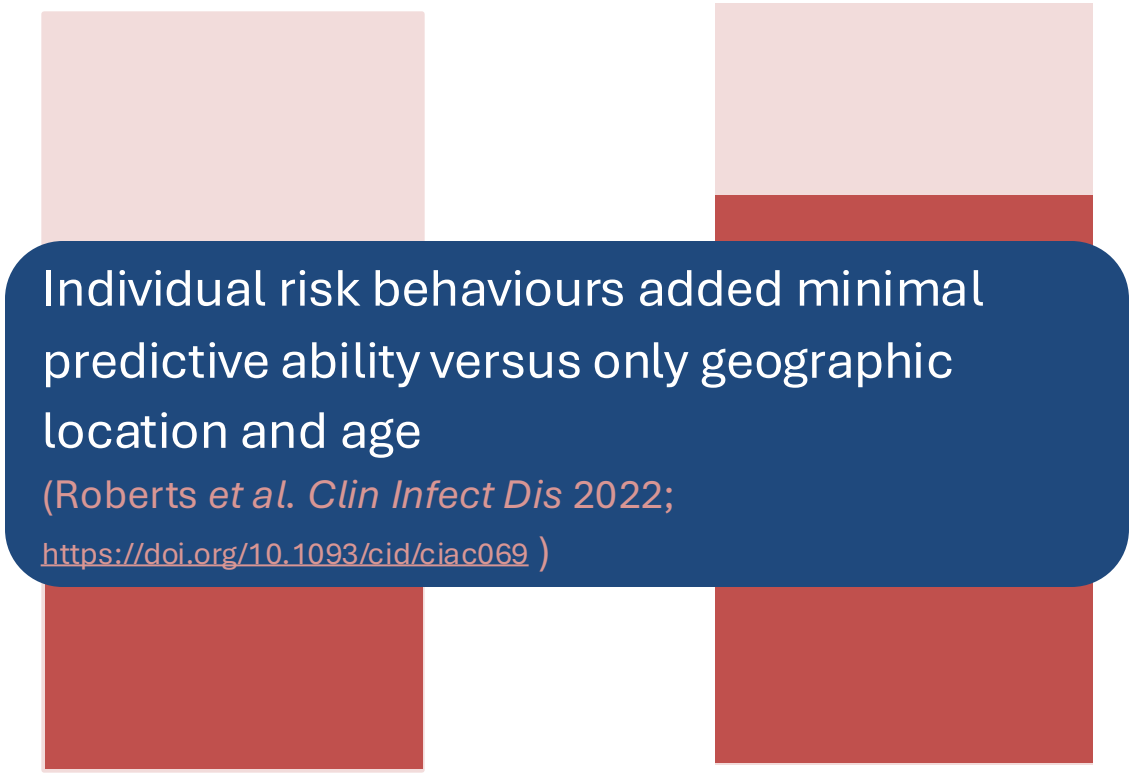
40-65% of population classified as 'high risk'…

…to identify 75% of HIV infections



Individual risk behaviours added minimal predictive ability versus only geographic location and age

(Roberts *et al. Clin Infect Dis* 2022; https://doi.org/10.1093/cid/ciac069)

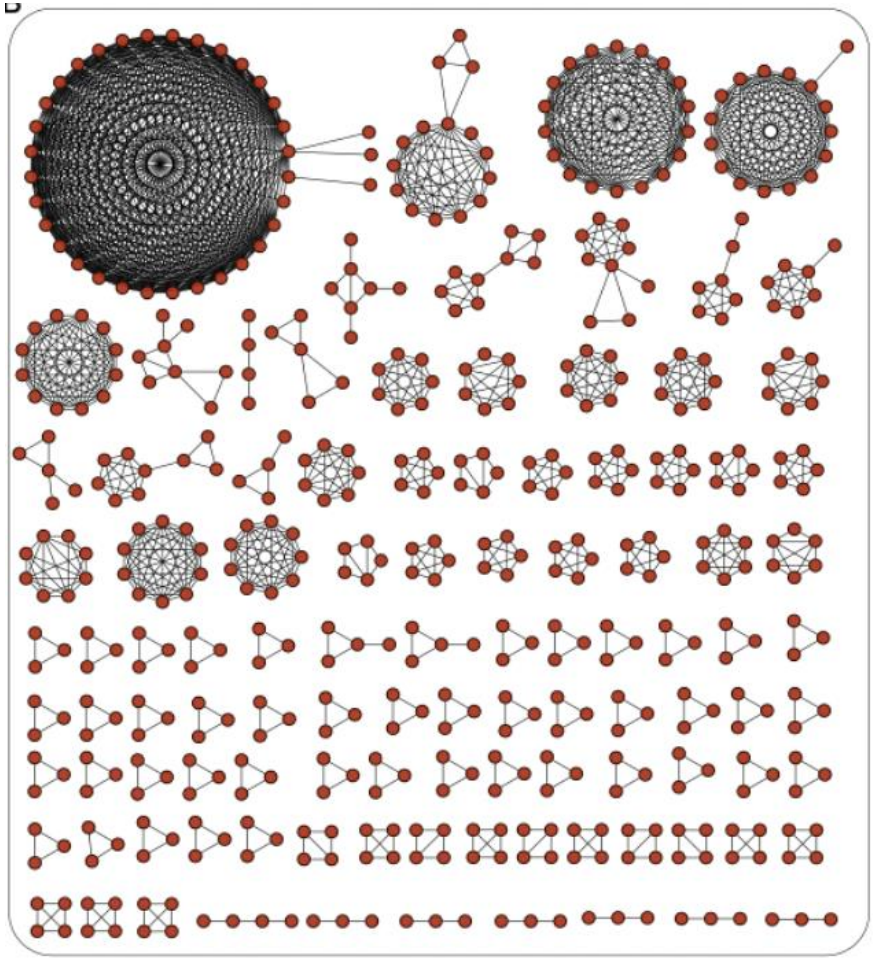
Jia *et al. J Int AIDS Soc* 2022; 25:e25861
https://doi.org/10.1002/jia2.25861

Small and diffuse HIV transmission clusters in Eastern and Southern Africa

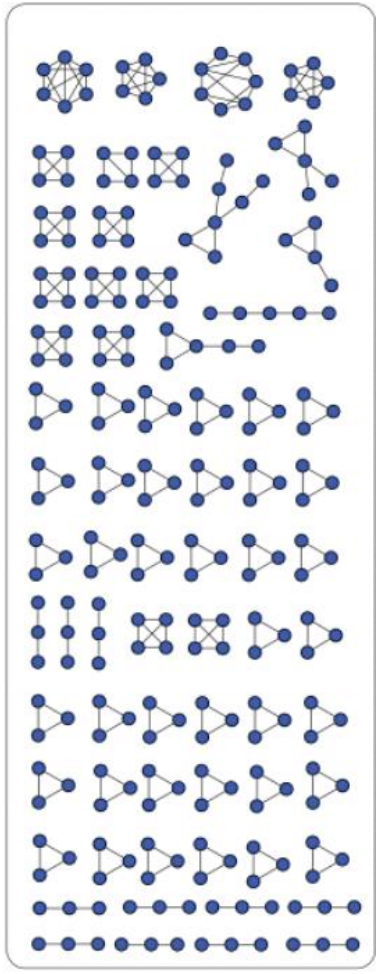
Clustering of HIV Transmissions: European compared to Zambian HIV epidemic

PANGEA HIV

Europe



Zambia

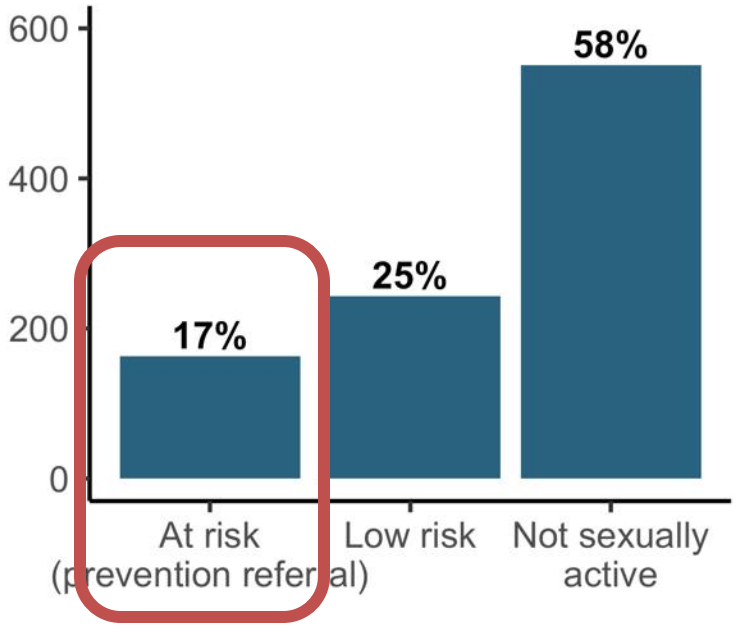


Abeler-Dörner *et al. in preparation*

Rapid change in individual risk and prevention needs

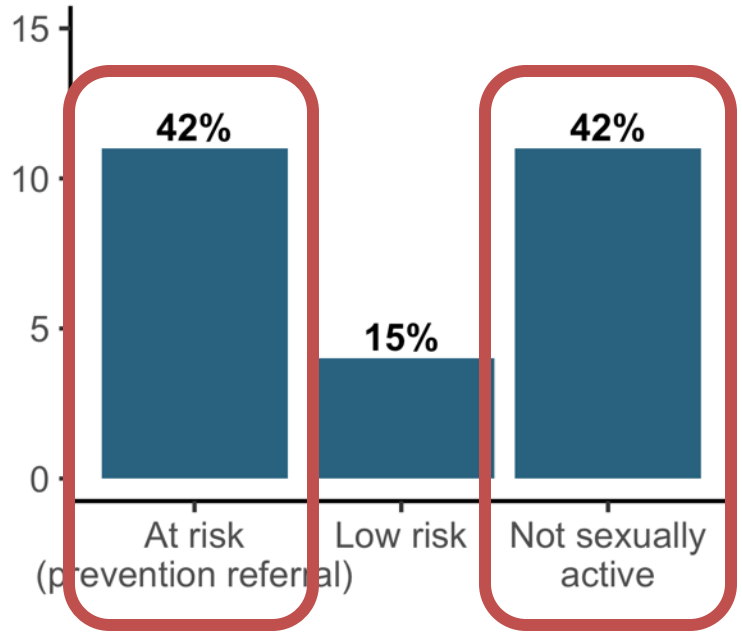
Moorhouse *et al.* medRxiv 2024
https://doi.org/10.1101/2024.09.10.24312897

Prevention group allocation
(n = 960 women 15-24y)



40% of infections among 17% 'at risk'

HSV-2/HIV infections
(n=26; 1 year follow-up)

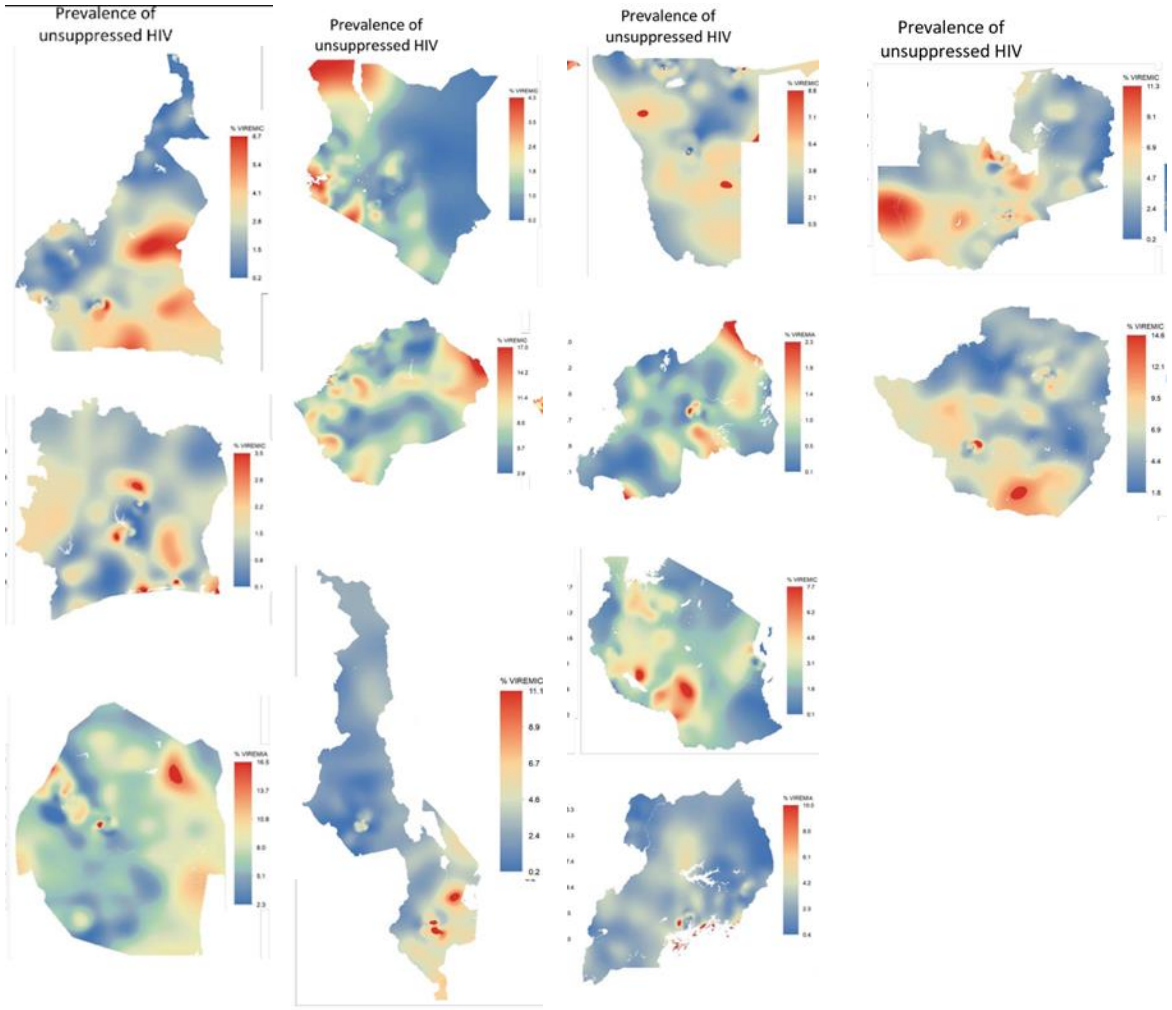


But—40% among AGYW 'not sexually active' at baseline assessment

Follow the virus: Most new infections occur in communities with high prevalence of unsuppressed HIV

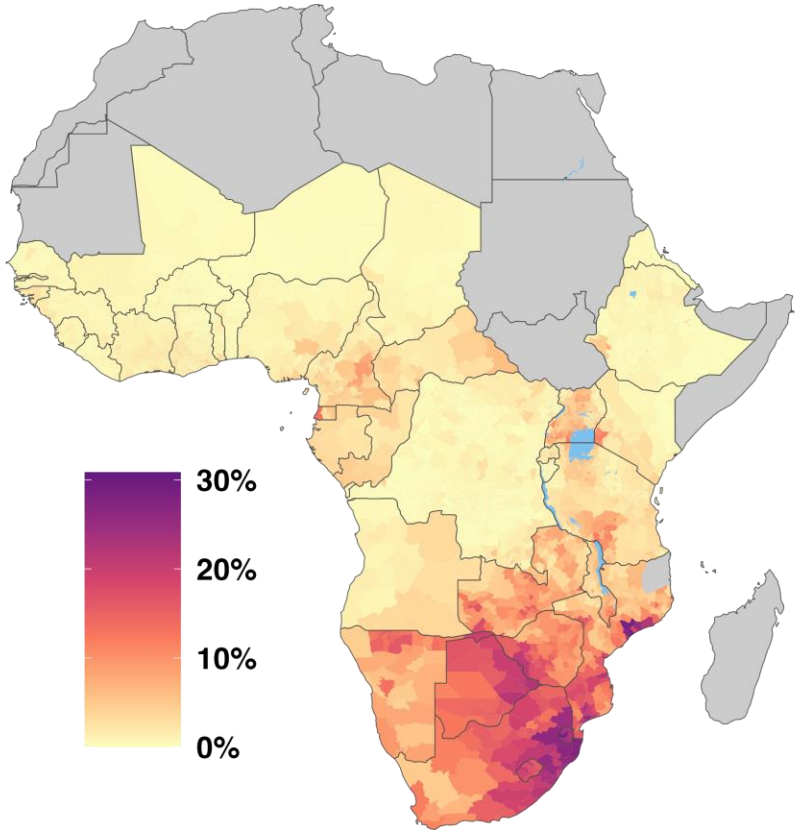
PHIA household surveys (2016-2019):

- **Prevalence of unsuppressed HIV highly correlated with community HIV incidence (R^2 =0.92)**



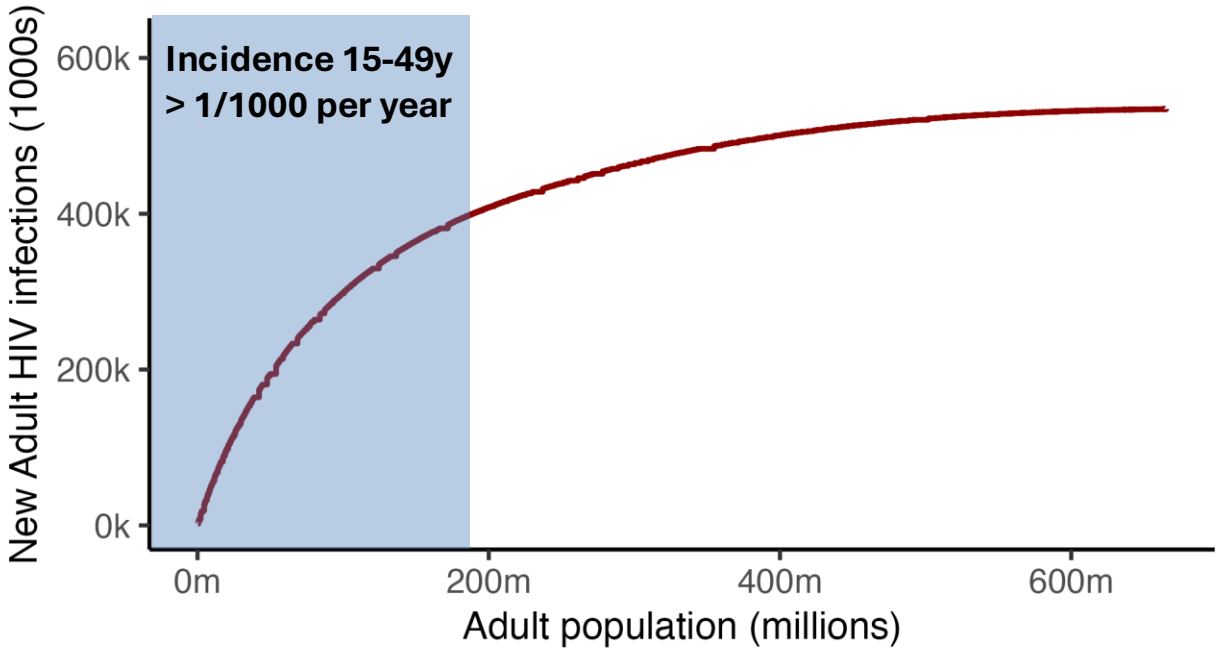
Hladik *et al.* PLOS One 2023; https://doi.org/10.1371/journal.pone.0275560

Follow the virus: Most new infections occur in communities with high prevalence of unsuppressed HIV



HIV prevalence, age 15-49 years, 2023; Source: UNAIDS HIV Estimates http://naomi-spectrum.unaids.org/

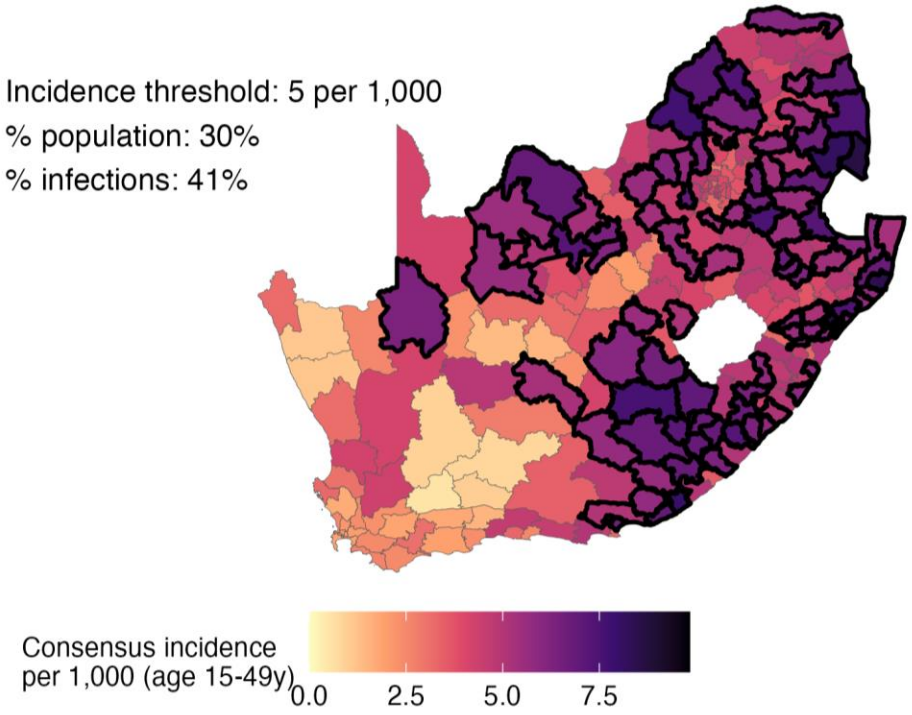
73% of new HIV infections in Africa in districts with incidence >1/1000 per year
and 27% of total adult population

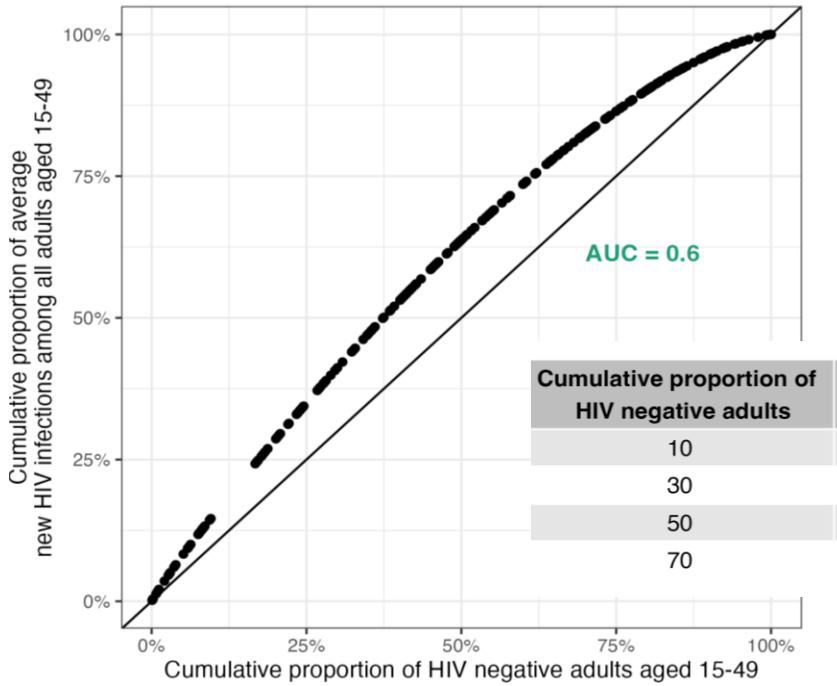


Source: UNAIDS HIV Estimates; *courtesy of Clemens Benedikt* http://naomi-spectrum.unaids.org/

Geographic prioritisation of prevention in South Africa

South Africa sub-district HIV incidence proxy





Cumulative proportion of HIV negative adults	Cumulative proportion of new HIV infections
10	15
30	41
50	64
70	83

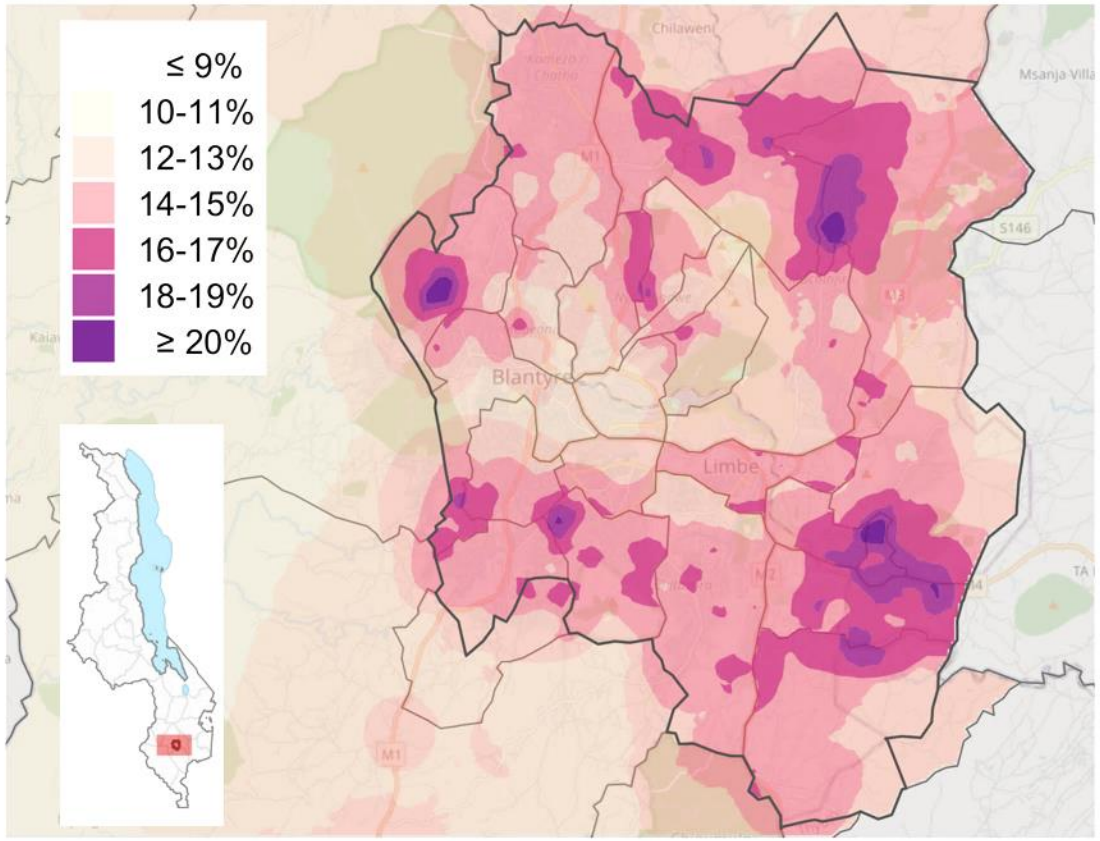
GAPS:

- *Wow much can we improve this with geographic burden + individual/network risk?*
- *What delivery models can effectively reach those with differentiated individual risk?*

Linganisa

Large HIV variation in at small geographic scales: Blantyre City, Malawi

HIV prevalence (15-49 years)



Across wards on Blantyre City (southern Malawi), HIV prevalence ranged between **13%** and **19.5%**

GAP: what data can identify small-scale socio-geographic variation?

Malawi-Liverpool-Wellcome Clinical Research Programme

BPS BLANTYRE PREVENTION STRATEGY

COOPER/SMITH

Burke *et al*. *AIDS 2022* Abstract #1666

Challenges with HIV prevention data

- **Overly 'supply driven'**—focused on delivered services and commodities (M&E)
- Lack information about **who is acquiring HIV infection** to guide strategies *(we have basically stopped collecting this)*
- Don't collect information effective **use of prevention among those who need it**
  - Rely heavily on household surveys: infrequent; coarse; untargeted

Case investigations among sample of new HIV diagnoses

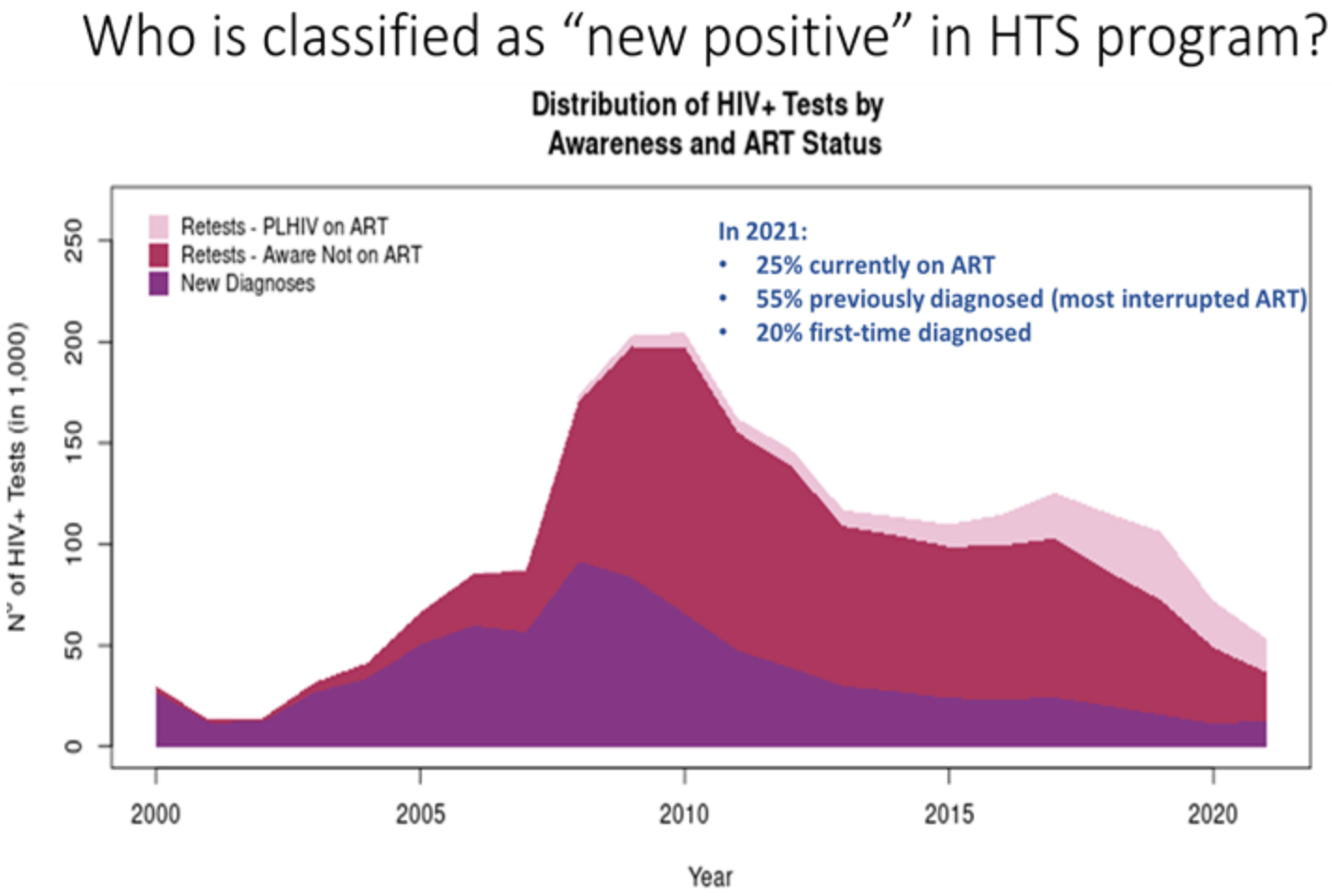
1. First-time vs. rediagnosis; likely timing
2. Characteristics, behaviours, circumstances around infection
3. Missed opportunities to intervene

Monitor prevention awareness and use among sentinel populations

1. Clients at STI, ANC, family planning
2. Anonymous surveillance; 'for free' as part of routine clinical care

Sentinel surveillance paradigm—*don't need data on everybody, just sufficient sample to monitor effective programmes*

Challenges with monitoring HIV epidemic using HIV diagnosis case reports



Challenge 1: 'New HIV diagnoses' are not what they seem

- 60-80% of people 'newly diagnosed' have been previously diagnosed or treated
- May not be indicative of who is *acquiring HIV infection*

Challenge 2: Diagnosis trends missing context

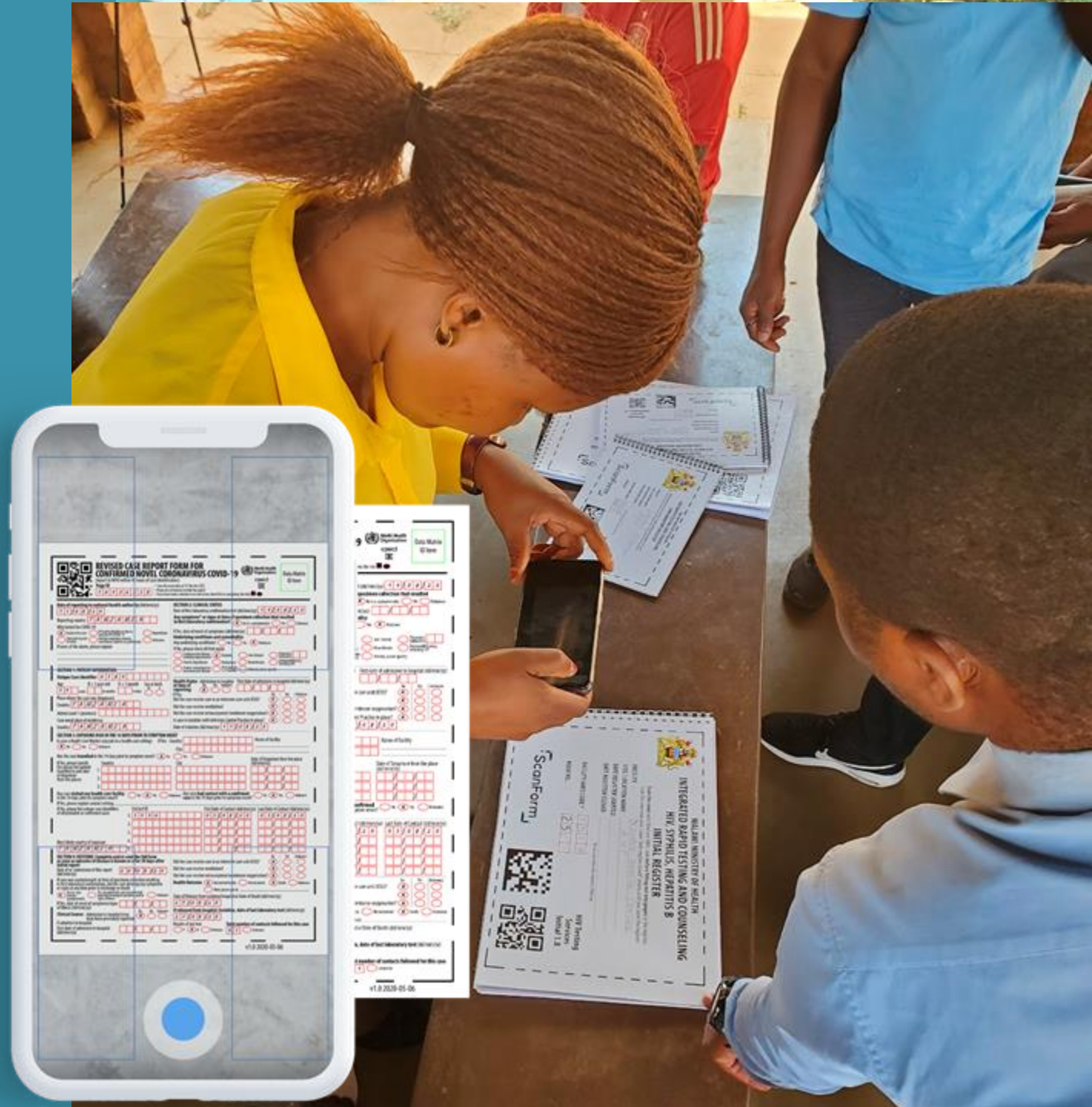
- An HIV diagnosis documents that a failure occurred.
  - Recent HIV infection → **Failure of HIV prevention**
  - Long-term undiagnosed/unlinked → **Failure of timely HIV testing**
  - Re-entering after tx interruption → **Failure of retention**

- Diagnosis does not tell us *why* failure occurred.
  - Risk behaviours, structures, or environments

- Diagnosis does not tell us *how* failure could have been prevented.
  - Missed opportunities for engaging in prevention or treatment

ScanForm

Automatic extraction, analysis, *and* DQA of data from paper registers, in seconds!



The right tool for the right place

Health workers prefer simple and robust solutions

75% of facilities: no connectivity, power, leaking roofs, no security → data collection not a priority, EMRS not sustainable

Chiunjiza Health Centre

Few large facilities with significant infrastructure and staffing investment: EMRS can be efficient, but big investment (and needs backup solution)

Nkhata Bay District Hospital

No EMR site is paperless!

(Courtesy of Andreas Jahn; Malawi HIV Department)

How ScanForm works

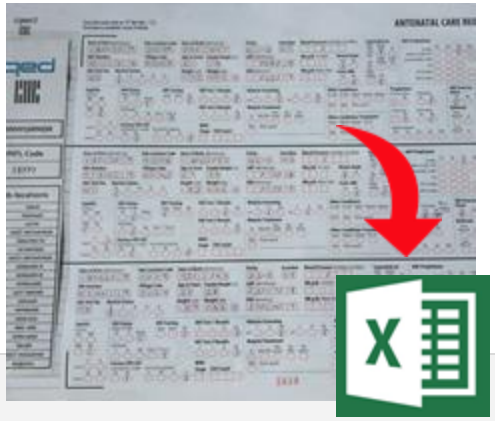
Rapid and Accurate Data Collection at National Scale

STEP 1

Write on paper

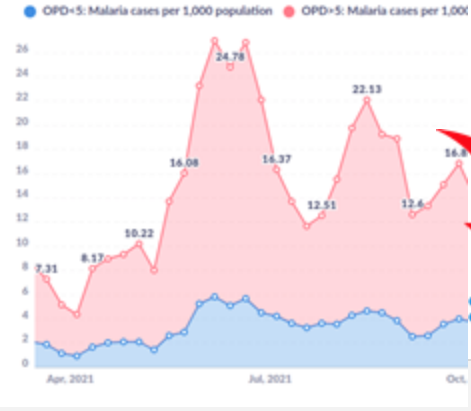
STEP 2

Take a picture



STEP 3

Get the data



dhis2

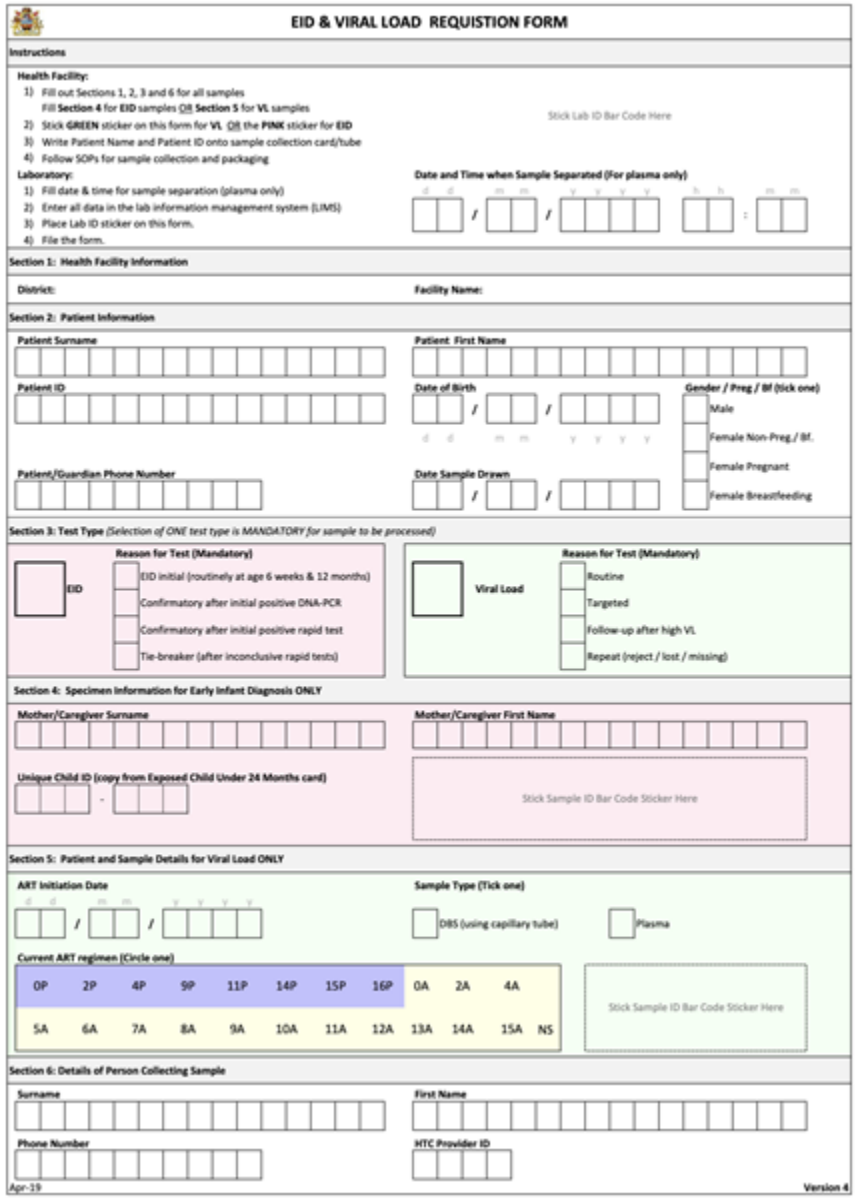
STEP 4

Use the data

(not required: computers or scanners)

(intermittently needed: electricity for phone charging and network for auto-upload of pictures)

Example Conversion: PCR Form



EID & VIRAL LOAD REQUISTION FORM

Instructions

Health Facility:
1) Fill out Sections 1, 2, 3 and 6 for all samples
Fill Section 4 for EID samples OR Section 5 for VL samples
2) Stick GREEN sticker on this form for VL OR the PINK sticker for EID
3) Write Patient Name and Patient ID onto sample collection card/tube
4) Follow SOPs for sample collection and packaging

Laboratory:
1) Fill date & time for sample separation (plasma only)
2) Enter all data in the lab information management system (LIMS)
3) Place Lab ID sticker on this form.
4) File the form.

Stick Lab ID Bar Code Here

Date and Time when Sample Separated (For plasma only)

Section 1: Health Facility Information

District: Facility Name:

Section 2: Patient Information

Patient Surname | Patient First Name | Patient ID | Date of Birth | Gender / Preg / Bf (tick one) | Patient/Guardian Phone Number | Date Sample Drawn

Male
Female Non-Preg./ Bf.
Female Pregnant
Female Breastfeeding

Section 3: Test Type *(Selection of ONE test type is MANDATORY for sample to be processed)*

EID — Reason for Test (Mandatory)
- EID initial (routinely at age 6 weeks & 12 months)
- Confirmatory after initial positive DNA-PCR
- Confirmatory after initial positive rapid test
- Tie-breaker (after inconclusive rapid tests)

Viral Load — Reason for Test (Mandatory)
- Routine
- Targeted
- Follow-up after high VL
- Repeat (reject / lost / missing)

Section 4: Specimen Information for Early Infant Diagnosis ONLY

Mother/Caregiver Surname | Mother/Caregiver First Name | Unique Child ID (copy from Exposed Child Under 24 Months card)

Stick Sample ID Bar Code Sticker Here

Section 5: Patient and Sample Details for Viral Load ONLY

ART Initiation Date | Sample Type (Tick one)

DBS (using capillary tube) Plasma

Current ART regimen (Circle one)

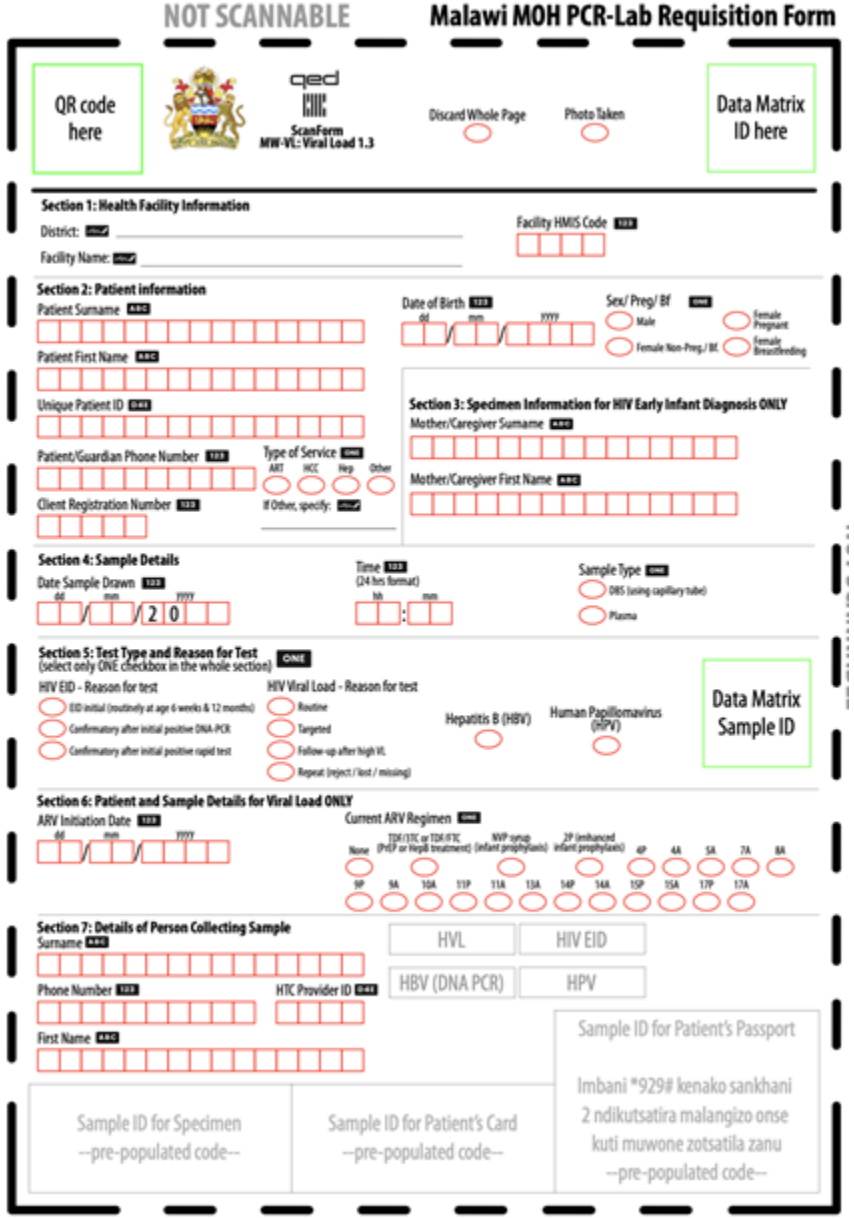
0P	2P	4P	9P	11P	14P	15P	16P	0A	2A	4A	
5A	6A	7A	8A	9A	10A	11A	12A	13A	14A	15A	NS

Stick Sample ID Bar Code Sticker Here

Section 6: Details of Person Collecting Sample

Surname | First Name | Phone Number | HTC Provider ID

Apr-19 Version 4



NOT SCANNABLE

Malawi MOH PCR-Lab Requisition Form

QR code here

ScanForm MW-VL: Viral Load 1.3

Discard Whole Page | Photo Taken

Data Matrix ID here

Section 1: Health Facility Information

District: Facility Name: Facility HMIS Code

Section 2: Patient information

Patient Surname | Patient First Name | Unique Patient ID | Patient/Guardian Phone Number | Client Registration Number | Date of Birth (dd mm yyyy) | Sex/ Preg/ Bf

Male | Female Pregnant | Female Non-Preg./ Bf. | Female Breastfeeding

Type of Service: ART HCC Hep Other | If Other, specify:

Section 3: Specimen Information for HIV Early Infant Diagnosis ONLY

Mother/Caregiver Surname | Mother/Caregiver First Name

Section 4: Sample Details

Date Sample Drawn (dd mm yyyy) | Time (24 hrs format) (hh mm) | Sample Type: DBS (using capillary tube) Plasma

Section 5: Test Type and Reason for Test (select only ONE checkbox in the whole section) ONE

HIV EID - Reason for test
- EID initial (routinely at age 6 weeks & 12 months)
- Confirmatory after initial positive DNA-PCR
- Confirmatory after initial positive rapid test

HIV Viral Load - Reason for test
- Routine
- Targeted
- Follow-up after high VL
- Repeat (reject / lost / missing)

Hepatitis B (HBV) | Human Papillomavirus (HPV)

Data Matrix Sample ID

Section 6: Patient and Sample Details for Viral Load ONLY

ARV Initiation Date (dd mm yyyy)

Current ARV Regimen: None | TDF/3TC or TDF/FTC (PrEP or Hepb treatment) | WHP syrup (infant prophylaxis) | 2P (enhanced infant prophylaxis) | 4P | 4A | 5A | 7A | 8A | 9P | 9A | 10A | 11P | 11A | 13A | 14P | 14A | 15P | 15A | 17P | 17A

Section 7: Details of Person Collecting Sample

Surname | Phone Number | HTC Provider ID | First Name

HVL | HIV EID | HBV (DNA PCR) | HPV

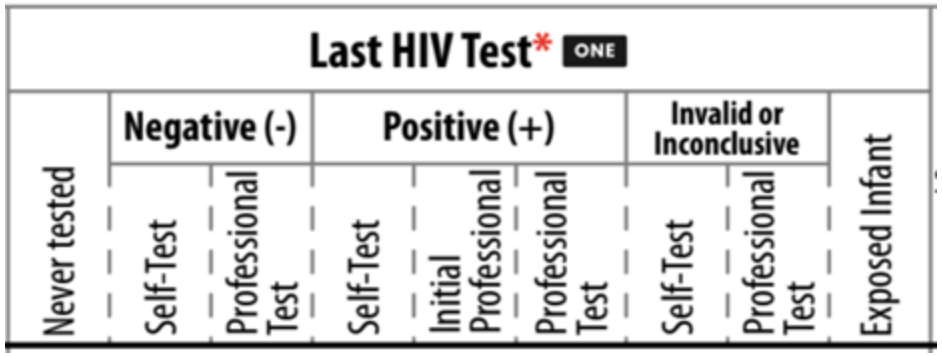
Sample ID for Specimen --pre-populated code--

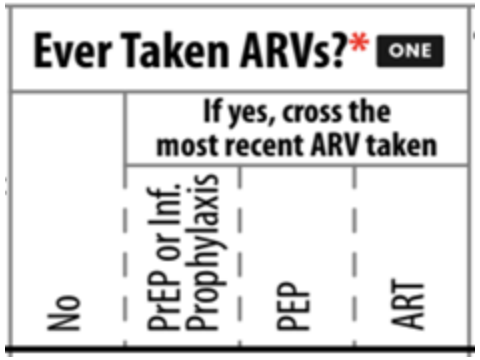
Sample ID for Patient's Card --pre-populated code--

Sample ID for Patient's Passport

Imbani *929# kenako sankhani 2 ndikutsatira malangizo onse kuti muwone zotsatila zanu --pre-populated code--

New opportunities from digitised HIV testing data





- *GAPS:*
  - *What are efficient and accurate ways to collect information about the timing and circumstances surrounding HIV acquisition?*
  - *Among whom should we prioritize additional detailed case investigations to maximise surveillance value?*