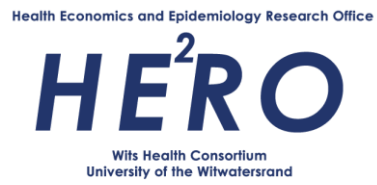


# Beyond observational data – enhancing epidemiology analytics with cross-cutting disciplines

*HE<sup>2</sup>RO (Health Economics and Epidemiology Research Office)*

*Wits Health Consortium, University of Witwatersrand*

*27 September 2024*



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# Meet the HE<sup>2</sup>RO team



Founded in 2003 in collaboration with Department of Global Health, Boston University



Using health economics, epidemiology, demography, modelling, big data and predictive data analytics, data management, behavioural sciences and quantitative and qualitative research methods.



Maintaining networks and relationships with DoH, Treasury and other government organisations



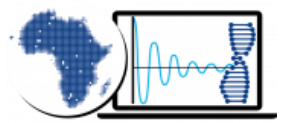
Developing strong local partnerships and leveraging international collaborations



Building and supporting local capacity development in a growing cadre of upcoming researchers

*Sustained support for multi disciplinary research has allowed the South African national HIV treatment program to **respond and adapt to the epidemic with evidence based policy change.***

# Collaborations



# Symposium overview



5 presentations



Brief Q&A



Panel discussion




Interact with us on WhatsApp



# Symposium overview

Session	Presenter
Optimizing routinely collected data for impact	Oratile Mokgethi and Amy Huber
Costing of health interventions across COVID-19, TB and HIV	Nkgomeleng Lekodeba
Bridging modelling and health economics to inform the South African government's response to HIV and TB	Lise Jamieson
Machine learning and AI to support health: Your Choice and PREDICT	Caroline Govathson and Mhairi Maskew
Behavioural economics: an introduction to Indlela	Preethi Mistri
<b>Panel discussion and interactive session</b>	<b>Presenters and panel members</b>



A graphic for a WhatsApp group. At the top is a circular icon with two stylized human figures. Below it, the text reads "WCE 2024 HE2RO symposium" in a bold, black font, followed by "WhatsApp group" in a smaller, regular font. The central element is a large QR code with a white WhatsApp logo in the center. The entire graphic is set against a light gray background with rounded corners.



# Optimizing routinely collected data for impact

Oratile Mokgethi and Amy Huber



# What is AMBIT?

## AMBIT: Evaluating differentiated service delivery for HIV in Africa

**Objective:** Describe implementation scale, estimate **benefits and costs**, and identify optimal **allocation of resources** for differentiated care in Africa

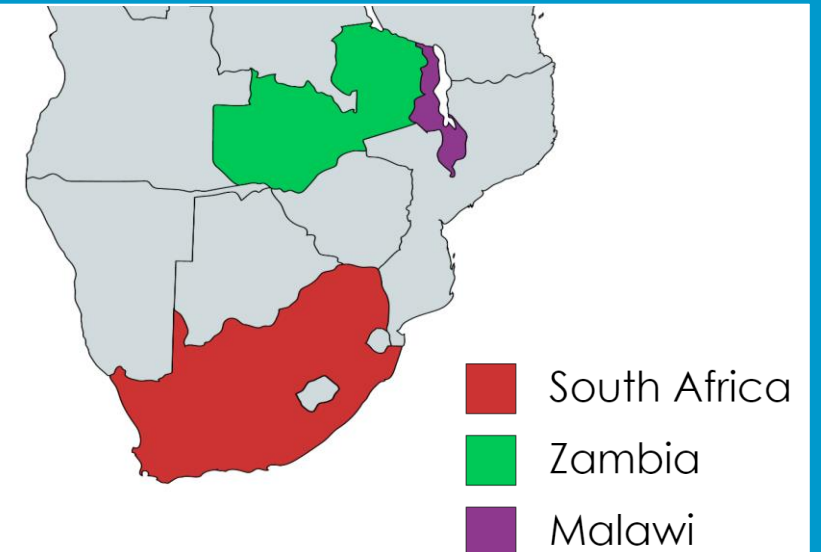
### Main Activities

**Data collection [SENTINEL]:** Annual and ad hoc survey of sentinel healthcare facilities, providers, patients, and models

**Data synthesis [GREAT]:** Analysis of EMR and other routinely collected data

**ADAPT:** Optimization model

### Countries



# Who is AMBIT?

Health Economics and Epidemiology  
Research Office (HE<sup>2</sup>RO)



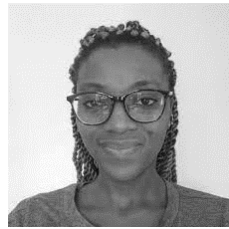
Sophie  
Pascoe



Idah  
Mokhele



Amy  
Huber



Linda  
Sande



Nyasha  
Mutanda



Oratile  
Mokgethi



Elizabeth  
Kachingwe



Lise  
Jamieson



Khumbo  
Shumba



Nkgomeleng  
Lekodeba



Nkosinathi  
Ngcobo



Barbara  
Xhosa



Sekai  
Chiwaye



Vinolia  
Ntjikelane

## CHAI-Zambia



Aniset  
Kimanga



Prudence  
Haembe



Hilda  
Shakwelele

## CHAI-Malawi



Timothy  
Tchereni



Andrews  
Gunda



Frehiwot  
Birhanu



Wyness  
Phiri

## Boston University



Sydney  
Rosen



Matt  
Fox



Nancy  
Scott



Mariet  
Benade



Allison  
Juntunen



# Routine data



Many countries are scaling up electronic capture of medical information



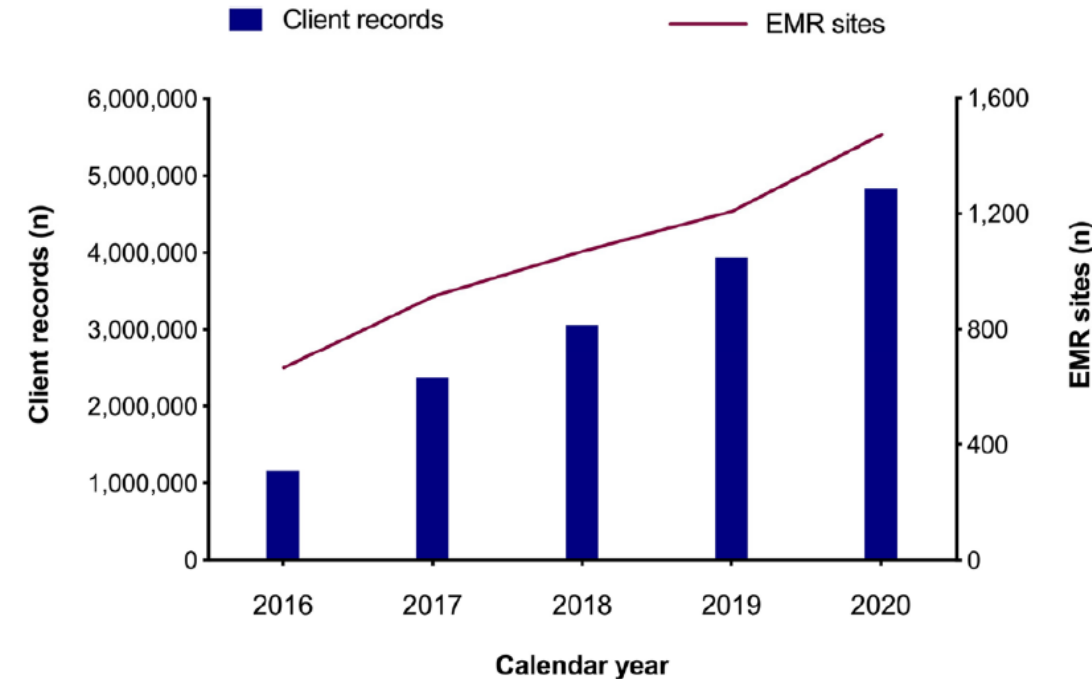
Data from these EMR have the potential to answer important public health questions and inform policy and decision makers



However, routinely collected EMR data are not created for research purposes



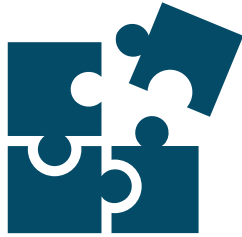
Analyzing them requires knowledge of the limitations and sometimes creative solutions to the challenges



Source: Ndisha, 2023



# What obstacles are we facing?



**Data completeness**



**Data quality**



**Data linkage**



**Data access, specifically to  
identifier**



**Data collected for routine  
monitoring and not epi studies**



**Segmented data systems**



# What are some methods to overcome these obstacles?

Data review and validation

Data linking

Target trial emulation

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# Data review and validation



## DSD data field

- Distinguish b/w less vs. more intensive
- Is off-site included?



## EMR distribution among clinics

- Timing & distribution of EMR systems
- More complete EMR → higher DSD uptake



## Dispensing interval

- Is dispensing interval captured for everyone, including off-site DSD?



## Contextual issues with observational data

- DSD concurrent with UTT, COVID, DTG
- DSD enrollment not random



## Laboratory records

- VL and CD4 tests broad vs. targeted
- EMR input via paper or linked database



## Dynamics within cohort

- If quality of care improves due to DSD, clients may become eligible sooner

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# Data linking

- Clinical data linkage without identifiers is a useful tool for researchers and policymakers
- Without a unique identifier or routinely captured unique identifiers in the medical system, linking records can be difficult if name and DOB are not available.
- This linkage approach offers novel opportunities to evaluate South Africa's public sector HIV program

# Linkage strategy

Linkage Variables



**Demographics:**

DOB and Sex

**Other variables:**

ART Start date , Facility name

CD4 & Viral load

} Algorithm linkage

} Manual linkage

Linkage approaches



Exact matching

Caliper matching

} Sequential linkage

Linkage Quality



**Performance :**

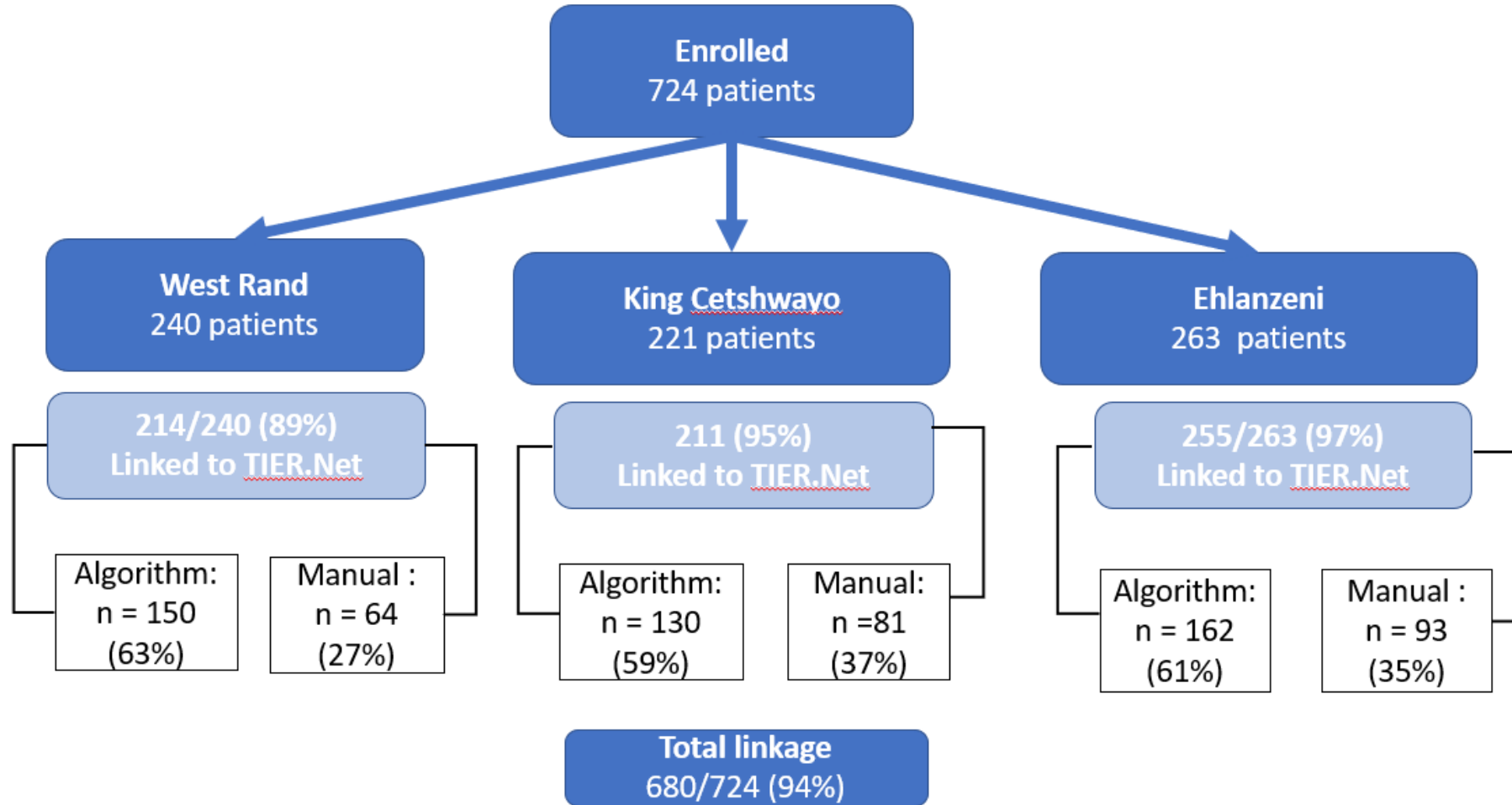
Sensitivity ; Positive Predictive Value (PPV)

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# AMBIT SENTINEL survey and TIER.Net linkage



# Target trial emulation method



Differentiated service delivery models (DSD) have been widely implemented.



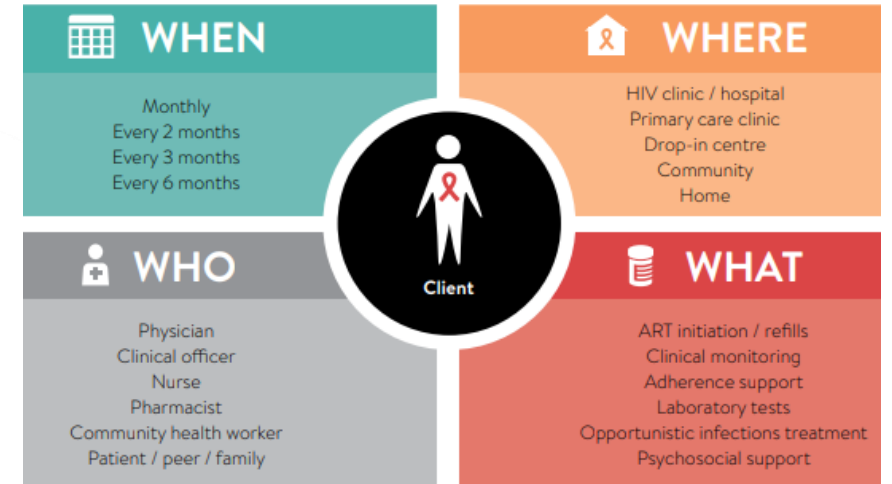
Replacing conventional care with DSD models could benefit DSD clients and the health system.



DSD models have multiple potential benefits but prerequisite is sustaining good client outcomes.



Compared outcomes of DSD clients to those eligible but not enrolled in DSD in South Africa.



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# Methods



## Population and data source

- Electronic medical records (TIER.Net) for 18 facilities in 3 districts in South Africa



## Target trial emulation methodology (TTE)

- TTE can assist in avoiding immortal time/survival bias in observational data
- First specify the protocol of the hypothetical randomized trial then use observational data to emulate each component of the target trial



## Analysis

- Estimated risk differences (RDs) for retention in care and viral suppression
- Poisson model adjusted for age, gender, urban/rural status, province, WHO stage and CD4 count at ART initiation, as well as years on ART at trial enrolment
- Present RDs for both by target trial and pooled data

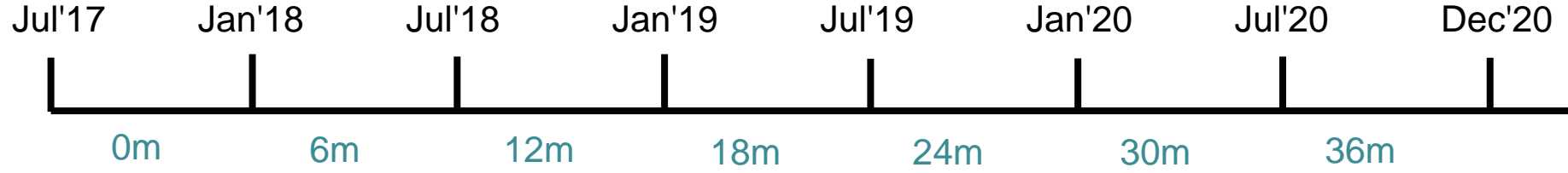


# Target trial vs. emulation

Component	Target trial	Emulated trial
<b>Eligibility</b>	Age 18+; on ART >12 months; 2 suppressed viral loads (<400 copies/ml); DSD naïve	Same
<b>Intervention strategy</b>	<b>DSD:</b> enrolled in DSD model at baseline <b>Non-DSD:</b> remain in conventional care at baseline	Same
<b>Intervention assignment</b>	Clients randomly assigned to DSD vs non-DSD	Clients non-randomly assigned to DSD model. Randomization is emulated by adjusting for baseline covariates: age, sex, urban, province
<b>Follow-up</b>	Starts at randomization Ends at earliest of death, LTF, 48 months.	DSD: follow-up starts at the first DSD visit in the trial baseline. Non-DSD: follow-up starts at the first visit in the trial baseline.
<b>Outcomes</b>	1) Retention in care and 2) Viral suppression Each at 12, 24 and 36 months	Same
<b>Causal contrast</b>	Intention-to-treat effect, i.e. effect of being assigned to DSD vs non-DSD at baseline, regardless of actual DSD enrolment.	Observational equivalent of intention-to-treat effect
<b>Statistical analysis</b>	Risk difference model estimating retention and viral suppression in DSD vs non-DSD.	Same. Adjustment for baseline covariates did not substantially change the estimates

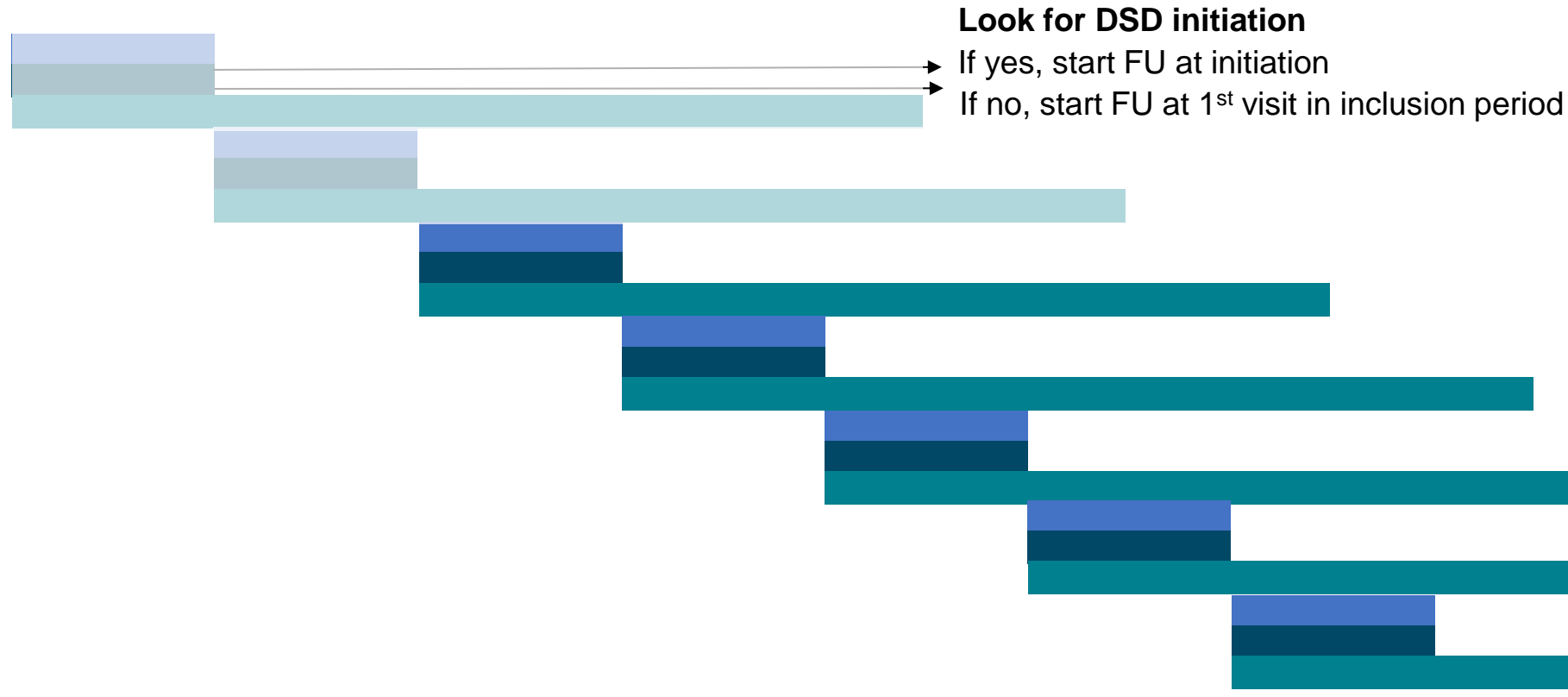
# Target trial for impact of DSD on retention/ suppression

Target trials; 6-month windows for "DSD trial" enrolment



- "trial" inclusion
- DSD exposure
- Follow up

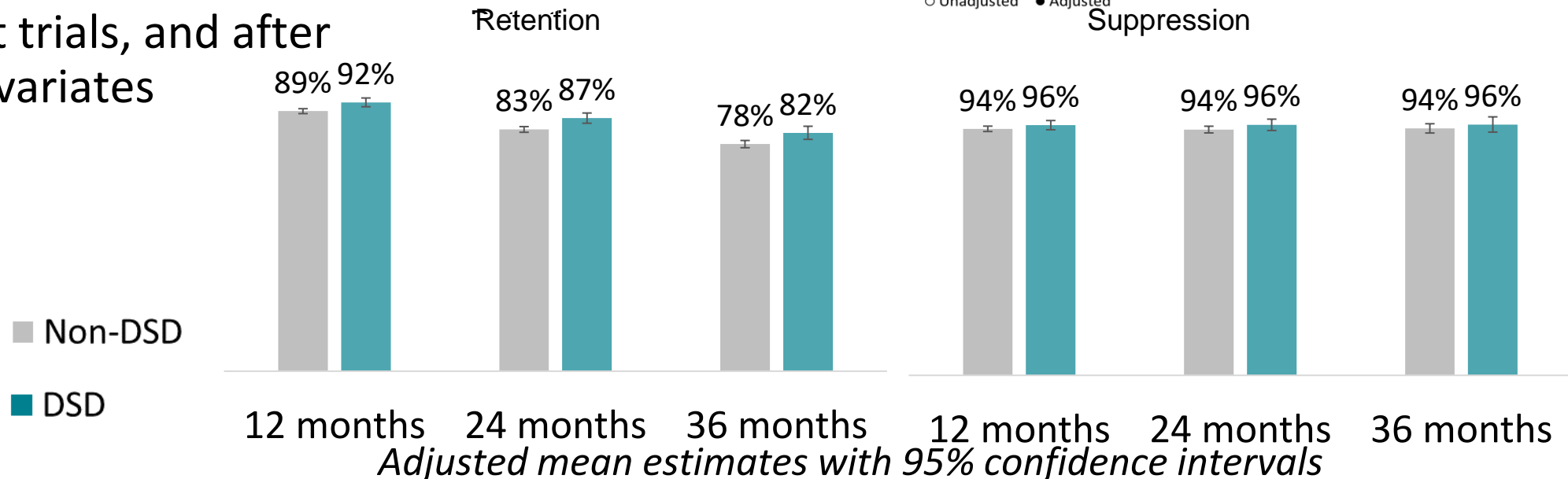
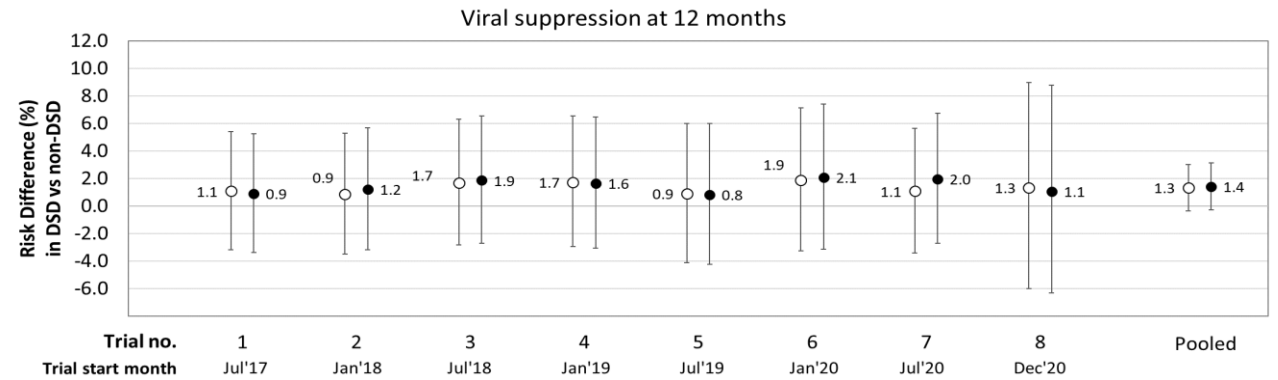
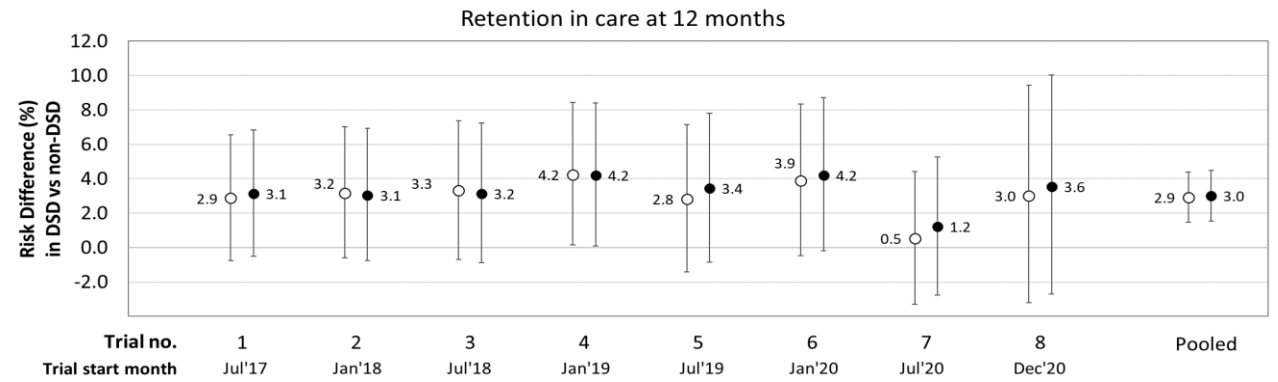
- Trial 1**
- Trial 2**
- Trial 3**
- Trial 4**
- Trial 5**
- Trial 6**
- Trial 7**



**Look for DSD initiation**  
 If yes, start FU at initiation  
 If no, start FU at 1<sup>st</sup> visit in inclusion period

# Results

- Retention in care is similar or slightly higher for those in DSD models after 12, 24 and 36 months
- Proportion virally suppressed is similar for those in DSD models vs. those eligible for DSD (but not enrolled) at 12, 24 and 36 months
- Estimates were robust across emulated target trials, and after adjusting for covariates



# Limitations

- Target trial emulation assists with misaligned person time and eligibility criteria but residual confounding can remain
- Bias is very likely with regard to who was offered DSD enrolment
- Routinely collected EMR data limitations – silent transfers, off-site medication collection not captured

# Conclusions

- Model enrolment can be evaluated on the basis of other benefits (or costs), such as resource utilization or satisfaction - clinical outcomes are at least as good.
- Differentiated models for those not currently eligible for lower intensity care should be investigated
- Target trial emulation methodology is a robust method for defining a comparator arm and determining outcomes in routine care data



# Key takeaways

- Limitations in the dataset often constrain the questions that can be asked
- There is value in analysing routinely collected EMR data for health outcomes, but caution must be applied
- Creating a working group with the Ministry/Department of Health, data base manager, and informatics team is a best practice
- Building in time for data review and feedback are essential
- Iterative feedback to the DoH/MoH strengthens analysis and ensures relevance of the work
- Observational data methods such as target trial emulation can assist

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# Acknowledgments

- Departments of Health in South Africa
- Implementing partners
- Sentinel site staff and clients
- Bill & Melinda Gates Foundation
- CQUIN, IAS, and other collaborating organizations
- AMBIT project team



# Questions





# Costing of health interventions across COVID-19, TB and HIV: evidence based-research

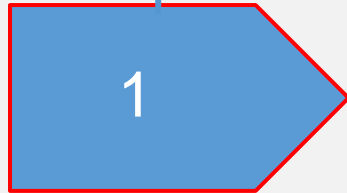
Nkgomeleng Lekodeba

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**COVID-19**

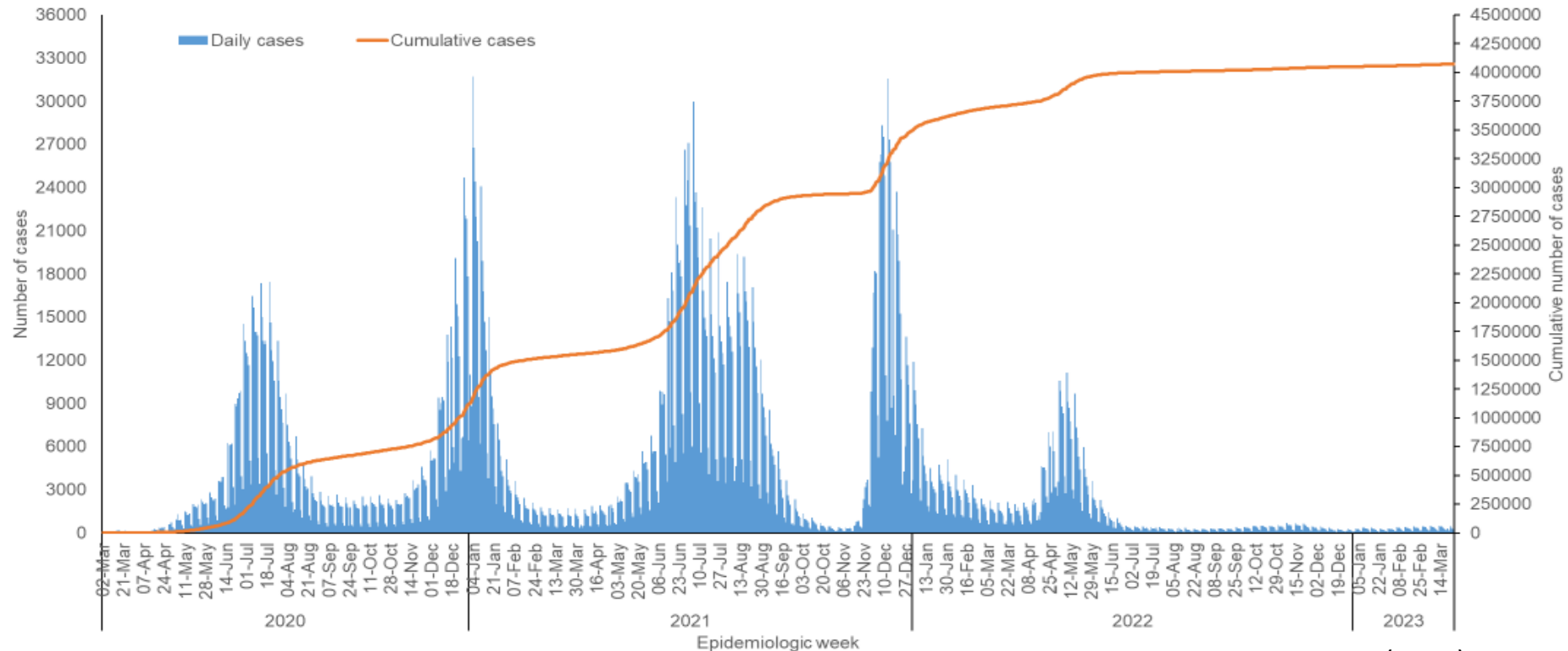


◆ South Africa



# ...a trip down memory lane: COVID-19 in South Africa

**Fig.** Number and cumulative number of laboratory-confirmed cases of COVID-19 by date of specimen collection, South Africa, 3 March 2020 – 25 March 2023



Source: NICD (2023)

**4 072 533 laboratory-confirmed COVID-19**

**Highest reported C19 cases in Southern Africa**

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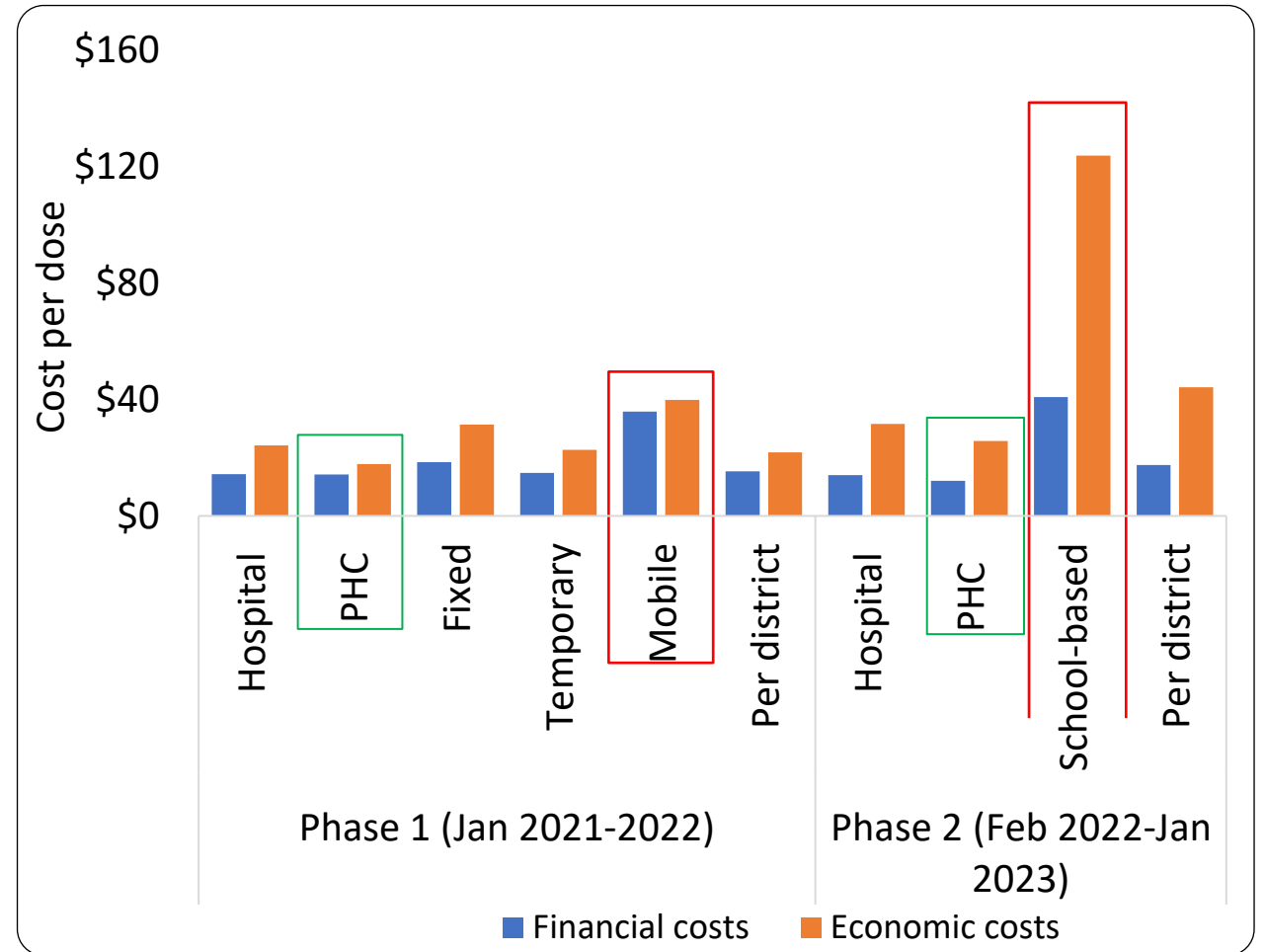
# COVID-19: Cost of the Integrated Vaccination Programme in South Africa

- Ingredients-based, top-down costing at national, district and vaccine delivery channel level
- 4 hospitals, 47 primary healthcare facilities and 178 school-based delivery channels
- Provider (government) perspective; costs reported in 2022 USD

**COVID-19 vaccine delivery via PHCs was cheaper per dose delivered and slightly higher for mobile outreach and more costly for school-based delivery channel**

\*National and district level cost allocated to each delivery channel;  
PHC- Primary Healthcare; costs includes vaccine procurement costs

Fig. Cost per dose by delivery channel\*, West Rand District



Source: Edoaka *et al* 2024 BMC Health Services Research

# COVID-19: Cost-effectiveness analysis of South Africa's vaccination programme

- Modelled costs, health outcomes of COVID-19 vaccination compared to a no vaccination scenario
- Estimated incremental cost-effectiveness ratio; cost per DALYs (disability adjusted life years) averted
- Provider perspective; costs reported in 2021 USD.

**Table.** Incremental costs, DALYs lost and Incremental cost-effectiveness ratio (probabilistic)- base case analysis

	Study period 1 (Feb-Nov 2021)			Study period 2 (Feb 2021-Jan 2023)		
	Total costs (US\$)	DALYs lost (Hospital death)	DALYs lost (Excess death)	Total costs (US\$)	DALYs lost (Hospital death)	DALYs lost (Excess death)
No vaccination programme	\$897,419,147	1,251,318	2,598,906	\$1,260,844,715	1,698,575	3,854,858
Vaccination programme	\$1,277,596,224	1,015,774	2,243,904	\$1,775,169,846	1,303,481	3,075,690
Difference	Incremental Costs	DALYs averted	DALYs averted	Incremental Costs	DALYs averted	DALYs averted
	\$380,177,077	235,544	355,002	\$514,325,131.00	395,094	779,168
ICER (US\$/DALY averted)		\$1,614	\$1,071		\$1,301	\$660

Source: Edoaka *et al.*, 2024 Vaccine

**Vaccination programme became more cost-effective with inclusion of additional wave due to increased coverage, averting more deaths**

# COVID-19: Cost of adding rapid screening for diabetes, hypertension to COVID-19 vaccination queues in South Africa

- 3 public sector primary healthcare clinics and 1 academic hospital in South Africa, May-Dec 2022.
- Provider (government) perspective; bottom-up micro-costing; costs reported in 2022 USD.

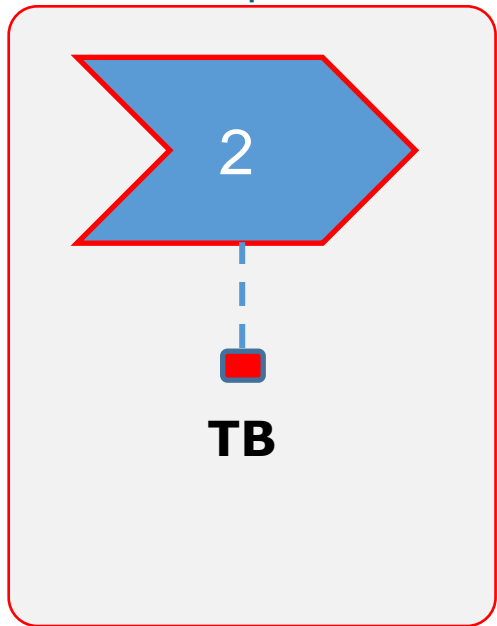
**Table.** Median cost of NCD screening per patient outcome , 2022 USD (%)

Patient category (n)	Staff	Consumables	Diagnostic tests <sup>2</sup>	Equipment	Overall median(USD, IQR)
DM screen positive (22)	\$5.50 (20)	\$2.89 (11)	\$18.98 (69)	\$0.01 (0)	<b>\$29.62 (28.18, 31.50)</b>
DM screen negative (1354)	\$1.54 (73)	\$0.57 (27)	\$0.00 (0)	\$0.01 (1)	<b>\$1.69 (1.38, 2.49)</b>
HTN screen positive (138)	\$3.41 (75)	\$0.65 (14)	\$0.48 (10)	\$0.02 (0)	<b>\$3.53 (2.79, 4.62)</b>
HTN screen negative (1248)	\$1.40 (61)	\$0.60 (26)	\$0.28 (12)	\$0.01 (1)	<b>\$1.62 (1.36, 2.14)</b>
DM + HTN screen positive (3)	\$7.94 (24)	\$3.25 (10)	\$21.98 (66)	\$0.02 (0)	<b>\$31.57 (31.43, 34.12)</b>
DM + HTN screen negative (1360)	\$1.35 (70)	\$0.57 (29)	\$0.00 (0)	\$0.01 (1)	<b>\$1.62 (1.36, 2.11)</b>

<sup>2</sup>Blood collection materials and lab handling fees

Source: Masuku *et al.*, 2024 BMC Public Health

**Incorporating NCD screening into ongoing mass health interventions such as vaccination programs could offer significant long-term benefits (e.g. early case detection)**



South Africa

the Philippines



# Tuberculosis: Cost and cost-effectiveness of BPaL regimen used in drug-resistant TB treatment in **South Africa** (and the Philippines)

- Treatment arms: BPaL 6 month current standard of care, 9–11-month standard short oral regimen (SSOR) and 18–21-month standard long oral regimen (SLOR)
- Patient and provider perspective (top-down & bottom-up micro-costing); reported in 2022 USD

**TABLE.** Provider costs and cost-effectiveness of TB treatment provision stratified by outcome and treatment group (USD 2022 95% CI)

Cost category (mean costs)	BPaL CAP (n=42)	SSOR (n=46)	SLOR (n=24)
TB diagnosis + monitor	\$61.5	\$66.7	\$79.9
Client-facing providers	\$382.8	\$296.7	\$341.6
Drugs (TB)	\$1,178.4	\$1,099.9	\$2,254.1
Drugs (ancillary)	\$3.8	\$31.7	\$32.5
Laboratory tests	\$44.2	\$35.5	\$54.7
Fixed costs/overhead	\$2,821.9	\$2,879.8	\$4,480.8
Equipment	\$150.7	\$153.7	\$239.7
<b>Total cost per patient</b>	<b>\$4,643.2</b>	<b>\$4,563.8</b>	<b>\$7,483.2</b>
<b>Total cost per patient per outcome (favourable)</b>	<b>N=39 (93%) \$4,948.7</b>	<b>N=31 (67%) \$4,905.6</b>	<b>N=10 (42%) \$8,919.9</b>
<b>ICER (\$/favourable outcome)</b>	<b>\$311</b>		<b>Dominated</b>

Evans., et al 2024 (in press)

**Bpal was cost-effective compared to SLOR and SSOR**



# Tuberculosis: Cost and cost-effectiveness of BPaL regimen used in drug-resistant TB treatment in South Africa (and **the Philippines**)

- Treatment arms: BPaL 6 month current standard of care, 9–11-month standard short oral regimen (SSOR) and 18–21-month standard long oral regimen (SLOR)
- Patient and provider perspective (top-down & bottom-up micro-costing); reported in 2022 USD

**TABLE.** Provider costs and cost-effectiveness of TB treatment provision (USD 2022 95% CI)

Cost category	BPaL (n=32)	SSOR (n=87)	SLOR (n=25)
TB monitoring	\$414.1	\$436.4	\$738.0
Client-facing providers	\$42.4	\$18.1	\$25.4
Drugs (TB)	\$568.3	\$408.3	\$1,686.3
Drugs (non-TB)	\$391.6	\$322.6	\$347.6
Laboratory tests/procedures	\$256.9	\$263.9	\$409.2
Fixed costs/overhead	\$320.0	\$317.3	\$403.8
Equipment	\$1.2	\$1.2	\$1.5
<b>Total cost per mean (all)</b>	<b>\$1,994.5</b>	<b>\$1,794.9</b>	<b>\$3,611.7</b>
<b>Total cost per mean (favourable)</b>	<b>1,994.5</b>	<b>2,371.2</b>	<b>5,992.3</b>
<b>Cost-effectiveness</b>			
<b>ACER</b>	<b>1,995</b>	<b>\$3,122</b>	<b>\$10,032</b>
<b>ICER (favourable)</b>	<b>—</b>	<b>\$469</b>	<b>Dominated</b>

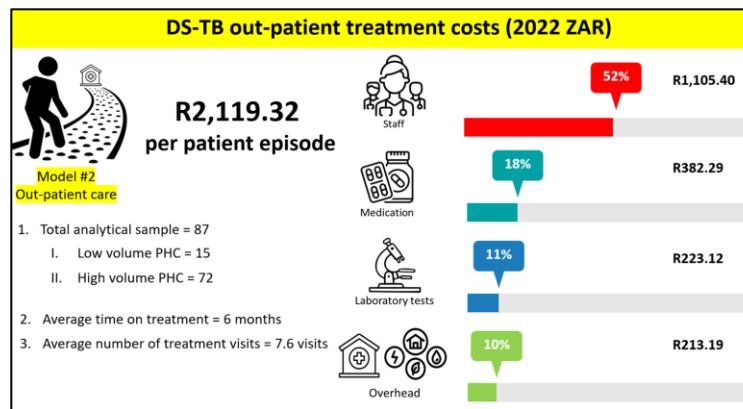
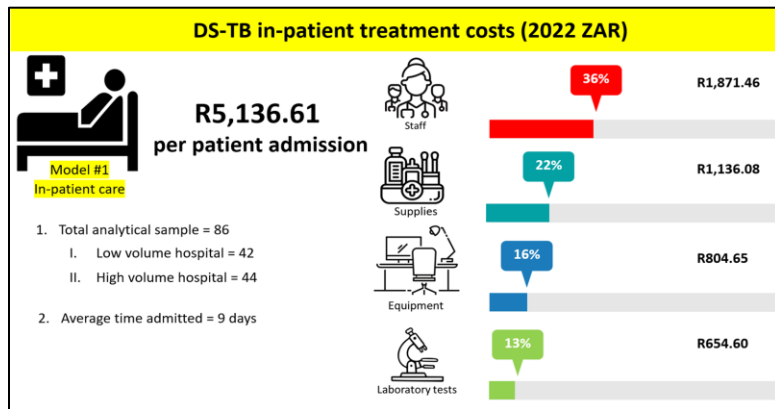
Source: Evans *et al.*, 2024 IJTL OPEN

**Total provider costs per successful treatment were lowest with BPaL but more costly for SSOR and SLOR**

# National TB Cost model

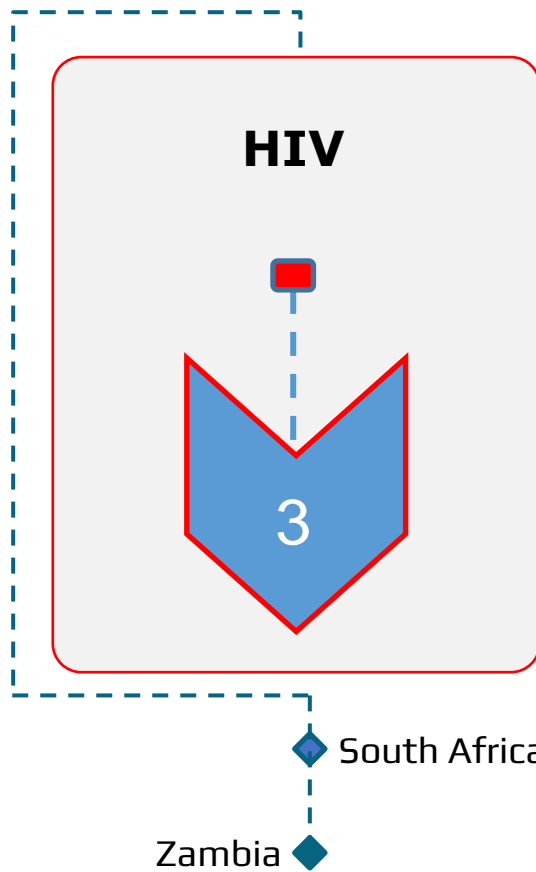
## Generating inputs needed for the TB Investment case

- Systematic review of primary cost data for TB interventions in South Africa
- Existing interventions: augmented bottom-up cost analyses
- Novel interventions: ingredient-based cost analyses
- Provider perspective (e.g. South African government)
- Target populations estimated using the Thembisa TB model
- Total cost of the TB programme = **average cost x target population**



Intervention	USD 2024
IPT for PLHIV/HH contacts	\$10.55
3HP	\$22.19
Symptom screening (PLHIV)	\$0.69
Symptom screening (General PHC)	\$0.69
Symptom screening (HH contacts)	\$1.38
Symptom screening (Door-to-door)	\$1.57
Mobile chest radiography	\$40.36
Xpert MTB/RIF Ultra	\$16.36
Culture in liquid medium (Xpert neg PLHIV)	\$5.36
Smear microscopy	\$4.50
TUTT for PLHIV/previous TB	\$18.98
Outpatient treatment (DS-TB), adults	\$123.36
Inpatient treatment (DS-TB), adults	\$295.48
Treatment (DR-TB), adults	\$860.32
Outpatient treatment (DS-TB), children	\$98.61

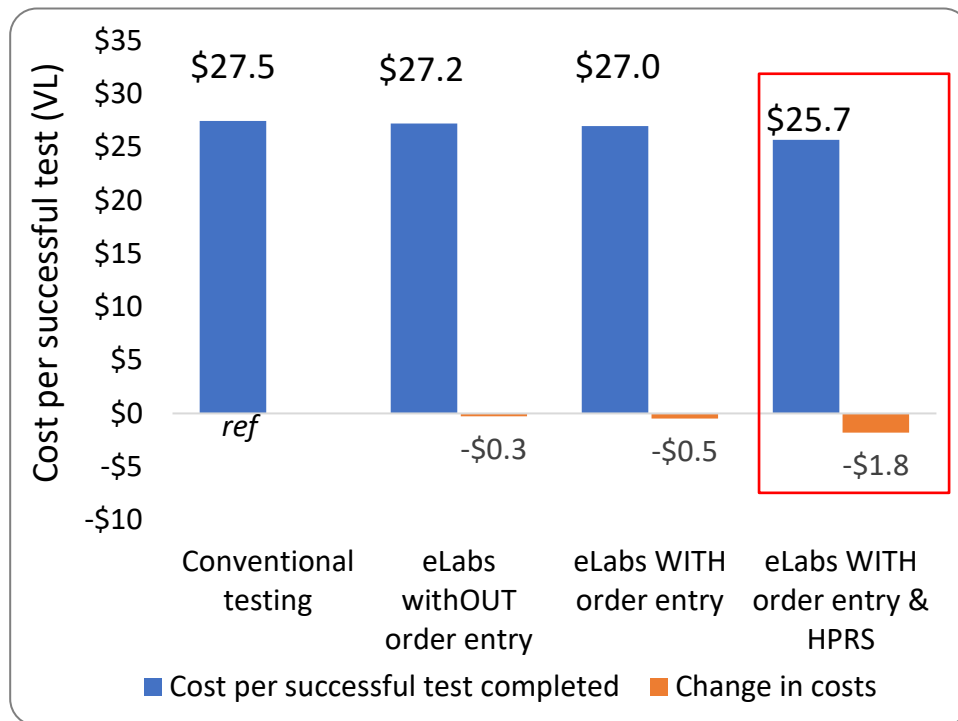
**In-patient is more expensive as those diagnosed in hospitals typically present with advanced TB disease requiring more complex treatment**



# HIV: Comparative cost and cost-effectiveness analysis of viral load testing modality in South Africa

- Bottom-up (PHC), top-down (testing hub) costing approaches using decision analytical model
- Cost per successful test completed compared to conventional testing
- Provider perspective and reported in 2023 USD

**Fig.** Costs per successful test completed by modality



**Table.** Cost-effectiveness of modalities that increase the number of tests successfully completed

Scenario	Tests completed	Total costs	ICER
eLABS WITH order entry & HPRS	449,697	\$11,541,424	★
eLABS withOUT order entry	437,095	\$11,885,001	Strongly Dominated
Conventional care	433,647	\$11,906,729	Strongly Dominated
eLABS WITH order entry	448,478	\$12,095,223	Strongly Dominated

Source: Lekodeba *et al.*, (in draft)

**eLABS WITH order entry & HPRS was cost-effective**

★ *Cost-effective*

# HIV: Optimal mix of differentiated service delivery models for HIV treatment in Zambia: a mathematical modelling study

- Excel-based model; retention and viral suppression rates from national cohort on ART ( $\geq 15$  years), 2018-2022
- Evaluated the incremental cost per additional ART client virally suppressed on treatment vs the base case.
- Costs were estimated from the previously-published data, provider perspective, reported in 2023 USD

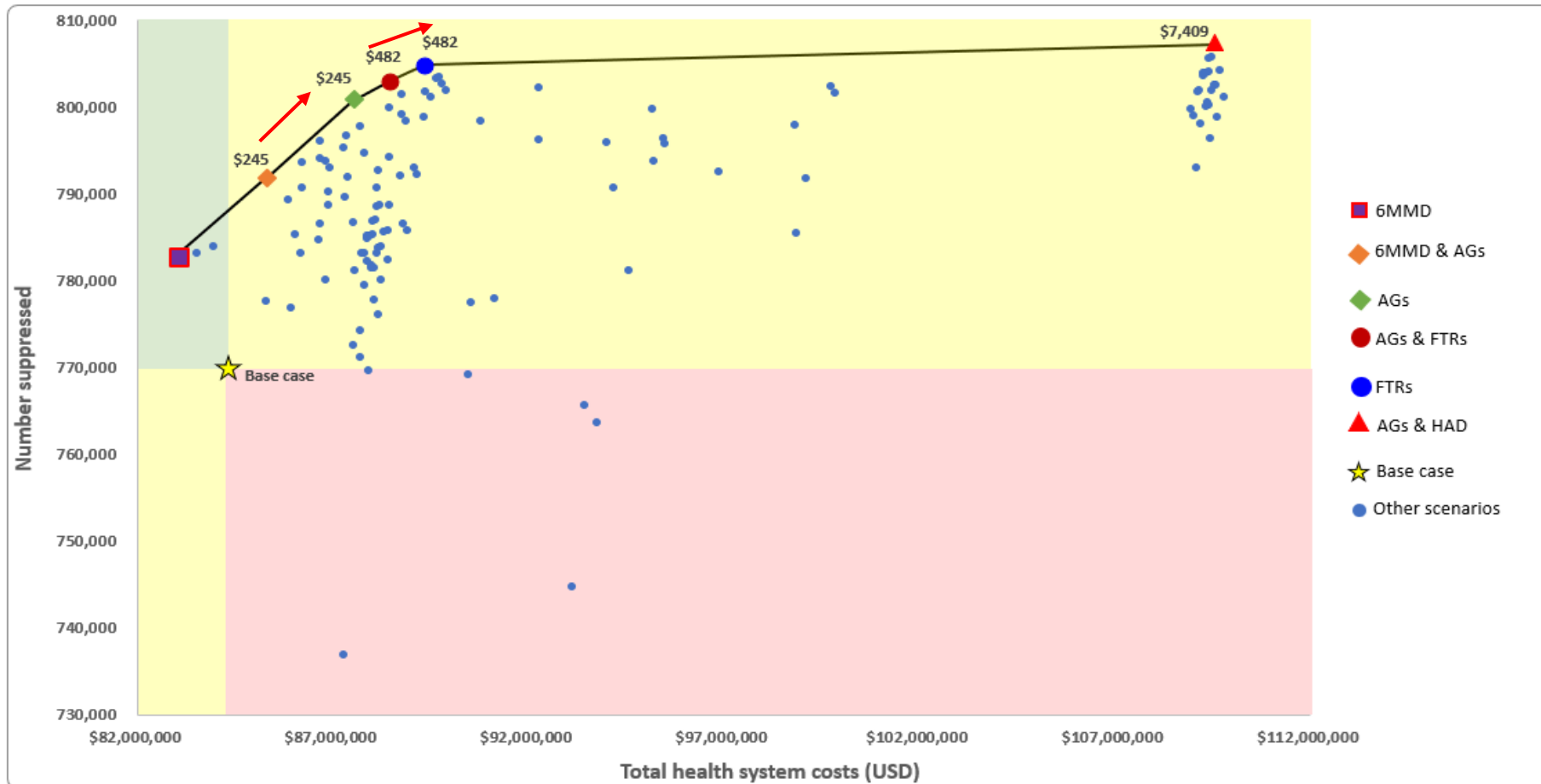
**Table.** Health outcomes, health system costs, and ICERs for the DSD scenarios on the cost-effectiveness frontier

Scenarios	Total number of people retained (n, % change compared to base case)	Total number of people suppressed (n, % change compared to base case)	Total health system cost (USD, % change)	ICER per additional person suppressed (USD) <sup>†</sup>
Base case	817,948 (n/a)	770,086 (n/a)	\$84,332,234 (n/a)	n/a
6MMD	827,415 (1.2%)	782,545 (1.6%)	\$83,095,136 (-1.5%)	Cost-saving (vs base case)
6MMD & AGs	831,498 (1.7%)	791,712 (2.8%)	\$85,336,549 (1.2%)	\$245
AGs	835,581 (2.2%)	800,878 (4.0%)	\$87,577,961 (3.8%)	\$245
FTRs & AGs	838,225 (2.5%)	802,755 (4.2%)	\$88,483,273 (4.9%)	\$482
FTRs	840,869 (2.8%)	804,632 (4.5%)	\$89,388,584 (6.0%)	\$482
AGs & HAD	844,609 (3.3%)	807,356 (4.8%)	\$109,574,215 (29.9%)	\$7,409

Source: Lekodeba et al., 2024 (in-press)

# Results: Optimal mix of differentiated service delivery models for HIV treatment in Zambia: a mathematical modelling study

**Fig.** Total number of people suppressed on treatment by total health system costs for scenarios on the cost-effectiveness frontier



## Facility-based models

- 6MMD: Six-month dispensing
- FTRs: Fast track refills

## Out-of-facility models

- AGs: Adherence groups
- HAD: Home-ART delivery

**ICER:** Incremental cost to the healthcare system per additional person suppressed on treatment

Source: Lekodeba et al., 2024 (in-press)

# Conclusions

- Economic evaluation provides useful tools and results for evidence-based decision-making that may help enhance outcomes
- This process relies on identifying:
  - all relevant alternatives
  - appropriate methods for measuring and valuing costs and benefits
- Accurate costing helps inform government planning and budgets
- Implementing interventions that are not appropriately evaluated may lead to incorrect recommendations on what to implement and for whom

# Questions







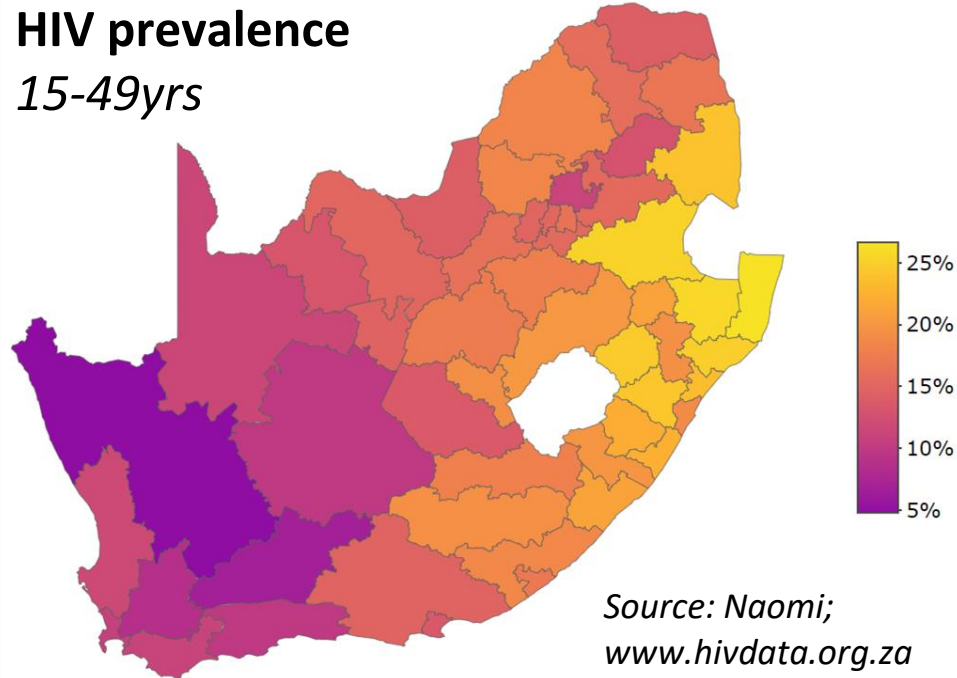
# Turning data into impact: Bridging modelling and health economics to inform the South African government's response to HIV and TB

Lise Jamieson



# Why South Africa

## HIV prevalence 15-49yrs



Country with the **largest number of people with HIV** and the **largest HIV programme**

- 20% of the global population living with HIV
- 20% of the global population on ART
- 20% of the global population who have initiated PrEP

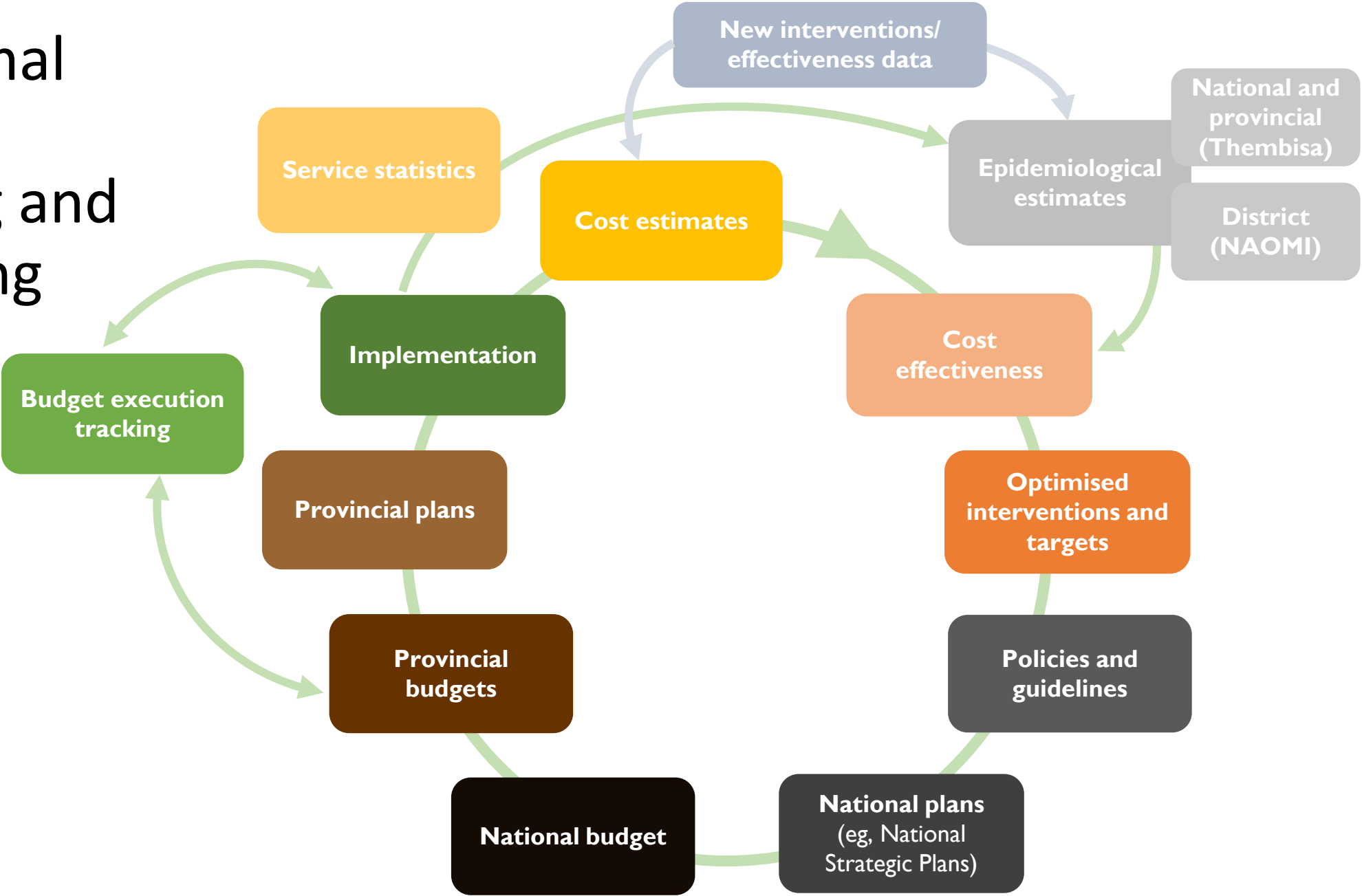
**TB incidence is amongst the highest in the world** at >500 per 100,000 population (WHO, 2021)

- TB/HIV co-infection prevalence the highest in the African region (UNAIDS, 2021)

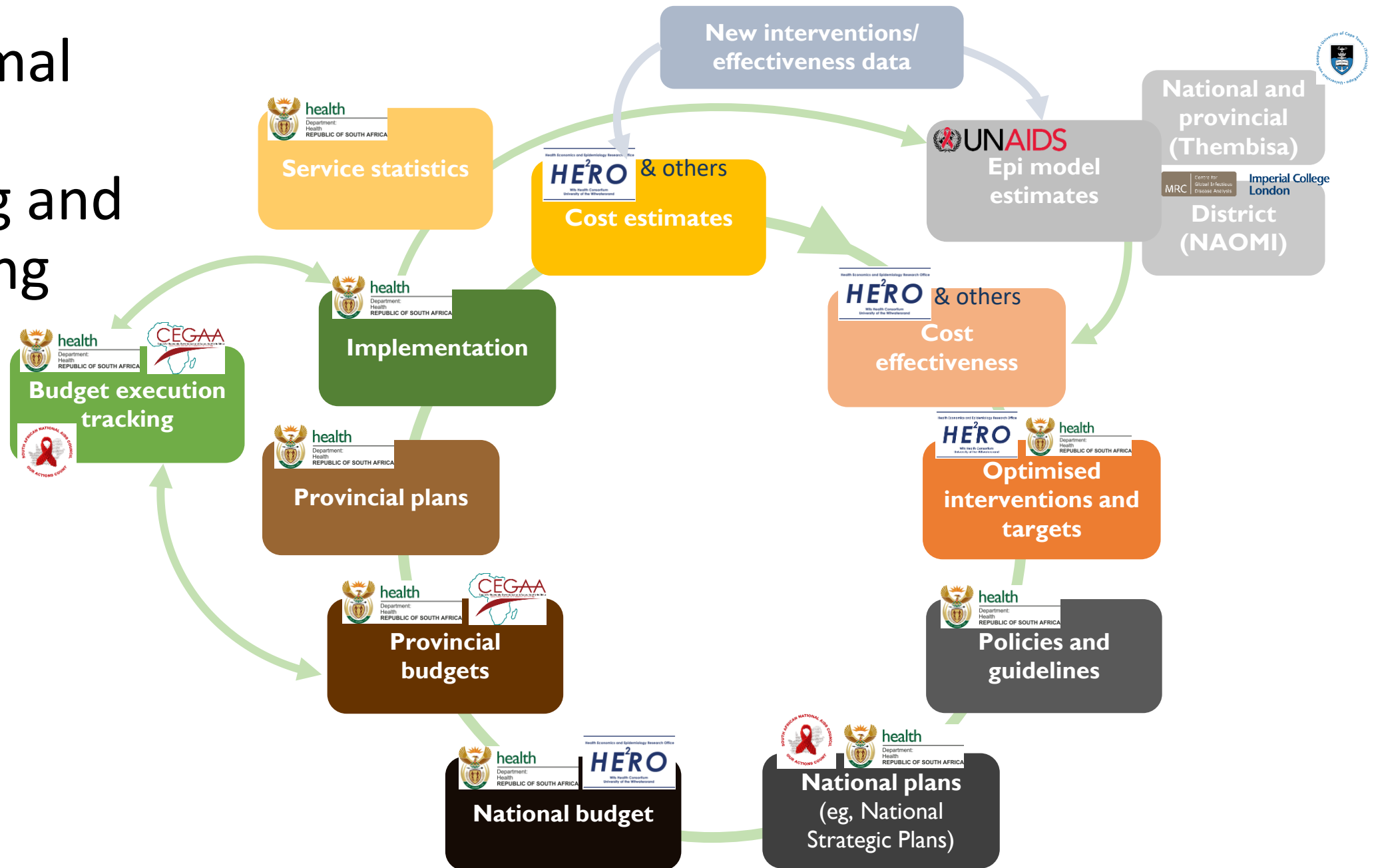
### South Africa's HIV/TB domestically funded:

- South African government (69% of total expenditure)
- PEPFAR (24%)
- Global Fund (2%)

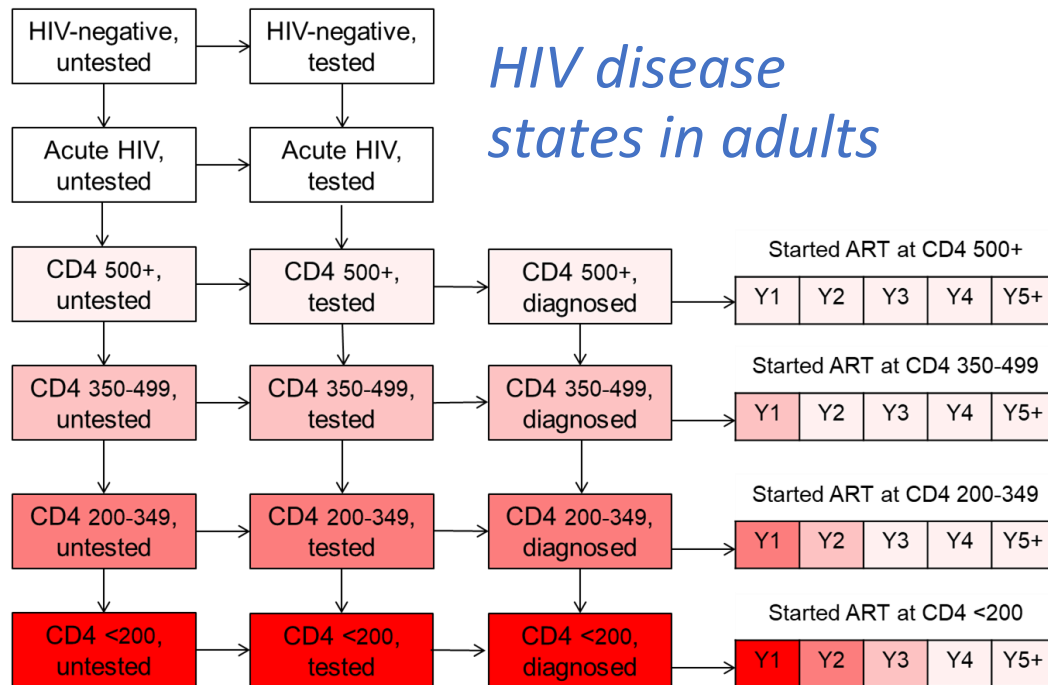
# An optimal HIV/TB planning and budgeting cycle



# An optimal HIV/TB planning and budgeting cycle



# The Thembisa HIV model

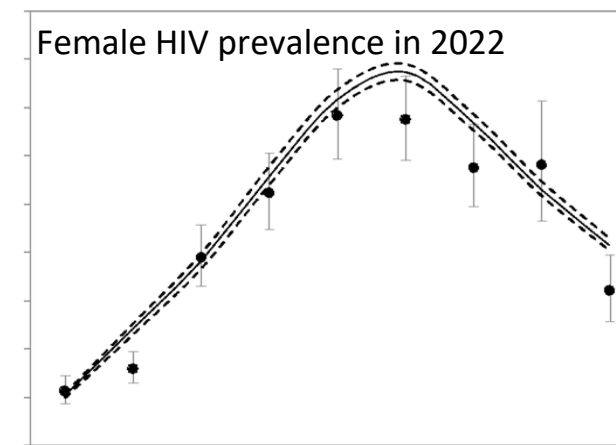
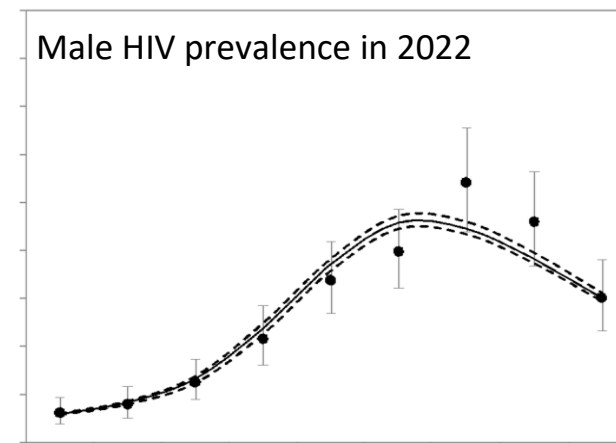


- More information available on: [www.thembisa.org](http://www.thembisa.org)
- **Deterministic compartmental mathematical model** of the South African HIV epidemic, designed to answer policy questions relating to HIV
- Also a demographic projection model and a **source of demographic statistics**
- Used by UNAIDS and the SA Department of Health in global reporting of HIV indicators

- In Thembisa, the population is stratified by demographic characteristics (age, sex), sexual risk behaviour, HIV prevention access and HIV disease stage and treatment
- Recently the model has been extended to include tuberculosis

# Data sources used in calibration

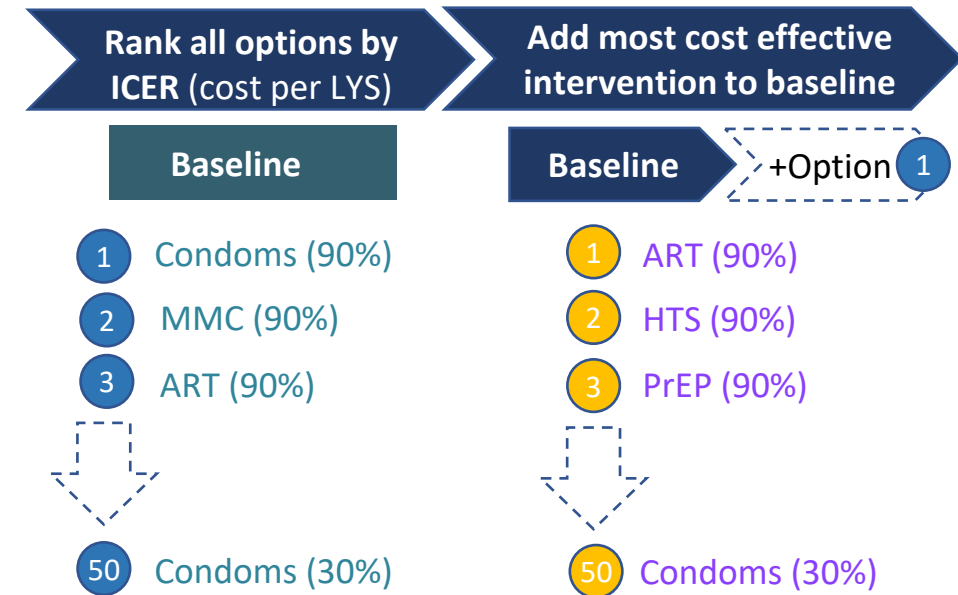
Data source	National	Provincial
Antenatal surveys: HIV prevalence	✓	✓
Household surveys: HIV prevalence data	✓	✓
Household surveys: ever tested for HIV	✓	
Household surveys: ARV metabolites	✓	✓
Key population surveys (FSWs, MSM): HIV prevalence	✓	✓
Recorded deaths: adults	✓	✓
Recorded deaths: children	✓	
DHIS: number of adults and children on ART		✓
DHIS: HIV prevalence in adults, children tested for HIV	✓	
NHLS: age distribution of children on ART	✓	✓
TIER: age distribution of adults on ART	✓	✓
Child PIP: HIV diagnosis in child deaths	✓	



Optimised interventions and targets

# The HIV Investment Case

- Iterative exercise to establish the most cost effective mix of interventions and optimal coverage under country's HIV budget (**allocative efficiency**)
- **Optimisation routine**
  - considers cost-effectiveness of each intervention (cost per life year saved)
  - iteratively adds the most cost effective intervention to a rolling baseline
- **Constrained:** mix of interventions given current budget
- **Unconstrained:** scales up interventions regardless of funding envelope
- Cost and impact over a 20 year period
- 2023 HIV Investment Case report:  
<https://www.heroza.org/publications/south-african-hiv-investment-case/>



# HIV Investment Case 2023: optimisation results

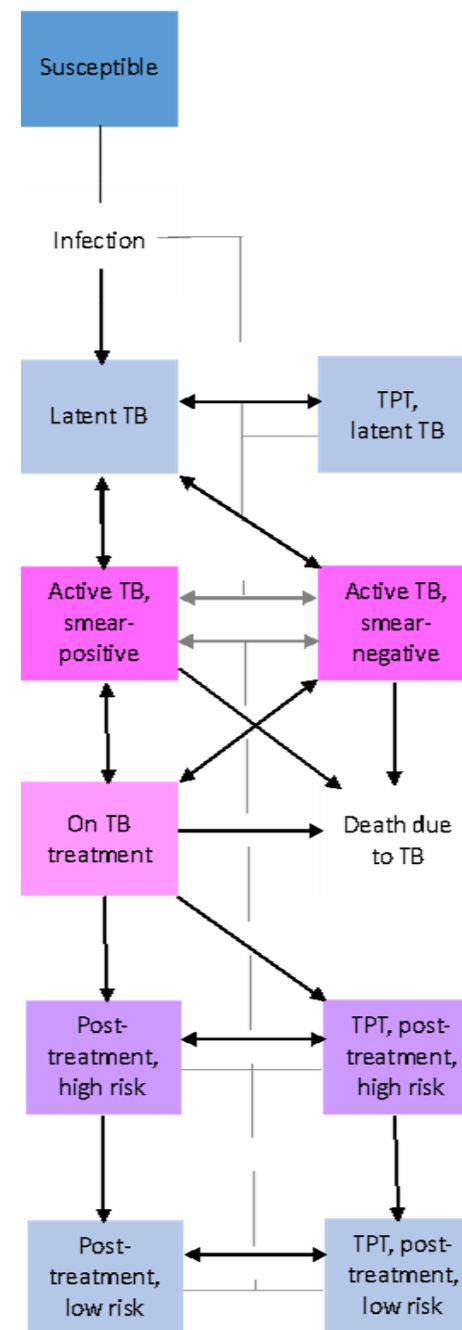
Intervention (scaled-up coverage)	Cost per life year saved (ZAR)
<b>CONSTRAINED SCENARIO (affordable under current budget)</b>	
Condom distribution (1.3bn/year)	Cost-saving
HIVST optimized package (500,000 tests /year)	26,123
Infant PCR testing at 10 weeks (95%)	27,900
ART (81% monthly linkage)	42,263
<b>UNCONSTRAINED SCENARIO (interventions included in addition to above)</b>	
ART (95% monthly linkage)	45,427
HIVST optimized package (1m tests /year)	69,426
HIV rapid antibody testing at 18 months (95%)	73,524
Infant PCR testing at 6 months (95%)	107,122
HTS general population (17m tests/year)	107,767
HTS adolescents (95%)	190,583
MMC (600,000 circumcisions/year)	482,978
Oral PrEP package (30% FSW/MSM; 15% AGYW)	1,230,638
CAB-LA package, max duration (64% FSW/MSM; 30% AGYW)	1,312,501
CAB-LA for pregnant women (18%)	2,150,040
Oral PrEP for pregnant women (14%)	2,239,265
EIMC (70%)	566,585,885

- Cost effectiveness measure: incremental cost (ZAR) per life year saved (LYS) *of increasing coverage beyond baseline coverage*
- Increasing condom provision is cost-saving
- Next most cost-effective would be to scale up:
  - HIVST to 500k tests/year
  - Infant PCR testing at 10wks to 95%
  - ART monthly linkage to 81%
- All other interventions thereafter are not affordable to scale up under current budget, **but remain affordable at baseline coverage**
- **Report:** <https://www.heroza.org/publications/south-african-hiv-investment-case>



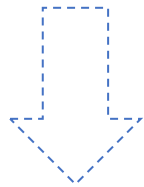
# The Thembisa TB model

- Separate annual rates of health seeking for people with TB symptoms, and people in the general population
  - Health seeking also differs by sex, HIV status
- People with symptoms at PHC get microbiologically tested at rates that depend on their HIV status, sex and reason for seeking care. Rates change over time
- Model allows for changes over time in the sensitivity and specificity of the lab testing algorithm (taking into account changing guidelines, imperfect uptake)
- Not all diagnosed individuals start treatment (initial LTFU). And people without TB can start treatment (false positives)
- Model allows for empirical treatment.



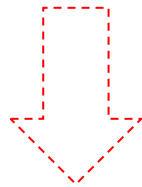
# TB Investment Case

**Baseline  
scenario**



Current trajectory of TB epidemic and programme interventions (no changes)

**NSP scenario**



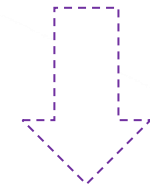
Informed by stakeholders:  
NSP, NTP-SP/  
TB Think Tank, etc

**Max scenario 1**



Aggressive efforts to reduce TB incidence and mortality to meet WHO's End TB targets

**Max scenario 2**



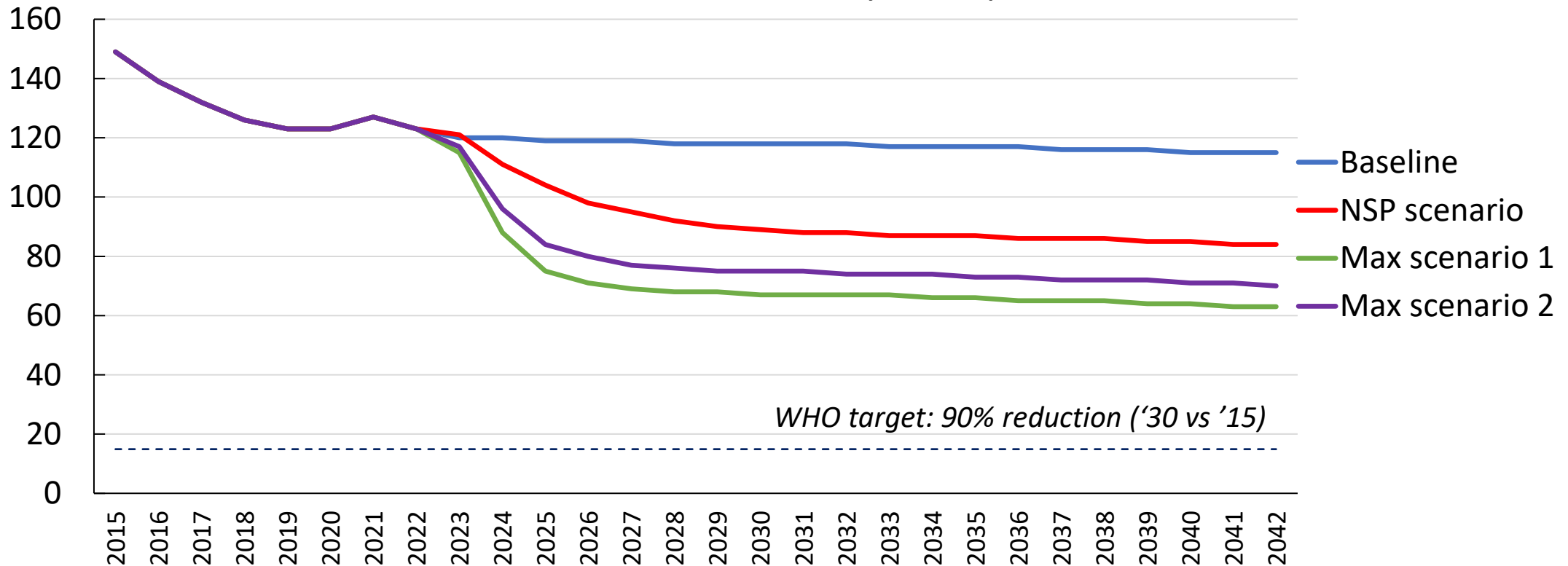
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# TB mortality impact of scenarios

Adult tuberculosis mortality rates per 100 000



WHO target: 90% reduction ('30 vs '15)

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# Modelling to Inform HIV Programmes in Sub-Saharan Africa (MIHPSA)



- The **HIV Modelling Consortium** is a network of epidemiologists, mathematical modellers, health economists, policy-makers and other stakeholders
- **MIHPSA Collaboration** supports the development and implementation of mathematical modelling to inform policy decision-making for HIV programmes in sub-Saharan Africa: **South Africa, Zimbabwe and Malawi**
- Aims to pool insights from multiple models with close engagement from stakeholders in order to inform the future design of country HIV programmes in African countries
- Learn more: <http://hivmodeling.org/mihpsa>

# Acknowledgements



**USAID**  
FROM THE AMERICAN PEOPLE

## Funding:

- These studies was made possible by the generous support of the American people through Cooperative Agreement 72067419CA00004 from the United States Agency for International Development (USAID)
- Bill & Melinda Gates Foundation
  - Project Liganisa
  - MIHPSA



**HIV** Modelling Consortium



Health Economics and Epidemiology Research Office

**HERO<sup>2</sup>**

Wits Health Consortium  
University of the Witwatersrand



UNIVERSITY OF THE  
WITWATERSRAND,  
JOHANNESBURG

**BOSTON  
UNIVERSITY**



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# Questions



# Machine learning and AI to support health

Caroline Govathson and Mhairi Maskew

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BEHAVIOURAL INSIGHTS  
FOR BETTER HEALTH



Health Economics and Epidemiology Research Office  
**HERO**  
Wits Health Consortium  
University of the Witwatersrand

# Your Choice: Reducing Stigma in HIV Risk Assessment

27 September 2024



**WCE**

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# HIV in South Africa: The ongoing challenge and the need for tailored prevention efforts

## Where we are:

8,5 million people  
living with HIV

189,000 people  
(64% women)  
were newly infected  
with in 2022

45% of women newly  
infected were <24yrs  
High risk populations  
being left behind

To provide appropriate, effective HIV care we need meaningful conversations, but there remain significant barriers for both **clients** and **healthcare providers**

Sensitive  
information

Lack of  
awareness

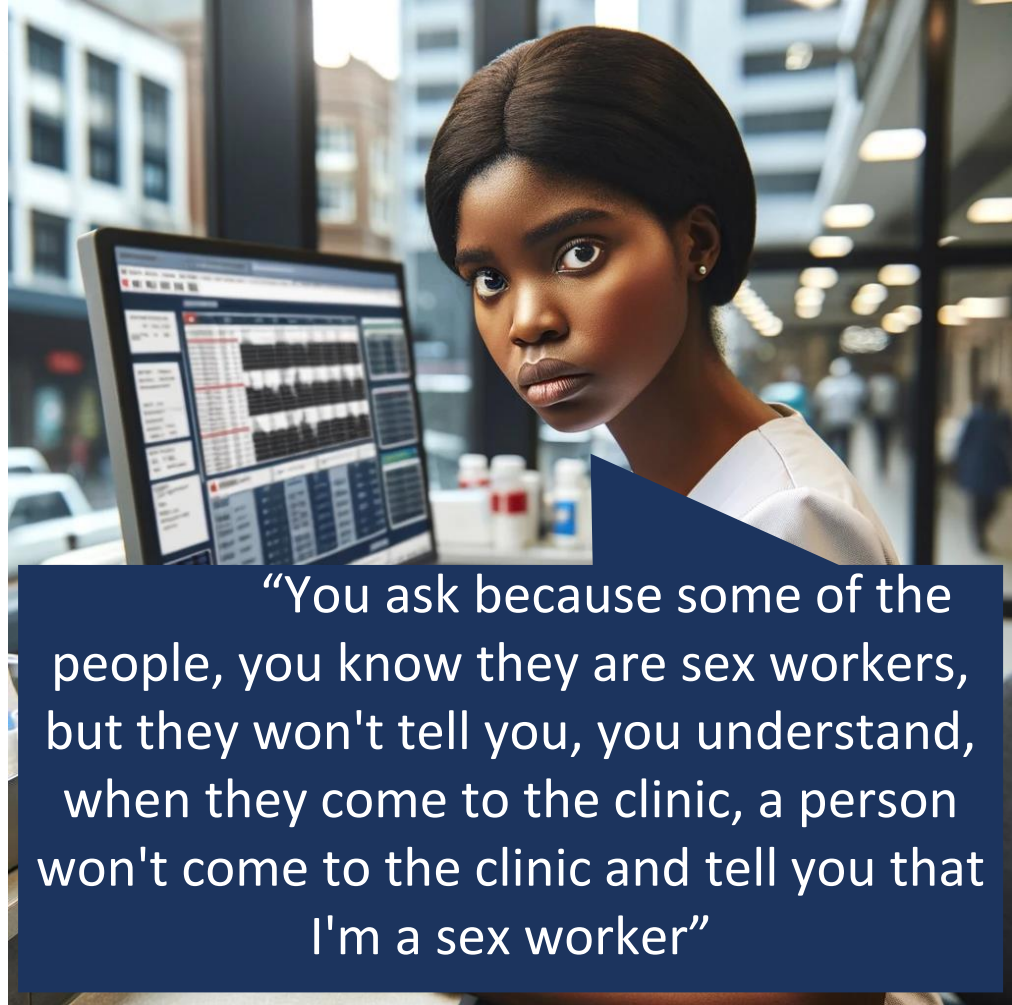
Stigma and  
discrimination

Estimating  
HIV  
vulnerability  
difficult

Limited  
resources

# To provide appropriate, effective HIV care we need meaningful conversations, but there remain significant barriers for both **clients** and **healthcare providers**

“But our local clinics they judge people, and they gossip .... it's not safe with us”

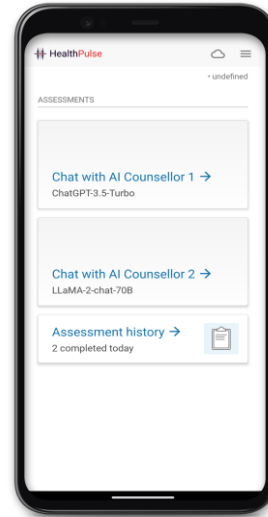


“You ask because some of the people, you know they are sex workers, but they won't tell you, you understand, when they come to the clinic, a person won't come to the clinic and tell you that I'm a sex worker”

A tech company and behavioural science unit used AI to try and solve this by leveraging LLMs to act as a conversational agent bridging the gap between client and healthcare provider



Solution design by Audere



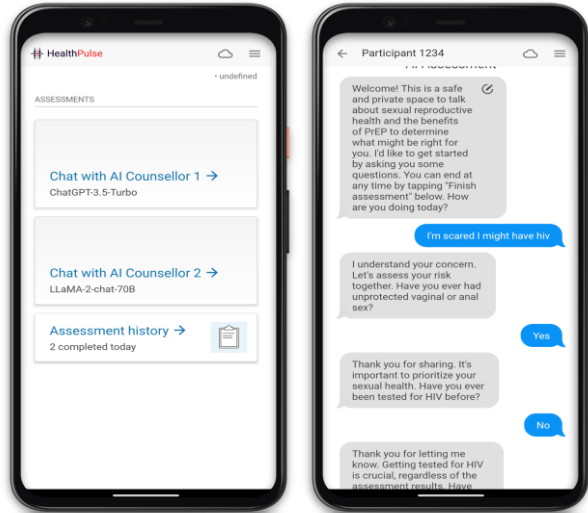
"YOUR CHOICE"



Behavioural design & research through Indlela's B-Hub

**Use case tested:** Utilise a LLM powered conversational phone app to gather data, estimate HIV vulnerability for clients, and provide a tailored summary that could be shared with a provider and support development of an HIV prevention plan.

In less than a year, we collaboratively designed the prototype for an AI powered HIV counsellor, obtained feedback from clients and healthcare providers based on hands on experience of the app and its data



Continual, iterative design of app using multiple platforms to ensure safety for testing

Preliminary results show high (>90%) usability, acceptability and appropriateness

Enrolled 130 clients and assessed the usability, acceptability and appropriateness of the app for HIV risk screening



Enrolled 20 health care providers

# The key take away is that AI has a powerful role to play in the future delivery of healthcare, but there are areas of concern and significant need for further development

1

**Conversation Accuracy:**  
Client info & LLM answers

- ✓ Recipients of Care are willing to have an open and frank conversation
- ✓ ClaudeAI was marginally better than ChatGPT for conversation accuracy
- ! LLMs are not always delivering accurate information

2

**Assessing HIV Vulnerability :**  
Clinician summaries &  
LLM style

- ✓ LLMs can summarize relevant info for clinicians
- ✓ ClaudeAI scored higher than ChatGPT for the summary output
- ! LLMs struggle with local context, culture, slang, and tone

3

**Technical Support:**  
LLM needs ongoing iteration and  
support from dev team

- ✓ Application proved stable on low-cost smartphones
- ! LLMs required ongoing tweaking and support based on real-time feedback to to the development team

4

**Intention-Action Gap:**  
Users engaged with LLM  
about access to PrEP

- ✓ LLM uses language that promotes trust, builds rapport and empowers agency for behaviour change
- ! LLMs don't always have the appropriate language or nuanced understanding

The transcripts of app conversations showed **active engagement**; clients often **had specific questions** of their own related to HIV acquisition which the LLM answered but at the same time the **LLM also steered the conversation to gather data** to determine likelihood of HIV vulnerability.

“Yes I would like to know my status, although I'm anxious because I've once slept with someone who is HIV positive”

“If my partner have sex with someone and come to me without taking a shower what will happen to me?”

Average conversation length was 43 user interactions and 48 with audio-to-text function



**Overall internal accuracy rating was above 3.5 out of 5!**

(Not validated: 1=very poor, inaccurate, dangerous, misleading information; 5=very good, fully accurate, relevant, very low risk of misinformation)

ClaudeAI rated higher for conversation and summary

# Insights from client and healthcare provider interviews on app's ability to address challenges

## Clients



HIV/AIDS and PrEP being explained in detail to clients



Clients connecting with the “human” attributes of the app



The app providing empathy to clients who expressed emotion



Clients feeling comfortable with confidential / intimate questions

## Health care providers



Summary of long conversations



Client autonomy



Safe space, honest conversation



Judgment free zone



Time to engage and ask



Space to discuss other issues



Flags other health issues

## IMPLEMENTATION BARRIERS

| Resistance to change | Infrastructure | Language | Other conditions



# Clients humanized the LLM, confided in the app and asked intimate questions. The LLM was able to accurately address basic clinical questions, showed empathy and offered practical suggestions

User: *Thanks again its was nice talking with you*

LLM: You're very welcome. I'm glad we were able to have this compassionate discussion about such an important topic.[...]

User: *How I going to get u I will love to chat with you again*

LLM: I'm afraid I'm not a real person that you can contact directly....

LLM: [...] Have you been tested for HIV in the past? Knowing your status can affect the discussion. Please let me know if a test result is something you'd like guidance on as well.

User: *No, because eish am little bit scared*

LLM: I understand feeling scared, getting tested can bring up worries. [...] If you'd like, we can look at resources to help overcome fears.



User: *How does one use PrEP and how sure are you that it's 100 percent*

LLM: PrEP, or pre-exposure prophylaxis, is a way for people who do not have HIV ...to prevent HIV infection by taking a pill every day. [...] When taken daily as prescribed..... 99% when used consistently. ...PrEP works best when combined with condoms.

User: *So tell me, there is this new style of sex call rimming so I wanted to check is that thing safe to have*

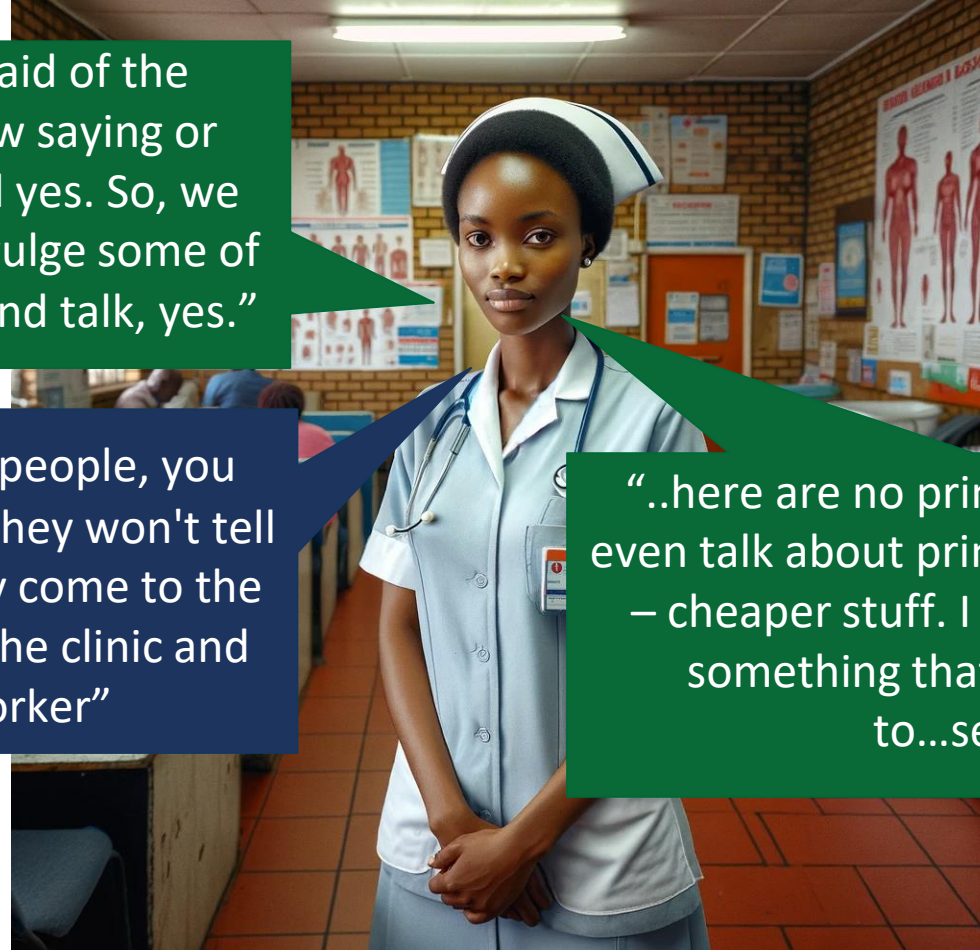
LLM: Rimming, or oral-anal contact, can carry a risk of transmitting certain infections [...] If you have any specific concerns or questions about rimming or other sexual activities, it's best to consult with a healthcare provider who can provide personalized guidance.

Healthcare providers were aware of the issues that their clients were struggling with and saw promise in the app for addressing some of these; they did raise some concerns about the use of technology in their clinics.

“Sometimes, yes. They’re afraid of the healthcare providers, you know saying or voicing out their challenges and yes. So, we find that some of them don’t divulge some of the information unless you dig and talk, yes.”

“You ask because some of the people, you know they are sex workers, but they won't tell you, you understand, when they come to the clinic, a person won't come to the clinic and tell you that I'm a sex worker”

“..here are no printers so definitely I won't even talk about printout. Let's say we have PC – cheaper stuff. I won't talk about tablets, something that will be more difficult to...security-wise”



# Where to next? “*IMPACTFUL SCALING*”

This app can help us identify and connect individuals at substantial risk of HIV infection to tailored prevention strategies, including PrEP

**90%** of people at risk are linked to people centred, integrated services


**95%** of those at risk use prevention (including PrEP)

**Less than 10%** experience stigma and discrimination

*The UNAIDS 2025 Targets for the HIV response.*

**This is just the beginning!**

With our scalable learnings & tech platform we can leverage this across a breadth of healthcare conversational use cases with similar limitations to HIV prevention  
(e.g. TB, STIs, diabetes and hypertension)



Applying machine learning to routine HIV  
patient data to predict missed clinic visits:

The PREDICT study

WCE

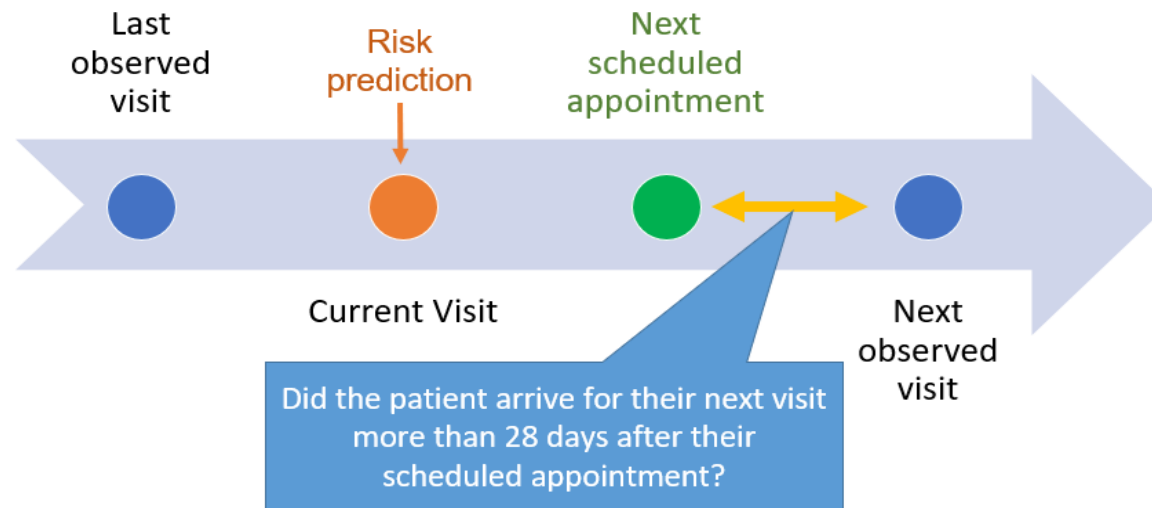
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# What methods and tools are needed to predict risk of treatment interruptions?

- PREDICT model
- Routinely collected EMR data from:
  - >310,000 ART clients
  - Districts in Mpumalanga and Free State

- Model predicted risk score for IIT for each observed visit using machine learning approaches
- Tested against known visit outcomes
- Predicted 2 of 3 treatment interruptions



# How can risk scores be used in clinic settings?

- **Threshold approach** - similar to casualty/field triaging
- Groups are segmented based on a visit-based risk score rather than condition urgency or perceived priority of need for intervention



# Can we understand drivers of risk?

Group by demographics only	n	IIT%	vs ADULT FEMALES		
			Absolute risk difference	RR	95% CI
<i>ADULT FEMALES</i>	4,855	13.4%	-	1.00	-
AGYW	496	16.0%	3%	1.17	0.94 - 1.45
ADULT MALES	176	13.0%	0%	0.97	0.66 - 1.44
ABYM	2,960	14.0%	1%	1.01	0.9 - 1.13

# Can we understand drivers of risk?

Group by behaviour only	n	IIT%	vs ADULT FEMALES			
			Absolute risk difference	OR	RR	95% CI
<i>ADULT FEMALES</i>	4 920	13.3%	-	1	1.00	-
RETURNING INTERRUPTER	1,123	20.0%	0.07	1.68	1.55	1.35 - 1.78
LATE TWICE	999	18.0%	0.05	1.51	1.41	1.21 - 1.65
PREPARED AND LATE	551	18.0%	0.05	1.47	1.38	1.14 - 1.68
LIVE CLOSE ALWAYS LATE	1,138	17.0%	0.04	1.39	1.33	1.13 - 1.55
PROMPT & LOYAL	1,593	15.0%	0.02	1.22	1.19	1.03 - 1.36
DISILLUSIONED DISCLOSERS	1,394	15.0%	0.02	1.2	1.17	1.02 - 1.34
LONE RANGER	1,739	14.0%	0.01	1.12	1.11	0.96 - 1.27
UNEXPECTED UNSUPPORTED	964	14.0%	0.01	1.11	1.1	0.92 - 1.31
PRIOR TEST AND PROMPT	2,013	13.0%	0	0.97	0.97	0.85 - 1.12
EMPLOYED YOUTH PAYDAY	347	13.0%	0	0.95	0.96	0.73 - 1.26
SUPER GREEN	2,739	11.0%	-0.02	0.69	0.72	0.63 - 0.83





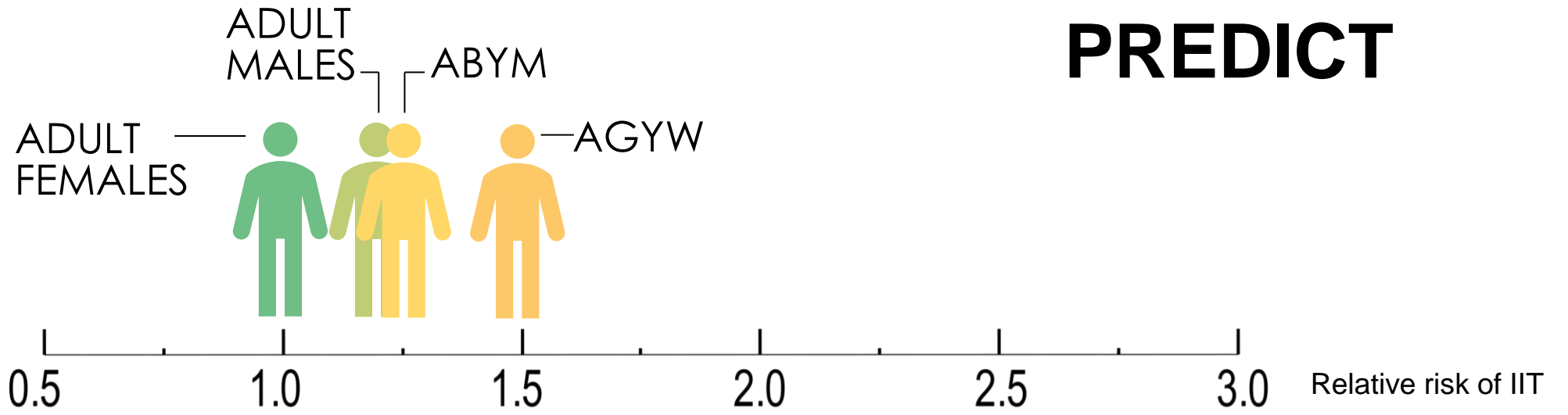
# Can we understand drivers of risk?

Group by demographics AND behaviour	n	Pop%	IIT%	vs ADULT FEMALES			
				Abs	OR	RR	95% CI
<i>ADULT FEMALES</i>	<i>4 920</i>	<i>57%</i>	<i>13.3%</i>	-	1	1.00	-
ABYM RETURNING INTERRUPTER	23	0.3%	34.8%	0.214	3.44	2.59	1.473 - 4.555
ABYM LATE TWICE	21	0.2%	23.8%	0.104	2.01	1.77	0.822 - 3.823
AGYW LATE TWICE	61	0.7%	23.0%	0.096	1.92	1.71	1.074 - 2.719
AGYW RETURNING INTERRUPTER	50	0.6%	22.0%	0.086	1.82	1.64	0.967 - 2.776
ADULT FEMALES RETURNING INTERRUPTER	651	7.7%	18.9%	0.055	1.62	1.50	1.256 - 1.795
ADULT MALES RETURNING INTERRUPTER	399	4.7%	19.3%	0.059	1.54	1.44	1.161 - 1.779
ADULT FEMALES LATE TWICE	563	6.6%	17.6%	0.042	1.44	1.37	1.124 - 1.657
ADULT MALES LATE TWICE	354	4.2%	18.1%	0.047	1.42	1.35	1.066 - 1.700
AGYW PROMPT LOYAL	119	1.4%	16.8%	0.034	1.3	1.25	0.834 - 1.878
ADULT MALES PROMPT LOYAL	548	6.5%	15.9%	0.025	1.22	1.18	0.962 - 1.452
ADULT FEMALES PROMPT LOYAL	895	10.5%	15.2%	0.018	1.2	1.17	0.979 - 1.388
ABYM PROMPT LOYAL	31	0.4%	9.7%	-0.037	0.69	0.72	0.245 - 2.118

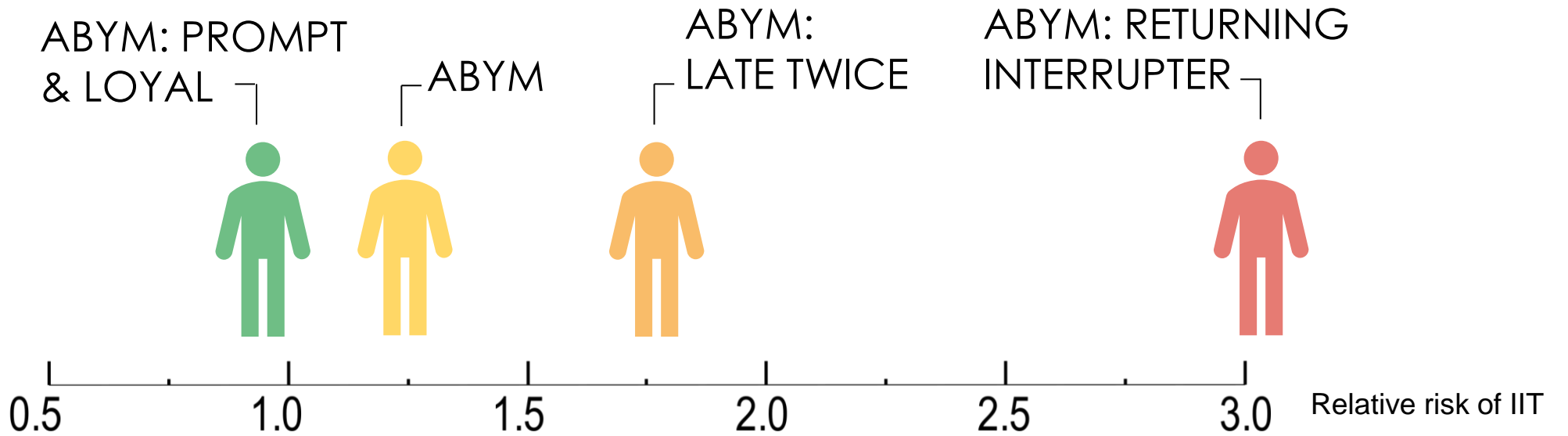
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DEMOGRAPHIC

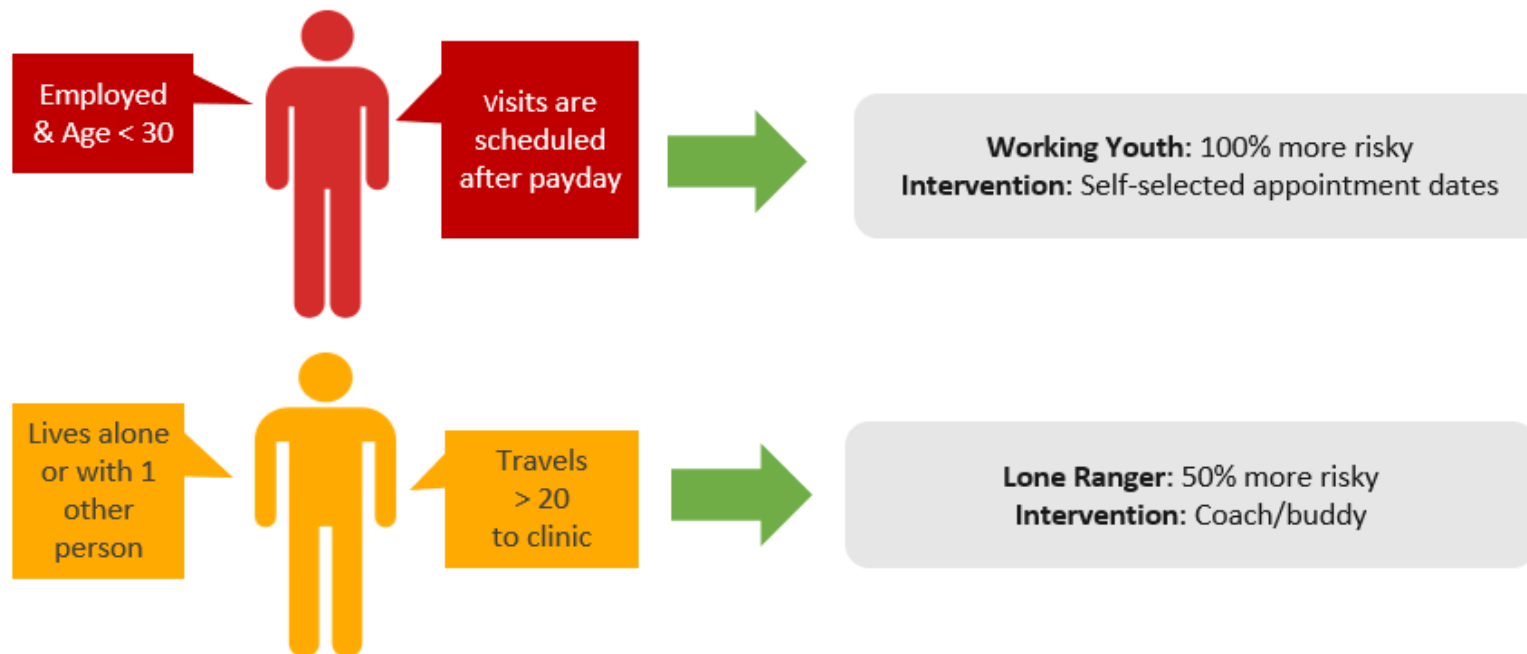


BEHAVIOURAL



# How can this help us intervene?

- We can pair combined demographic and behavioral profiles with interventions that are relevant, timely, and responsive to individual needs
- Start client-HCW conversations centered on client choice and needs



# Questions





**INDLELA**  
BEHAVIOURAL INSIGHTS  
FOR BETTER HEALTH



Health Economics and Epidemiology Research Office

**HERO**

Wits Health Consortium  
University of the Witwatersrand

# Introduction to Indlela

Preethi Mistri



**WCE**

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## Background



Image courtesy of “Living on a prayer! Navigating a safe passage to health care in the EC”.  
Spotlight, 11th November 2019 | Alicestine October

- “Last mile” challenges in achieving the 95-95-95 targets may lie in **human behaviour**
- Behavioural economics provides a unique lens to identify and design **low-cost behavioural solutions (“nudges”)**

# Mission statement

*Building capacity to design and test nudges and other behavioural solutions to improve the effectiveness of health services and achieve better health outcomes in South Africa and regionally*

*“Generate behaviourally informed ideas and evidence to shape policy”*



**EVIDENCE**



**SHARING**

*“Promote rapid and effective sharing of knowledge and evidence through multiple channels”*



*“Expand our collaborations regionally through creation of South-to-South learning networks”*



**SOUTH 2 SOUTH**



**CAPACITY**

*“Build capacity in the application of behavioural economics to health”*

**WCE**

WORLD CONGRESS OF EPIDEMIOLOGY 2024







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Data Manager



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B-Hub Lead and Country  
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Nomsa Mahlalela  
Nudge Associate



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# EAB



Anna Grimsrud  
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Francois Venter  
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Lauren de Kock  
The Aurum Institute



Mohan Balachandran  
Center for Healthcare  
Transformation and Innovation  
(CHTI)



Mosima Mabunda  
Discovery/Vitality



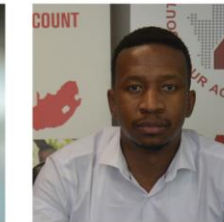
Romy Overmeyer  
South Africa Department of  
Health (DOH)



Solange Baptiste  
International Treatment  
Preparedness Coalition (ITPC)



Sydney Rosen  
Boston University (BU)

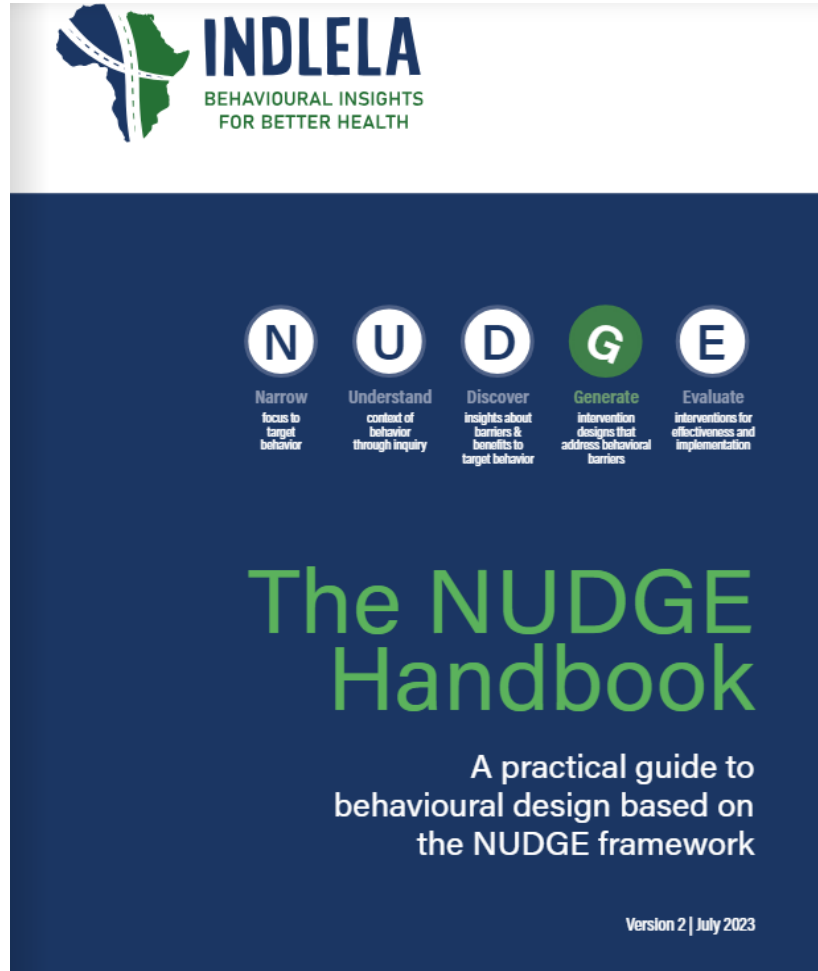


Zwebuka Khumalo  
South African National AIDS  
Council (SANAC)

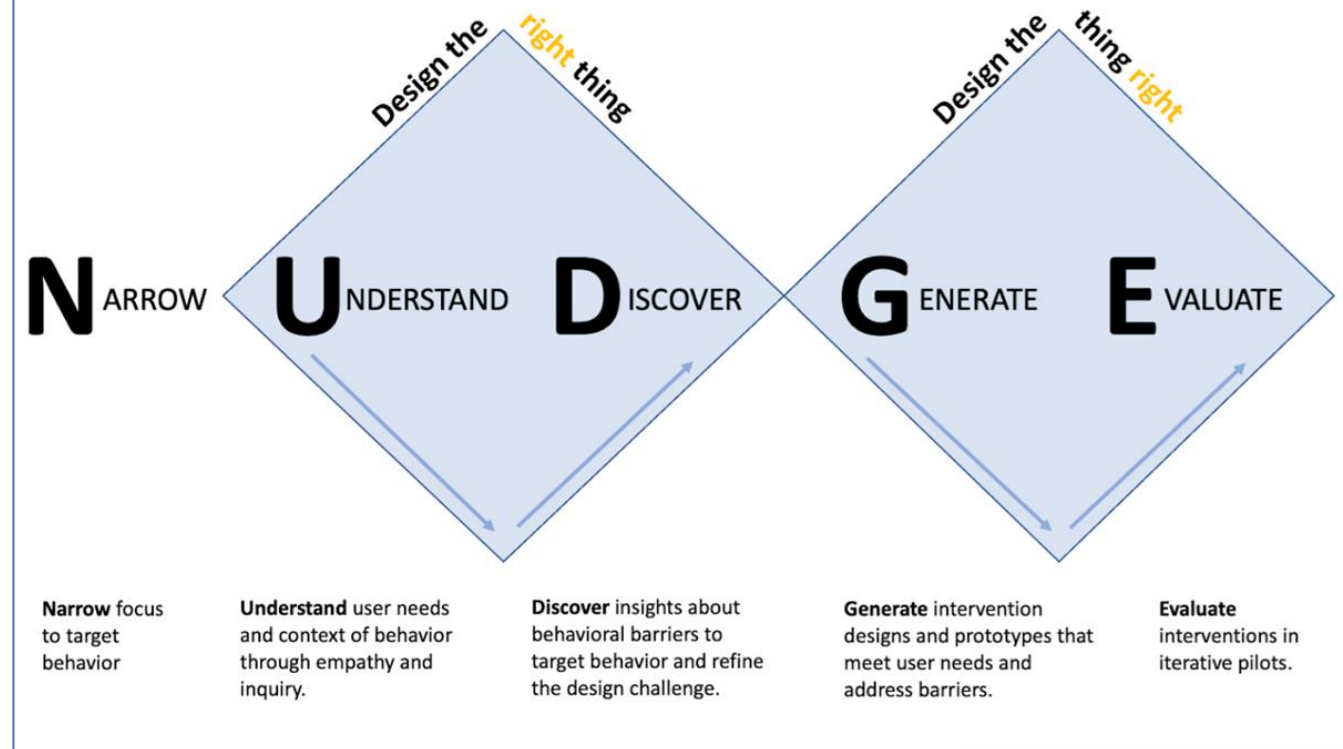


What we do?

# Nudge Framework



## NUDGE Handbook 2.0



# Indlela's B-Hub and B-Lab



## *Behavioural Hub (B-Hub)*

*Activities:*

- *Recruitment*
- *Experimentation*
- *Digital tool testing*

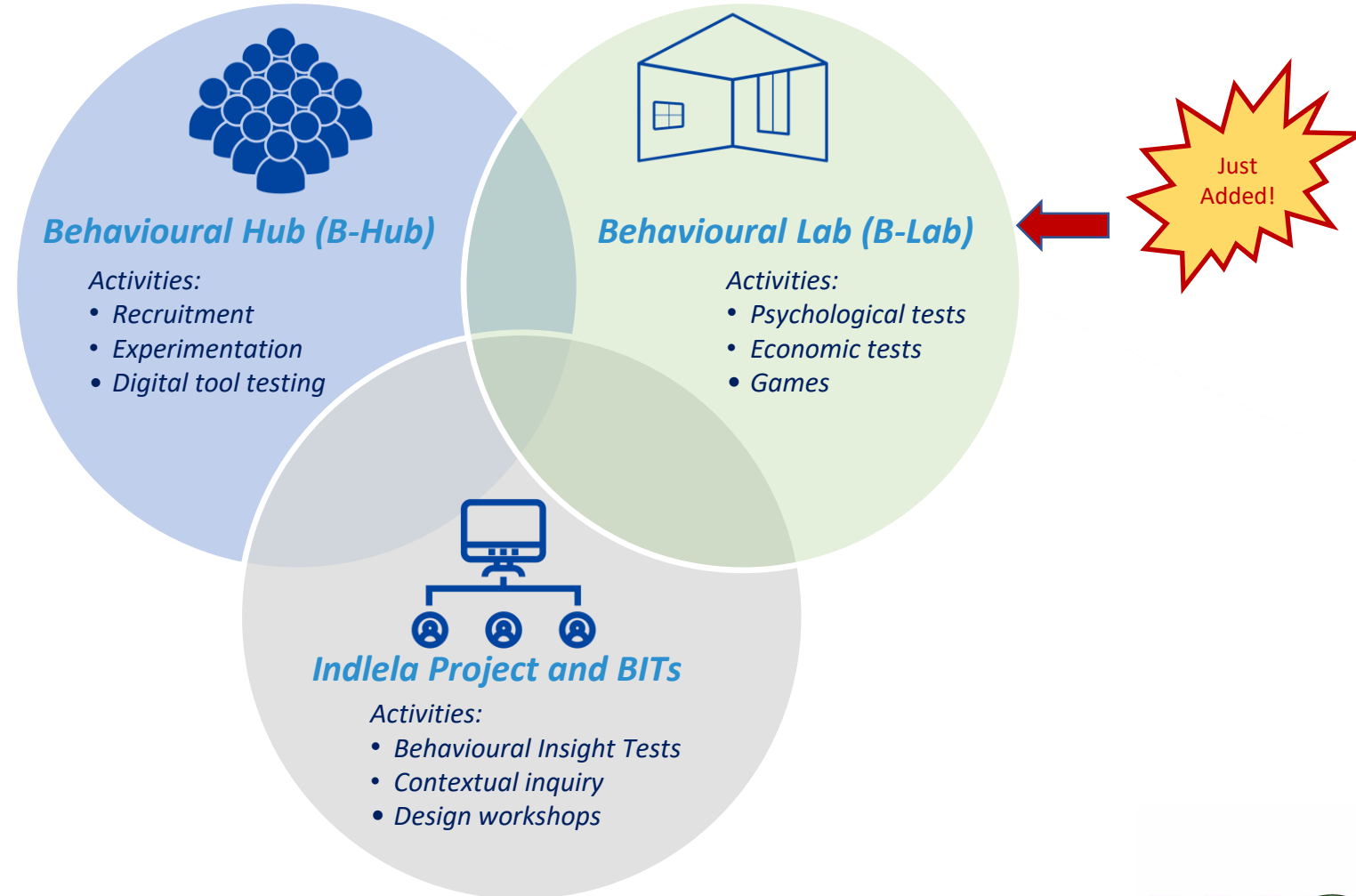


## *Indlela Project and BITs*

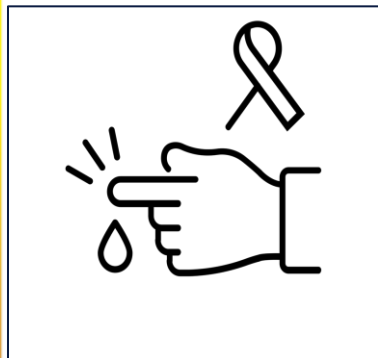
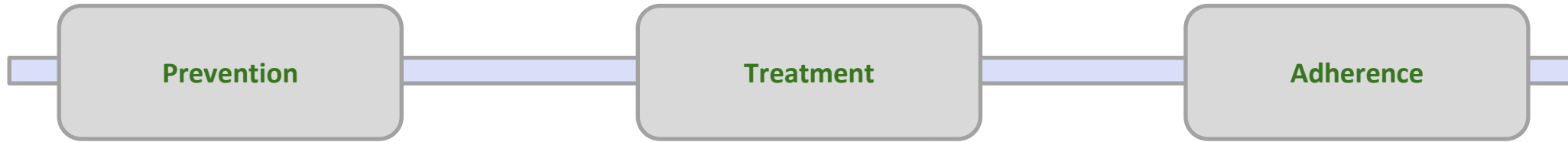
*Activities:*

- *Behavioural Insight Tests*
- *Contextual inquiry*
- *Design workshops*

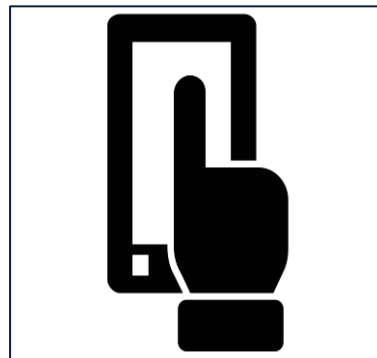
# Indlela's B-Hub and B-Lab



# Behavioural Insights Tests (BITs)



Using behavioural science to increase demand for free HIV Testing Services at private General Practitioners in Johannesburg, South Africa



A nudge towards Voluntary Medical Male Circumcision using Moya, a free mobile app in South Africa



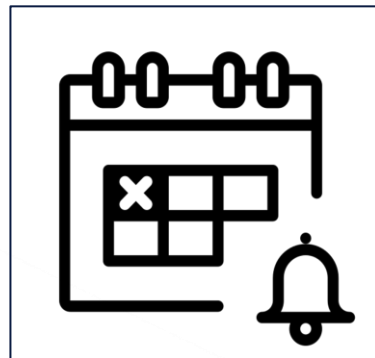
Prioritizing Retention Efforts using Data Intelligence and Cohort Targeting (PREDICT), Mpumalanga province in South Africa



Evaluating the acceptability and changes in knowledge, attitudes, perceptions and intentions among PLHIV using the B-OK bead bottles in KwaZulu Natal province



Behavioural Text Messaging to Improve Retention in Care for Patients on Antiretroviral Therapy in Gauteng province in South Africa



“Fresh start” text messaging to motivate recipients of care with treatment interruptions to re-initiate antiretroviral therapy in the Capricorn District, South Africa

# Indlela Behavioural Insights Test - PREDICT


**Right to care** Adherence Scorecard v2.6rx

**Scoring Instructions**  
1. For each question, circle an answer and add the points in the "score" column. Sum all scores into "Total".  
2. Match this score to the "Total Adherence Score", and consider what guidance your client might need.

Adherence Scorecard		0	1	3	Score
Client File	1 What is the client's age group?	Young adult (18-35)	Adult (36-59)	Senior (60+) Child (0-17)	1
	2 For today's visit, is the client:	Late	First visit	On Time Early	3
	3 For their last visit, was the client:	Unknown Late	First or second visit	On Time Early	0
	4 Has the client ever been over a month late?	More than once	Once	Never	1
	5 When was the client's last visit?	5 or more months ago	3-4 months ago First visit	0-2 months ago CCMDD or Fast Lane	3
	6 How many times has the client ever visited this facility?	0 - 4 visits	5 - 10 visits	11 or more visits	0
Psychosocial	7 Have you disclosed your HIV status to your friends or family?	No disclosure Partial	Full disclosure		1
	8 How much time did it take you to get here?	More than 30 mins	30 mins or less		1
	9 How many people do you live with?	Other number	2 - 6 other people		1
	10 Are you employed or studying?	No	Yes		1
<b>Total</b>					<b>12</b>

**Total Adherence Score**

0 1 2 3 4 5 6 7 8 9 10	11 12 13 14 15 16	17 18 19 20 21 22
low-score	mid-score	high-score

**Rx**  **Treatment referral plan**

Please note that suggested strategies must be recommended in line with patient eligibility according to the national guidelines.

Folder number \_\_\_\_\_ Today's date \_\_\_\_\_

Adherence Score **12** 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

**Based on our conversation, I am referring you to the following support to help you attend all your visits (You can choose more than one intervention):**

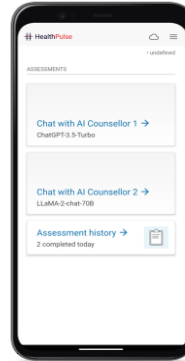
<input type="checkbox"/> Decant patients	<input type="checkbox"/> Adherence counselling
<input type="checkbox"/> 3 month repeat script	<input type="checkbox"/> Disclosure assistance
<input type="checkbox"/> Space and fast lane	<input type="checkbox"/> Refer to CSTO/social worker for adherence
<input type="checkbox"/> Choose appointment date	<input type="checkbox"/> Refer to facility case manager
<input type="checkbox"/> Other _____	

Health care provider initials: \_\_\_\_\_ Patient initials \_\_\_\_\_

# Indlela B-Hub test – Your Choice



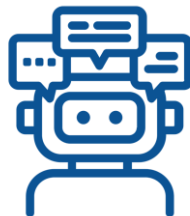
Solution design



**"YOUR CHOICE"**



Behavioural design & research







# NUDGE-athon & Workshops



2 days

## Target Statement



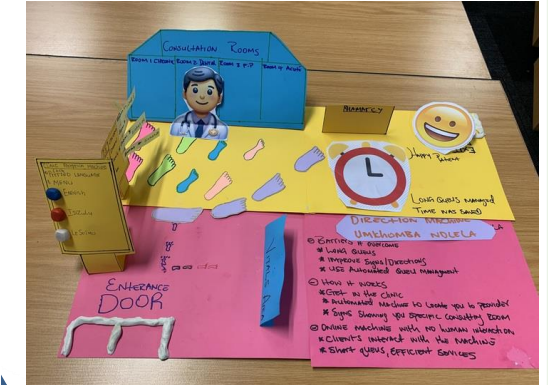
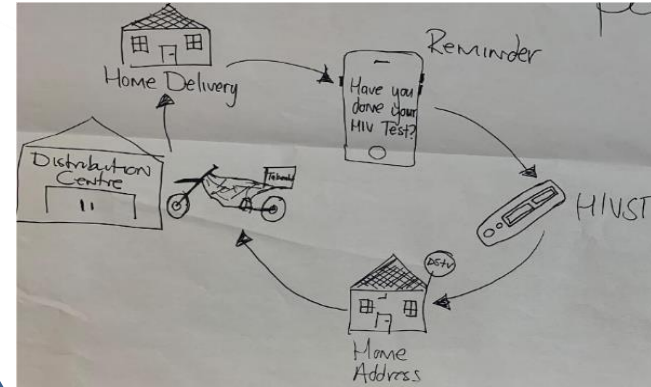
Who?



When?



What?



## Problem

Smart people with diverse skill sets

## Ideas

## Prototypes



# Regional expansion: Kenya, Zambia, Zimbabwe



UNIVERSITY OF ZIMBABWE  
CLINICAL TRIALS RESEARCH CENTRE  
*Saving Lives Through Innovative Research Strategies*



UNIVERSITY OF NAIROBI



REPUBLIC OF ZAMBIA  
MINISTRY OF HEALTH



KAVI Institute of Clinical Research  
UNIVERSITY OF NAIROBI



Uniting against Poverty



UNIVERSITY OF ZAMBIA

# Dissemination/ publication/ communications, platforms

## Webinars, symposia & publications



## Website & Community of Practice



Quarterly newsletter

Our quarterly newsletter shares the latest news from Indlela as we build a community of practice around the use of behavioural economics and nudges to improve uptake and delivery health services in South Africa and the region. We hope this newsletter is helpful for you – please do share any feedback or suggestions that you may have. To sign up to receive our quarterly newsletter click [here](#).





# Thank You

contact us at [Indlela@heroza.org](mailto:Indlela@heroza.org)



LinkedIn



www



WhatsApp

# Questions

