Learning objectives for Skills Track: Optima HIV

- Formulate policy questions for HIV and collect data with which to parameterise
- Use Optima HIV to address allocative and implementation efficiency questions in HIV policy and programmes
- Interpret results from Optima HIV analyses for program and policy improvement

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Overview of allocative and implementation efficiency in the HIV response

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Burnet Institute — Medical Research. Practical Action.
UCL
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symphony
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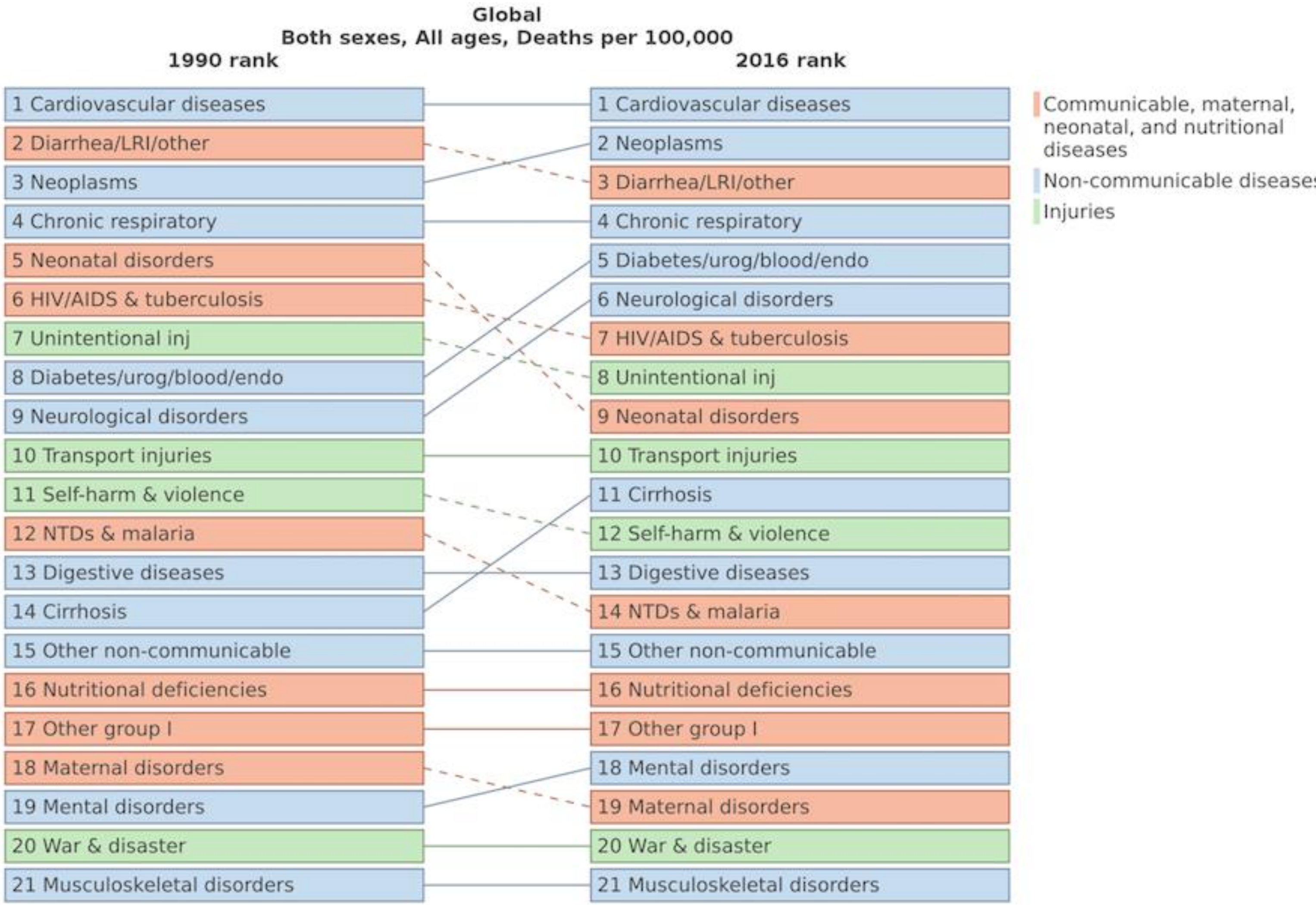
Machine Intelligence Institute of Africa — Transform Africa through Machine Intelligence
iDSI — Better decisions. Better health.
GHCC — Global Health Cost Consortium
UNDP
Bill & Melinda Gates foundation

Learning objectives

- Rationale for efficiency analyses
- Sources of inefficiency in health
- Overview of tools to conduct allocative and implementation efficiency analysis for HIV
- Case studies – how has the tool been applied?

SOURCE: Chisholm, D and Evans, D. 2010. Improving health system efficiency as a means of moving towards universal coverage. *World Health Report (2010) Background Paper, No 28.* World Health Organization

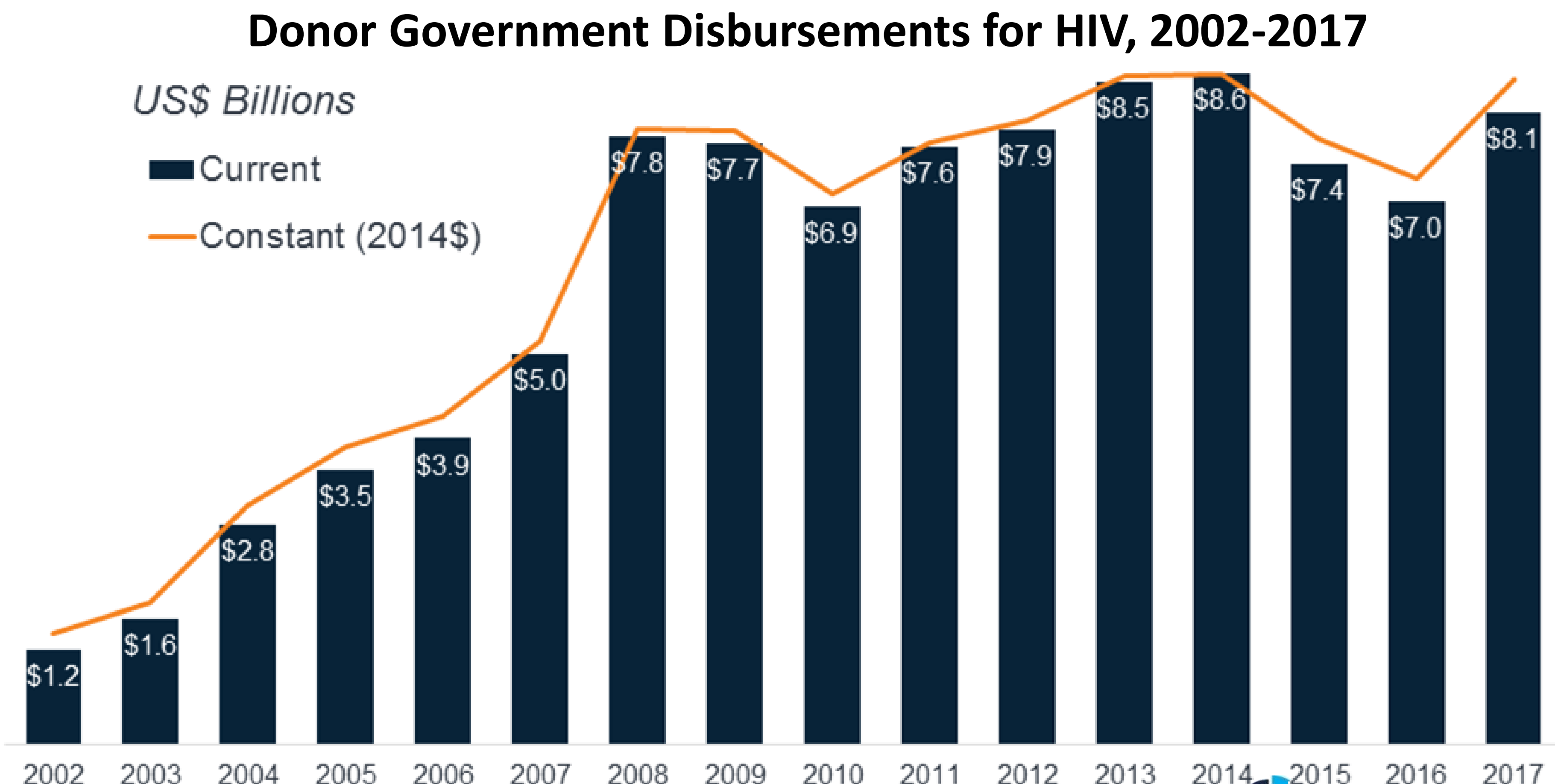
HIV/AIDS and the TB co-epidemic remain drivers of mortality worldwide



Source: IHME. Global Burden of Disease (2016)

Decline international HIV financing

- Kaiser report 2018 – the 2017 funding increase is due to timing of US funding, not a predicted sustainable increase in funding



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SOURCES: UNAIDS and Kaiser Family Foundation analyses; Global Fund to Fight AIDS, Tuberculosis and Malaria online data queries; UNITAID Annual Reports and direct communication; OECD CRS online data queries.

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2017 increased funding is due to delayed US funding,, not a projected increase in funding.


Effectively
Budget
Increases
Better Decision
and Delivery
Choices

Decision and Delivery Science Goals

Support countries to:

Make the best possible investment **decisions**

Generate demand for and **deliver services to the** **best feasible standards**:

for the right **people**

in the right **places**

at the right **time**

in the right **ways**

Achieve the best possible **health impact**

Plan early to ensure that proven approaches are **institutionalized and sustained**

Scarce health resources are not being put to their best use

10 sources of inefficiency in health systems

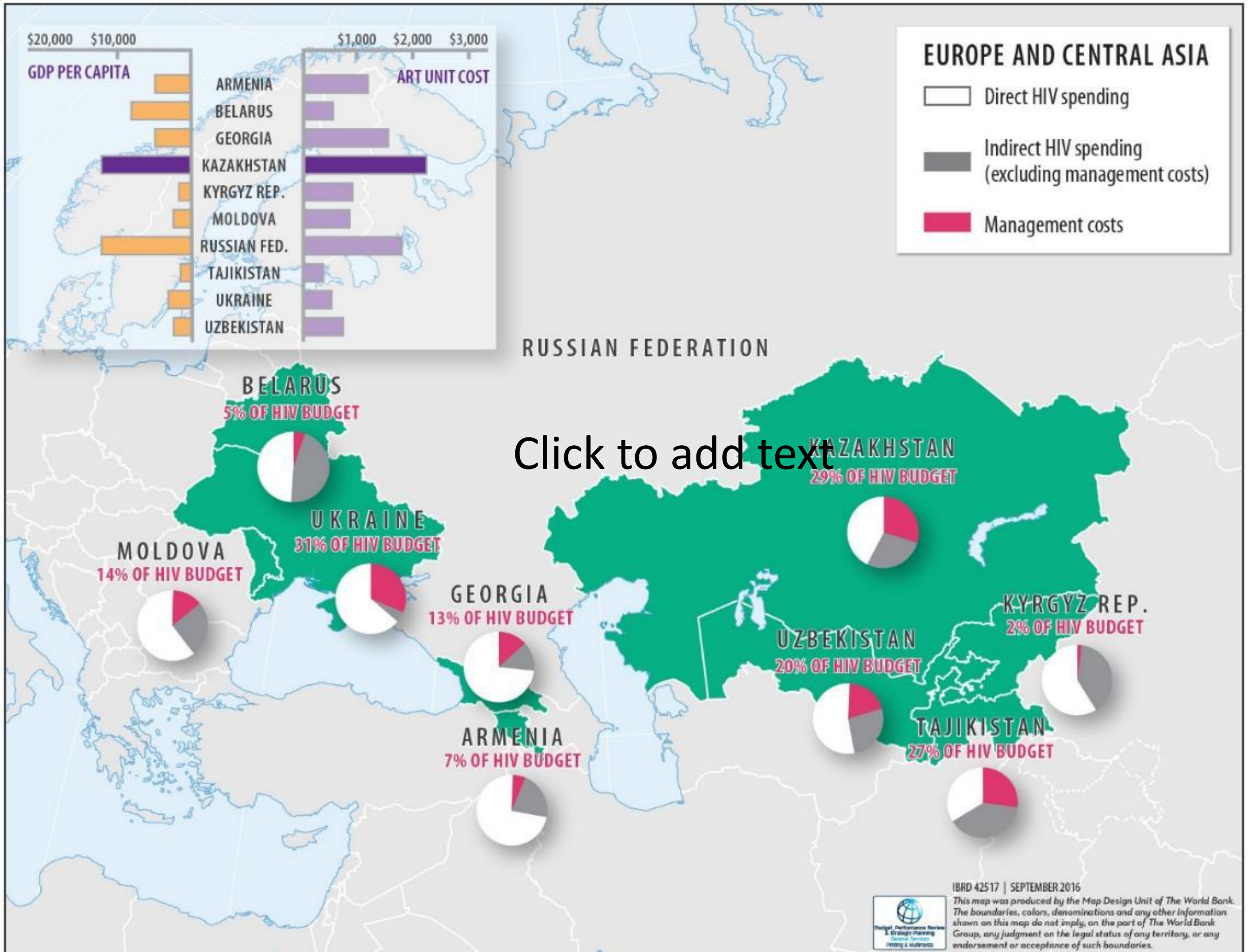
1. **Medicines:** underuse of generics and higher than necessary prices for medicines
2. **Medicines:** use of substandard and counterfeit medicines
3. **Medicines:** inappropriate and ineffective use
4. **Health-care products and services**: overuse or supply of equipment, investigations and procedures
5. **Health workers:** inappropriate or costly staff mix, unmotivated workers
6. **Health-care services:** inappropriate hospital admissions and length of stay
7. **Health-care services:** inappropriate hospital size (low use of infrastructure)
8. **Health-care services:** medical errors and suboptimal quality of care
9. **Health system leakages:** waste, corruption and fraud
10. **Health interventions:** inefficient mix/ inappropriate level of strategies

SOURCE: Chisholm, D and Evans, D. 2010. Improving health system efficiency as a means of moving towards universal coverage. *World Health Report (2010) Background Paper, No 28.* World Health Organization

Types of inefficiency in health systems

1. **Allocative inefficiency:** The distribution of resources to a combination of programs, which will yield the largest possible effect for available resources
2. **Pareto inefficiency:** economy is not producing the maximum with available resources
3. **Productive inefficiency:** not producing at its lowest unit cost
4. **Social inefficiency:** when price mechanism does not take into account all costs and benefits associated with economic exchange (typically, price mechanism only take into account costs and benefits arising directly from production and consumption)
5. **Dynamic inefficiency:** no incentive to become technologically progressive, i.e. not using or investing in new products and new production methods (or services and service delivery modalities)
6. **'X' inefficiency:** no incentive for managers to maximize output (typically, uncompetitive markets)

‘X’-Inefficiency in HIV programmes



Click to add text

Source: Optima HIV ECA studies

Types of Inefficiency in Health Systems

WHAT to do: Allocative efficiency

1. **Allocative Inefficiency:** The distribution of resources to a combination of programs, which will yield the largest possible effect for available resources
2. **Pareto inefficiency:** economy is not producing the maximum with available resources

HOW to do: Implementation efficiency

3. **Productive inefficiency:** not producing at its lowest unit cost
4. **Social inefficiency:** when price mechanism does not take into account all costs and benefits associated with economic exchange (typically, price mechanism only take into account costs and benefits arising directly from production and consumption)
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To improve health outcomes in resource constrained settings, we need to….

- ….focus on both what and how

Focusing on the WHAT

Improving the WHAT: Improving Allocative Efficiency

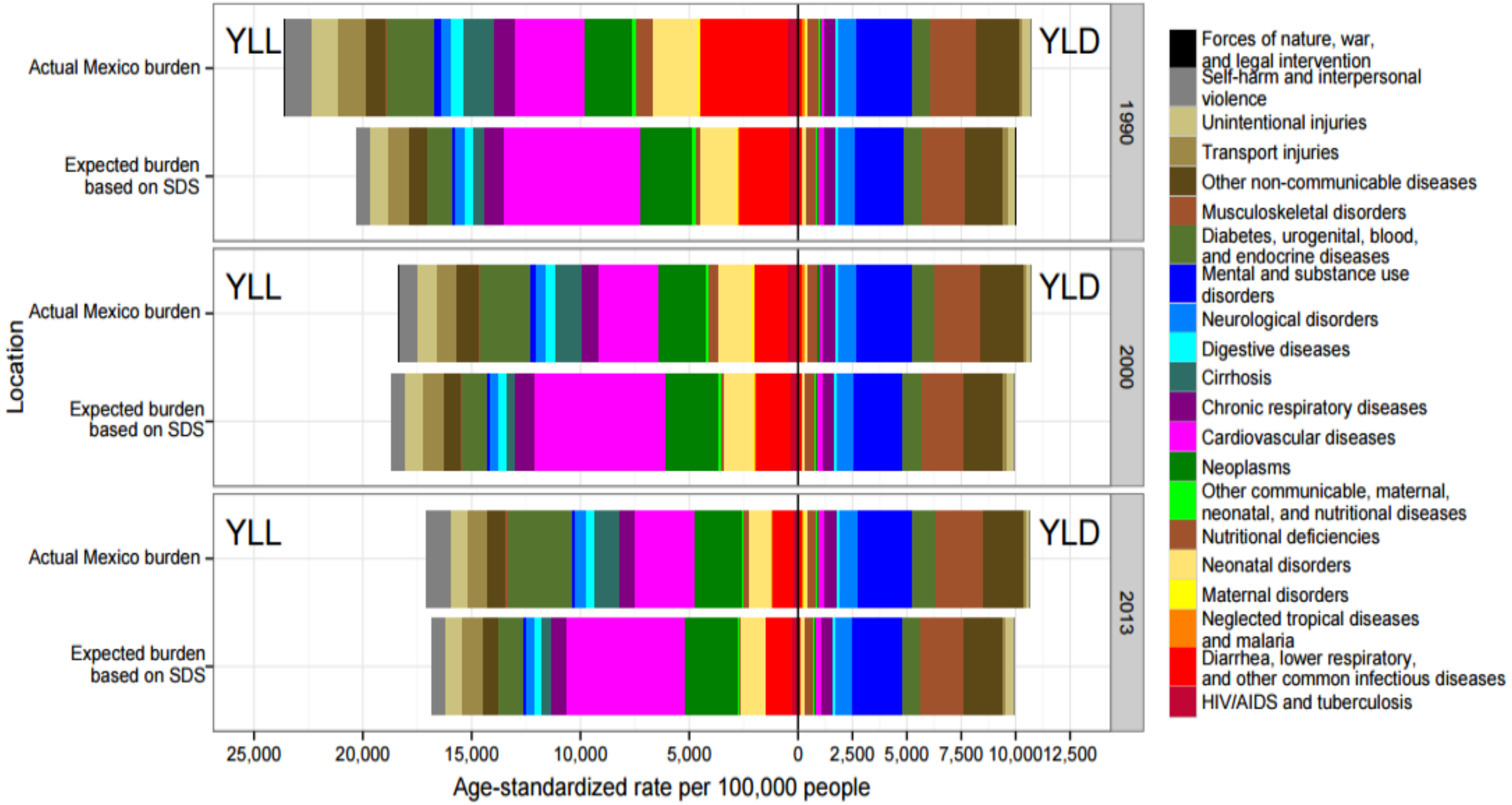
- The distribution of resources to a combination of programs, which will yield the largest possible effect for available resources
- The right intervention being provided to the right people at the right place in a way that health outcomes are maximized for a given level of resource envelope
- Implies shifts in funding allocations over time, understanding funding envelopes, and a focus on service delivery modalities

Ways in which to improve the ‘WHAT’ (Allocative Efficiency)

A. Analyses of temporal changes in epidemiological trends and benchmarking between countries
B. Use of cost-effectiveness analysis
C. Use of mathematical modelling

A: Use of epidemiological modelling and benchmarking to improve allocative efficiency

What patterns are unexpected compared to epidemiological transition?



B: Use of Cost-Effectiveness Analysis (CEA) as a basis for improving decision-making in health

- CEA principle : healthcare interventions can be ranked on the basis of their incremental costs relative to their incremental benefits (subject to a number of important assumptions)
    - Benefits are usually measured in terms of expected health gain

Examples of HIV program decisions made with cost effectiveness analysis

CONVENTIONAL LEAGUE TABLE	ICER ($/LYS)
Condom availability	Cost saving
Male medical circumcision	Cost saving
SBCC 1 *(HCT in adolescents, reduction in MSP)*	46
ART (current guidelines	96
PMCTC	132
Universal ART	186
Infant testing in 6 weeks	208
HCT for sex workers	366
SBBC 2 *(condoms)*	566
SBBC 3 *(condoms, HCT, MMC)*	697
PrEP for sex workers	926
General population HCT	1,273
Infant testing at birth	1,349
HCT for adolescents	1,772
PrEP for young women	3,703
Early infant male circumcision	8,712,984

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But, cost effectiveness has its weaknesses

- The **interrelationship between causes of burden of disease and associated health interventions is missing**: it considers interventions as independent, neglecting their interactions.
- The **nonlinear relationship** between **health service coverage and health outcomes**.
- The **nonlinear relationship** between **cost and coverage of interventions**, by not calculating the marginal costs of scaling up or scaling down a service.
- The **dynamic nature of burden of disease** due to wider primary prevention, epidemiological, or population-wide impacts of the health services being implemented (e.g. the impact of vaccination or treatment on transmission of infection).
- The **changing nature of financing for interventions**, such starting costs and diminishing returns, or the fact that health services cannot instantly be either scaled up or scaled down.
- The fact that **priority-setting may change** at different funding levels or provide different scenarios for a health system stakeholder.
- Because **services and funding are already in existence** and both the development of, and priority-setting within, that context needs to take the context and existing services into account, to not contribute to further fragmentation.

↓

Mathematical modelling

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C: Mathematical modelling tools for improving allocative efficiency

"To address the limits of cost-effectiveness analysis and consider broader factors in decision systems, packages of services and technologies should be considered together rather than in isolation and analyses incorporate overall health, financial and equity objectives and relevant constraints. Optimization tools have recently emerged to do this and can help to optimize a health benefits package tailored to specific objectives and time horizons within available budget envelopes, local and changing epidemiology, dynamic costs, and variable, non-linear benefits on different populations."

Gorgens, Petravic, Wilson, and Wilson, 2017

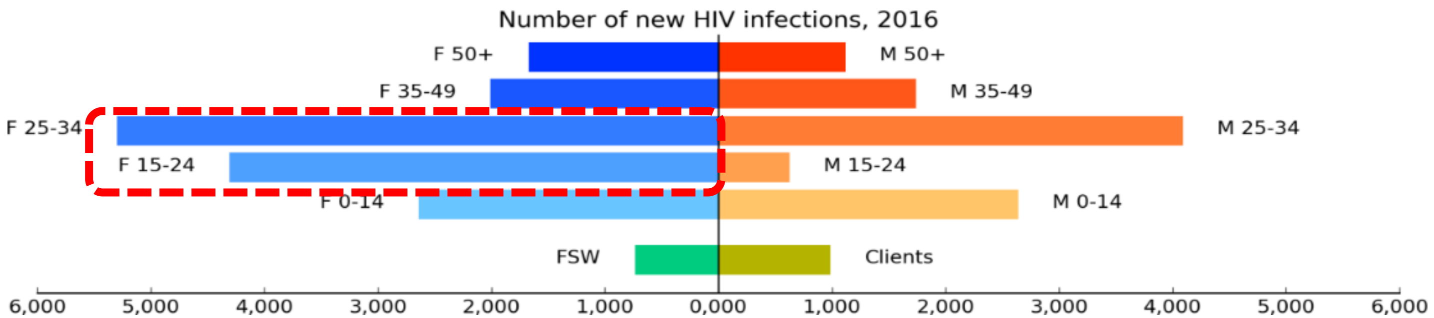
CEA to modelling comparison in South Africa

- League tables do not account for interacting effects
- Optimization around epidemiological model
  - account for interacting effects
  - any other quantifiable components in entire system

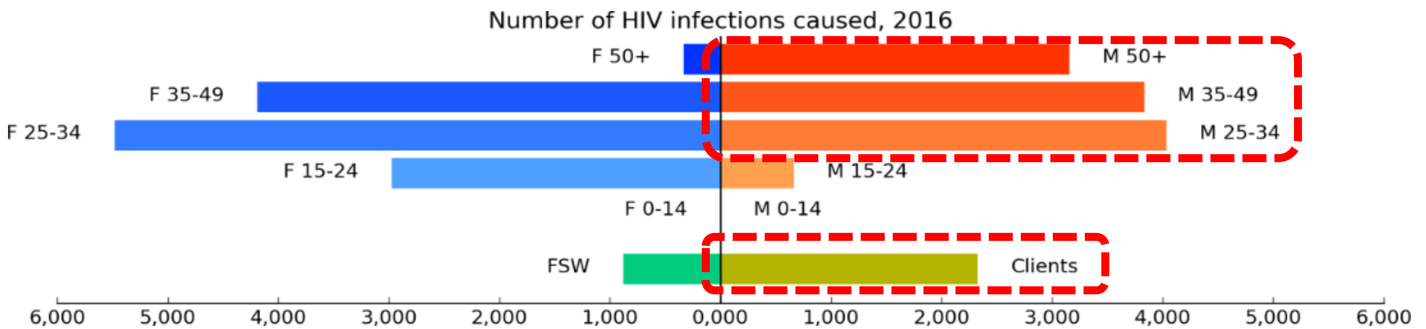
CONVENTIONAL LEAGUE TABLE	ICER ($/LYS)	OPTIMISATION ROUTINE	ICER ($/LYS)	ICER between methods
Condom availability	Cost saving	Condom availability	Cost saving	N/A
Male medical circumcision	Cost saving	Male medical circumcision	Cost saving	N/A
SBCC 1 *(HCT in adolescents, reduction in MSP)*	46	ART (current guidelines	109	14%
ART (current guidelines	96	PMCTC	142	7%
PMCTC	132	Infant testing in 6 weeks	248	20%
Universal ART	186	Universal ART	249	34%
Infant testing in 6 weeks	208	SBCC 1 *(HCT in adolescents, reduction in MSP)*	749	1525%
HCT for sex workers	366	SBBC 2 *(condoms)*	*1,200	112%
SBBC 2 *(condoms)*	566	General population HCT	1,236	-3%
SBBC 3 *(condoms, HCT, MMC)*	697	SBBC 3 *(condoms, HCT, MMC)*	1,816	161%
PrEP for sex workers	926	HCT for sex workers	2,643	621%
General population HCT	1,273	Infant testing at birth	2,937	118%
Infant testing at birth	1,349	PrEP for sex workers	9,947	974%
HCT for adolescents	1,772	HCT for adolescents	19,540	1003%
PrEP for young women	3,703	PrEP for young women Max	26,375	612%
Early infant male circumcision	8,712,984	Early infant male circumcision	89,642,731	929%

HIV: Epidemic modeling enables us to understand transmission dynamics

Number of new HIV infections acquired, 2016



Number of new HIV infections transmitted, 2016



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The World Bank. 2017. Improving the allocative efficiency of Malawi's HIV response: Findings from a mathematical modelling analysis. Washington DC: World Bank.

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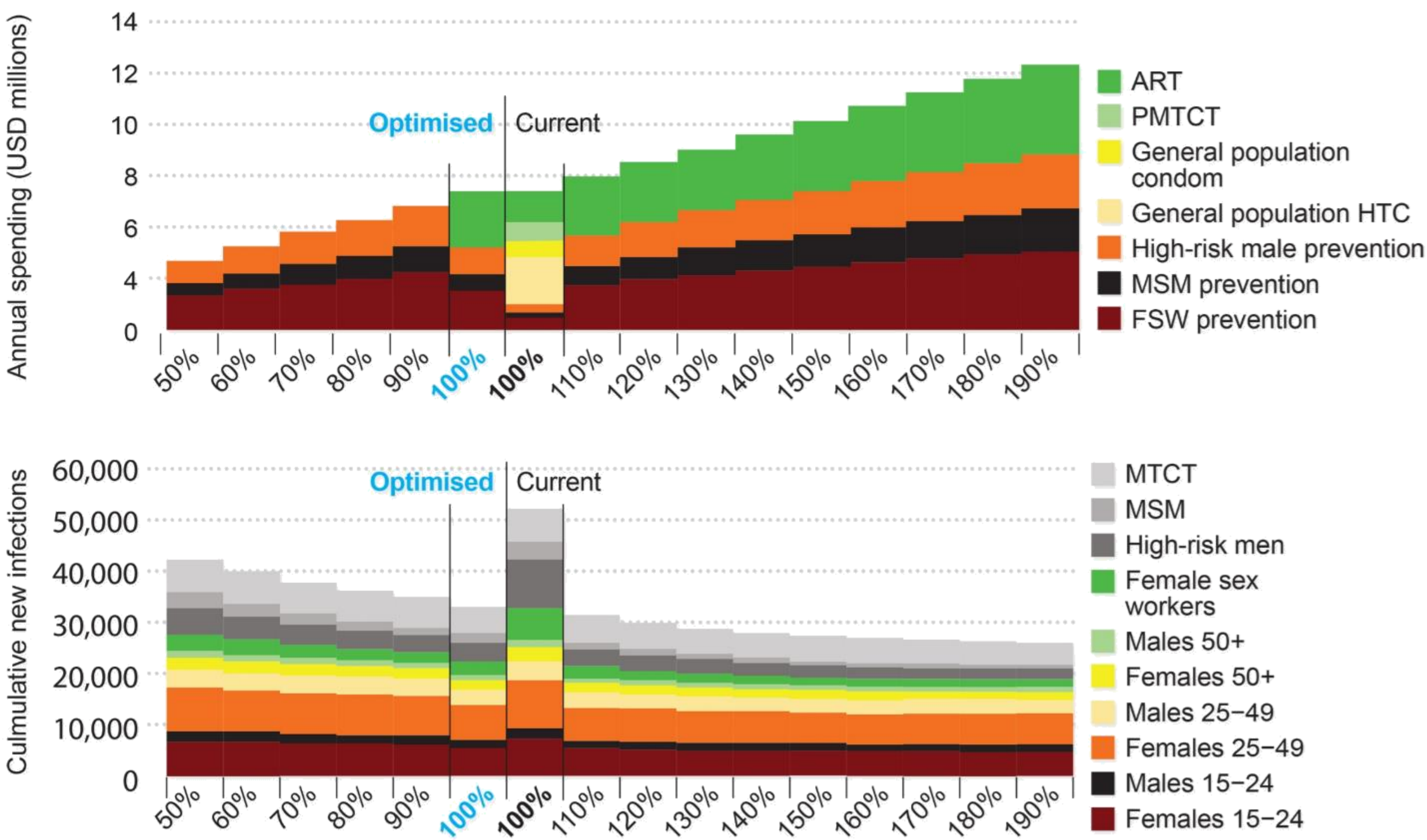
Example of using a mathematical model to improve HIV allocative efficiency in HIV in Sudan



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SOURCE: The World Bank Group. "A Case Study on How Allocative Efficiency Analysis Supported by Mathematical Modelling Changed HIV Investment in Sudan. From Analysis to Action" 2015

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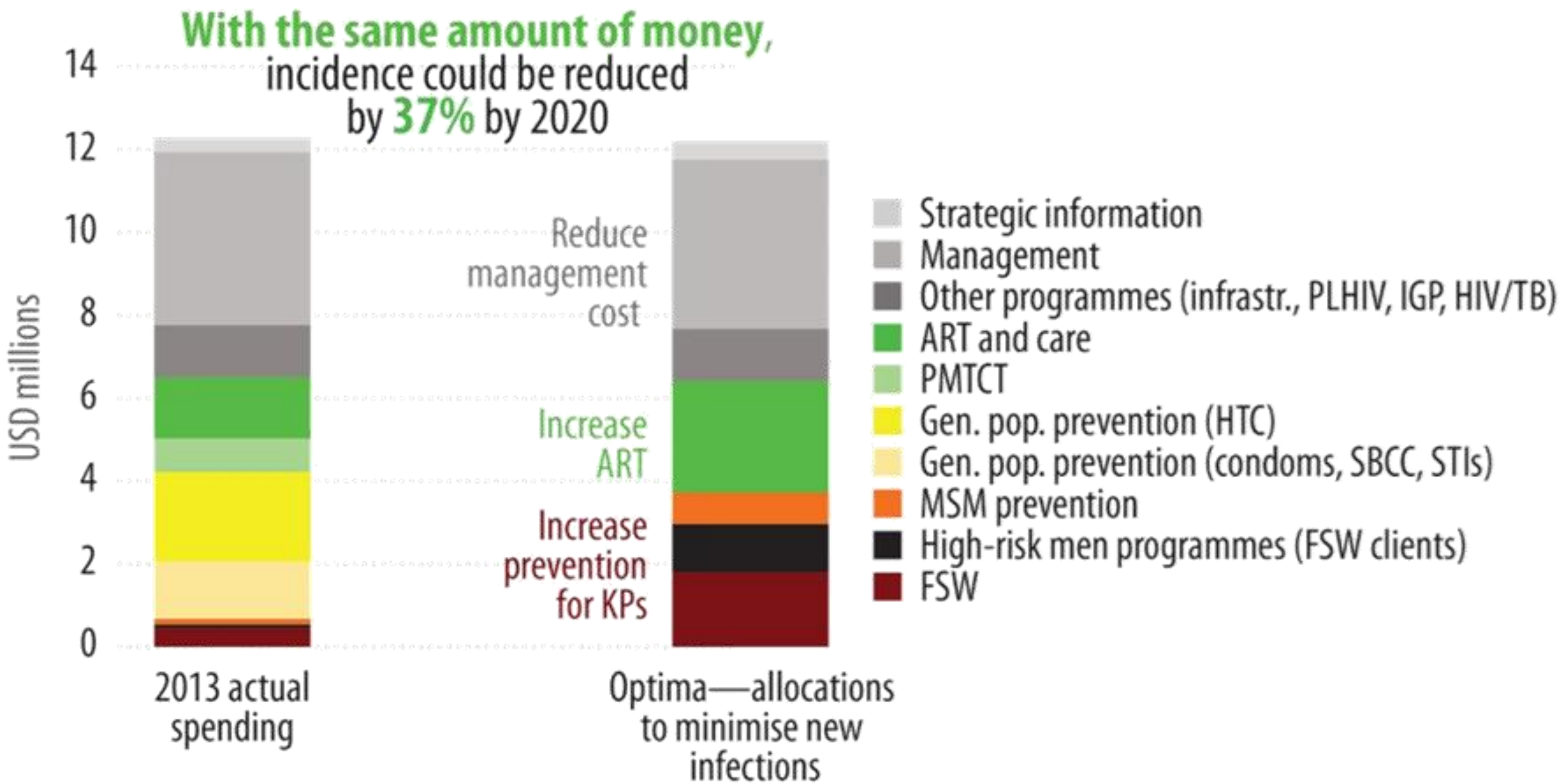
Sudan example, a Fragility, conflict, and violence (FCV) country with political and religious opposition to HIV programs

How were funds spent and where did the study recommend?

Spending pattern in 2013 and optimized allocations to minimize new HIV infections between 2014 and 2020, at 2013 resource level of USD 12.3 million



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SOURCE: The World Bank Group. "A Case Study on How Allocative Efficiency Analysis Supported by Mathematical Modelling Changed HIV Investment in Sudan. From Analysis to Action" 2015

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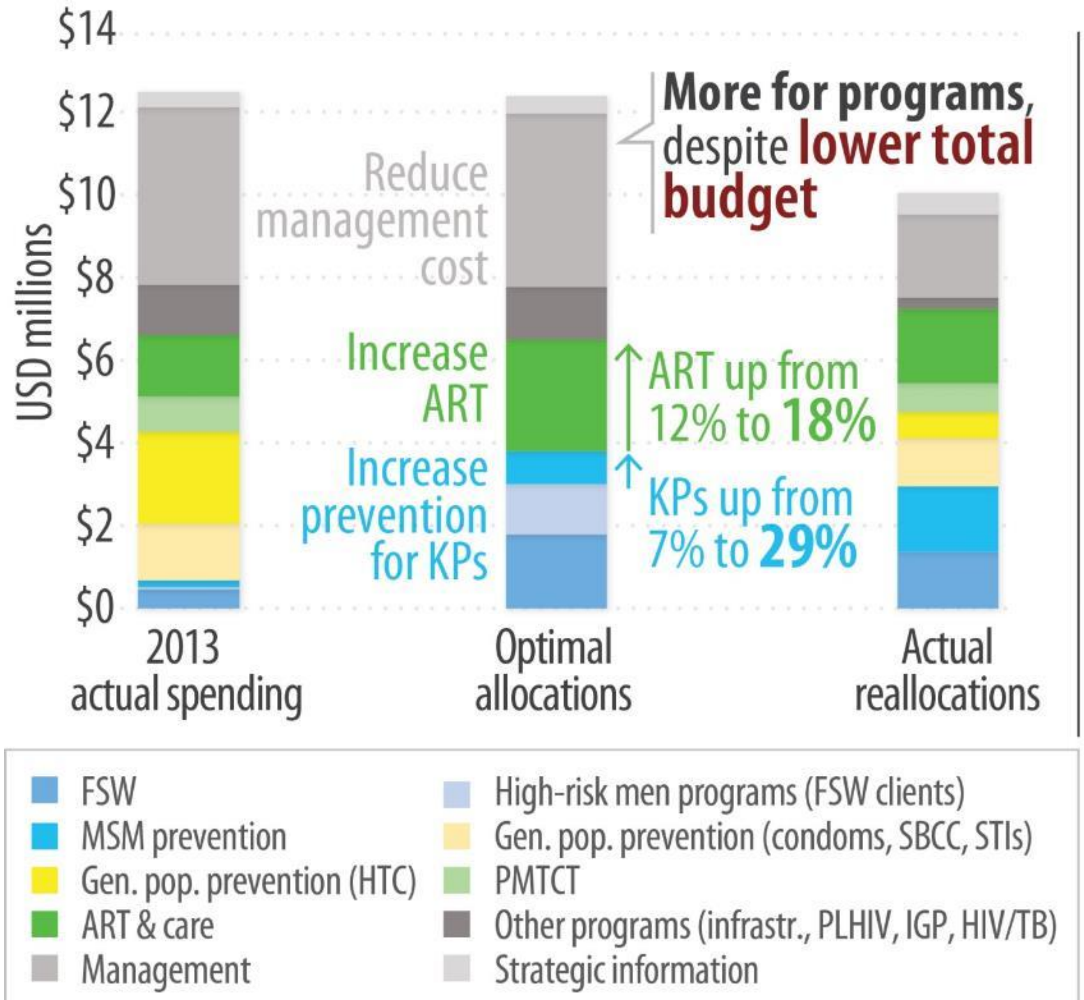
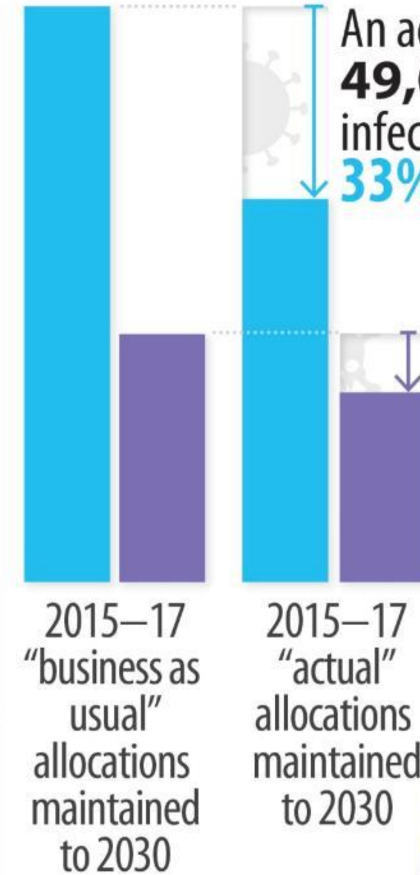
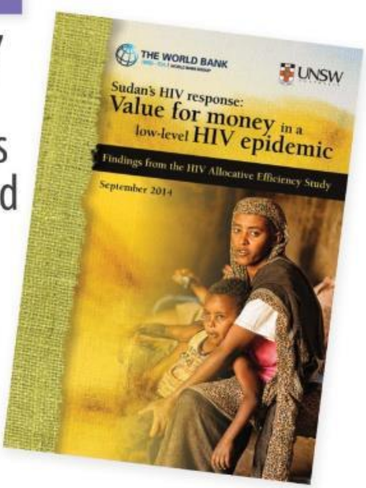
Sudan: Actual changes in allocations







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SOURCE: The World Bank Group. "A Case Study on How Allocative Efficiency Analysis Supported by Mathematical Modelling Changed HIV Investment in Sudan. From Analysis to Action" 2015

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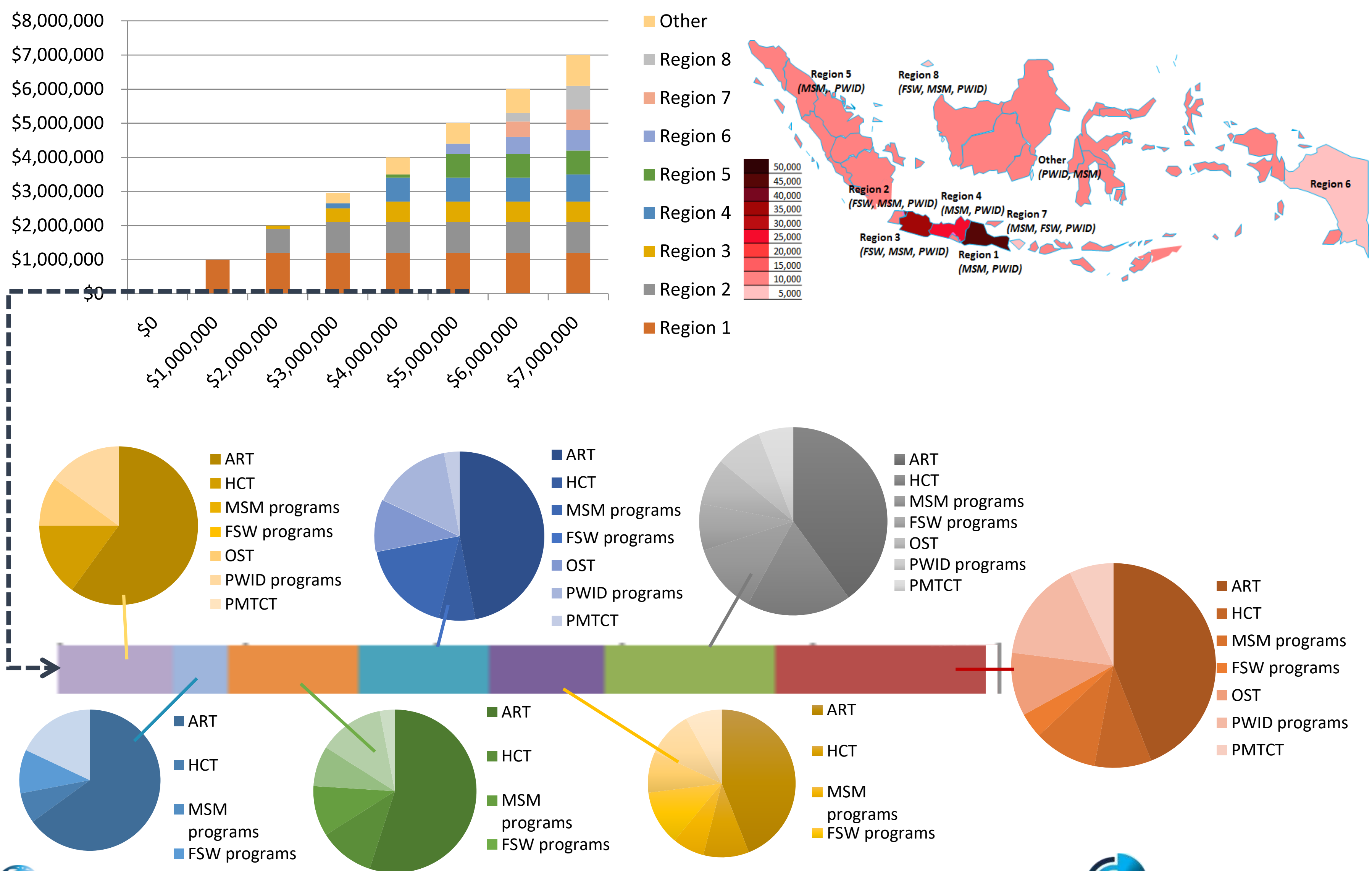
HIV sub-national: Geographical prioritization in Indonesia



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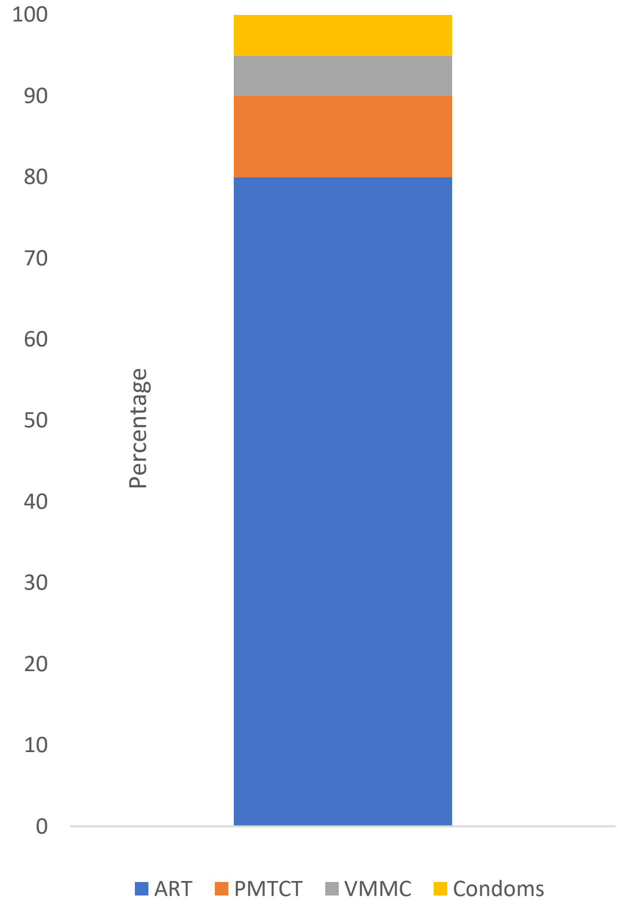
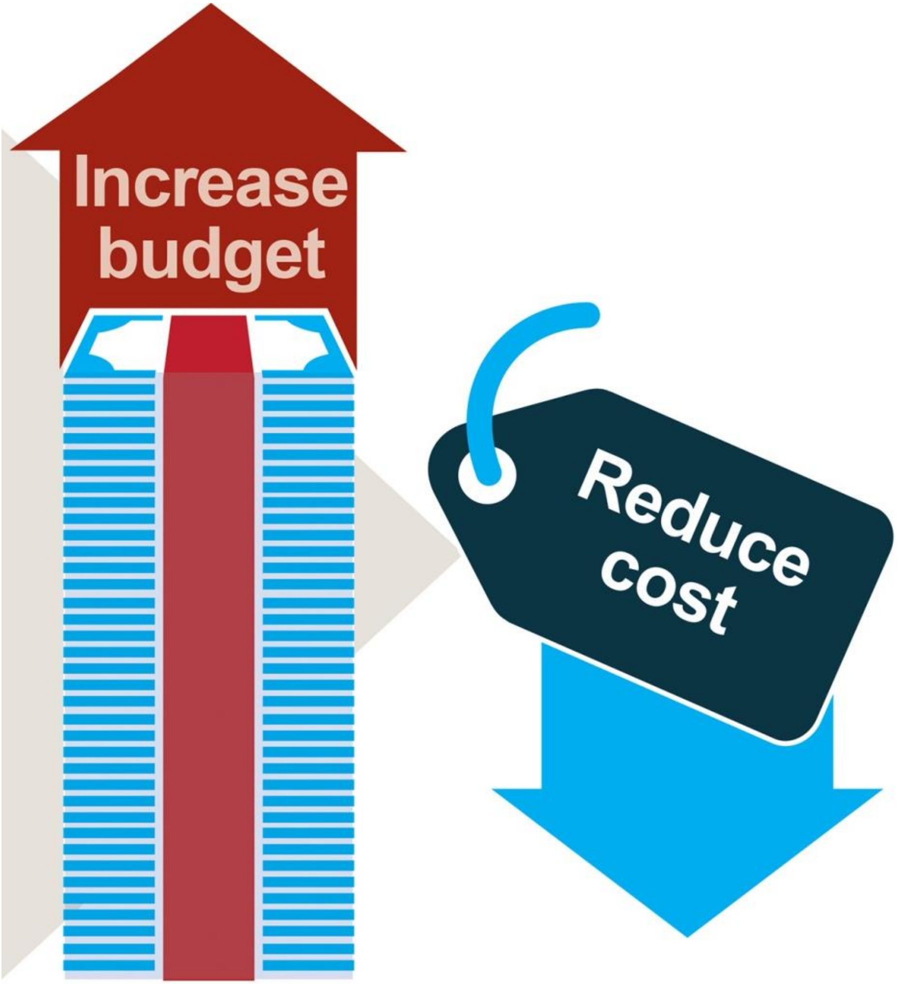
Limits to allocative efficiency in generalized HIV epidemics





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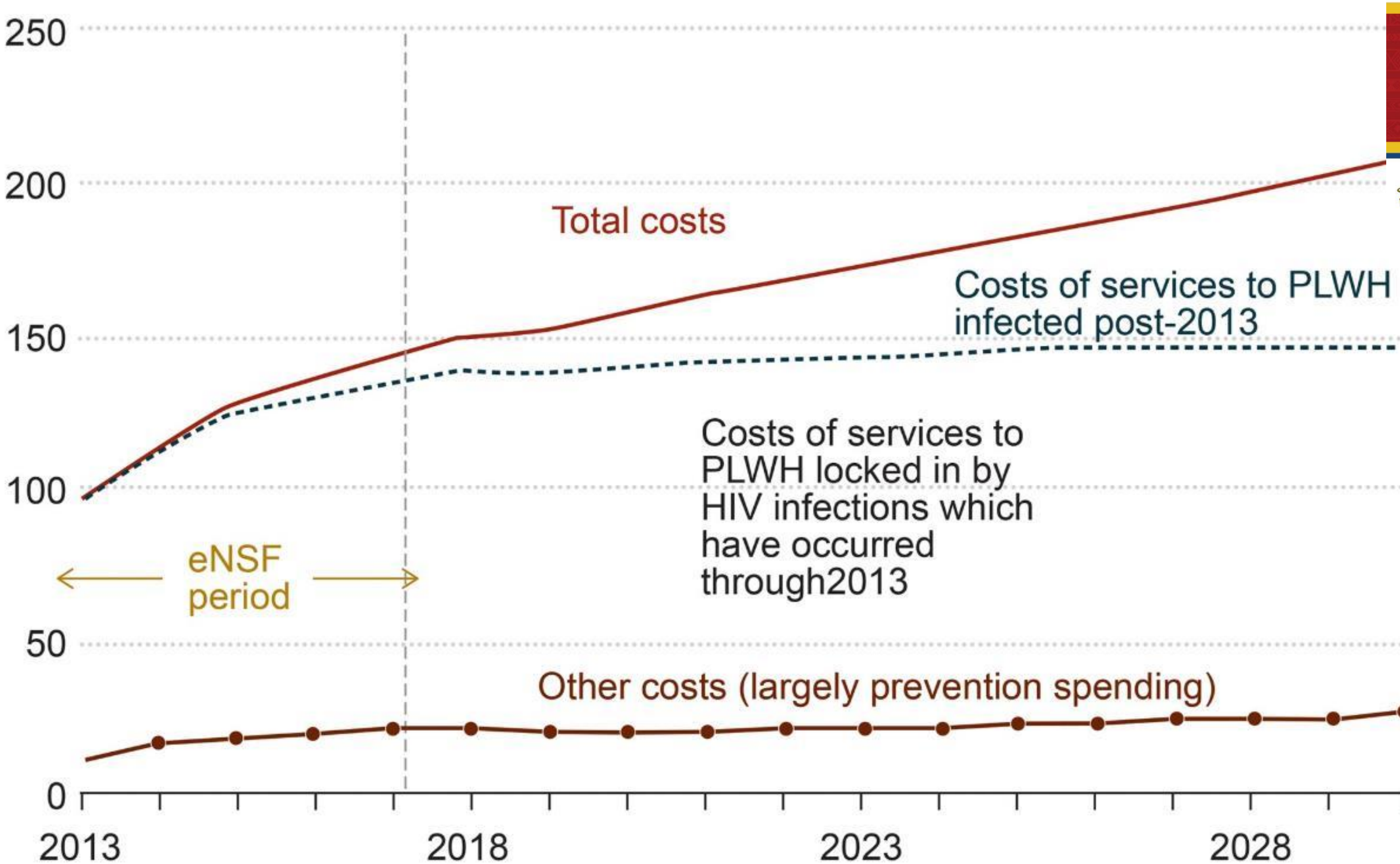
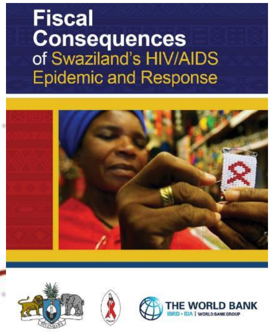
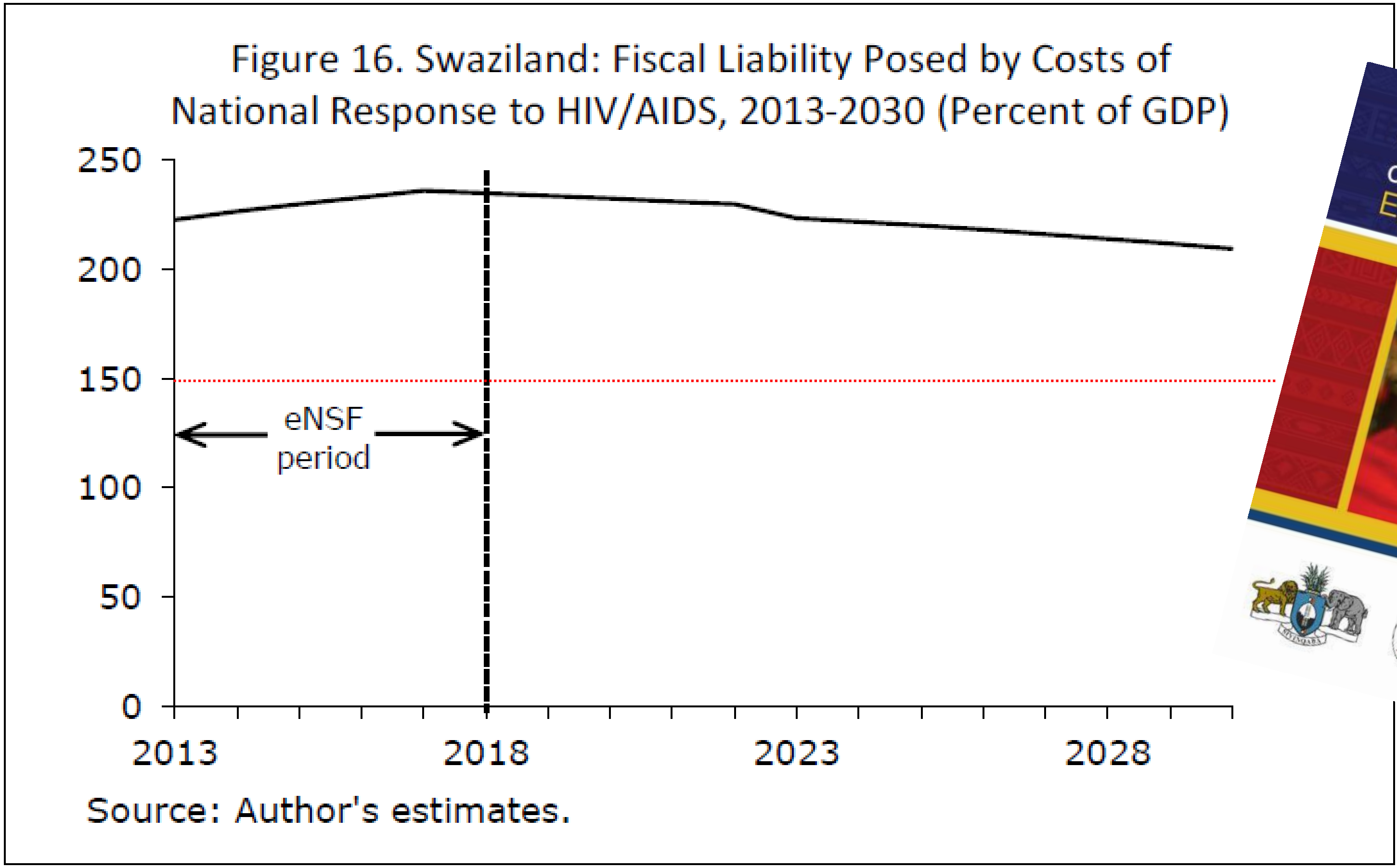
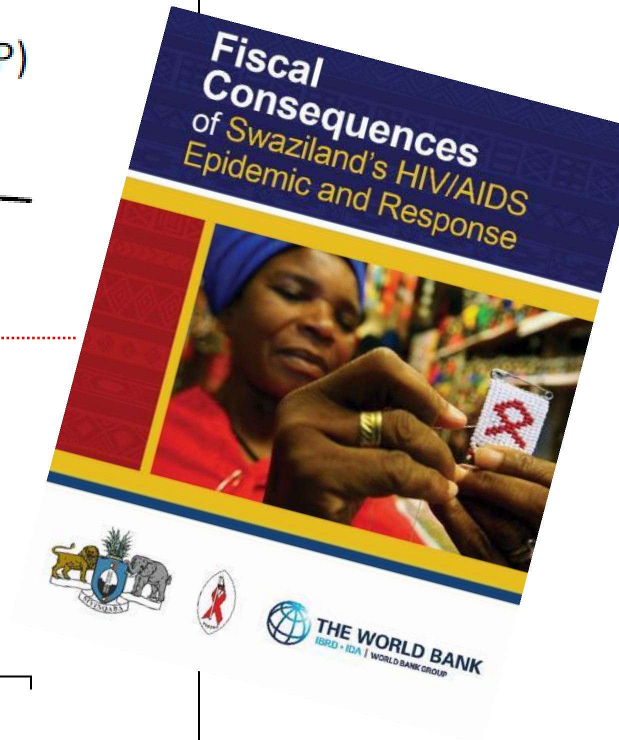
Limits to allocative efficiency in generalized HIV epidemics





Results of these limits on allocative efficiency: where to find efficiencies?





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Focusing on the HOW

When we discuss implementation, it is appropriate to consider failure

- Two key reasons interventions fail:
  - One reason is because of ignorance.
    - We just don't know what works, and therefore need research and discovery (i.e. need to figure out the WHAT)
  - Another reason is ineptitude.
    - The knowledge exists but an individual or group of individuals fails to apply that knowledge correctly. (i.e. need to figure out the HOW)

"What's really interesting to me about living in our time and in our generation is that … ineptitude is as much or a bigger force in our lives than ignorance."

Atul Gawande, author of The Checklist Manifesto

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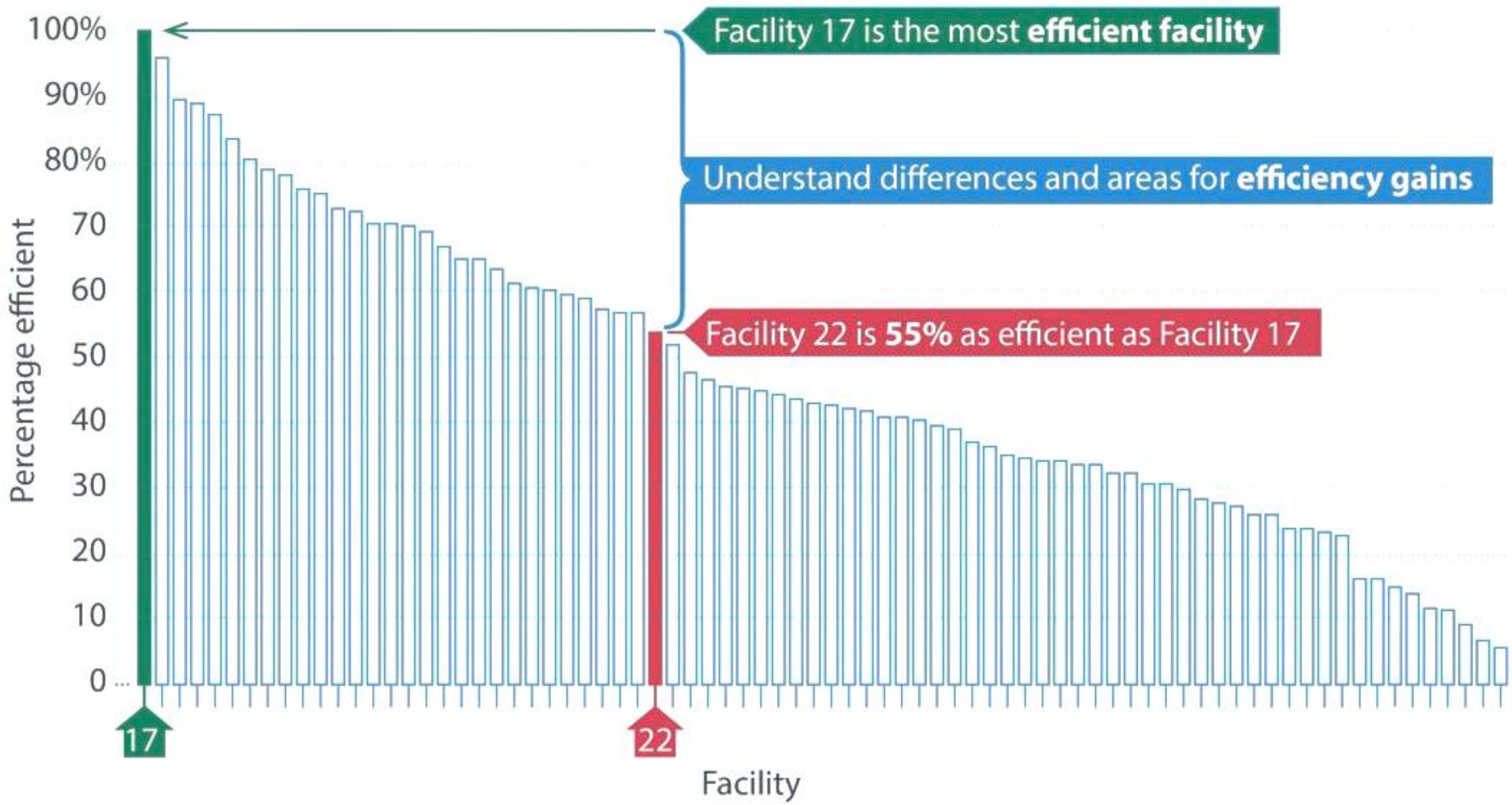
Tools and approaches to improve the **HOW**

- All about implementation
- Benchmarking
- Supply and demand analysis
- Management assessments
- Geospatial analysis
- Big data analysis
- Cascade analysis

Example: implementation efficiency analysis



Cascade concept

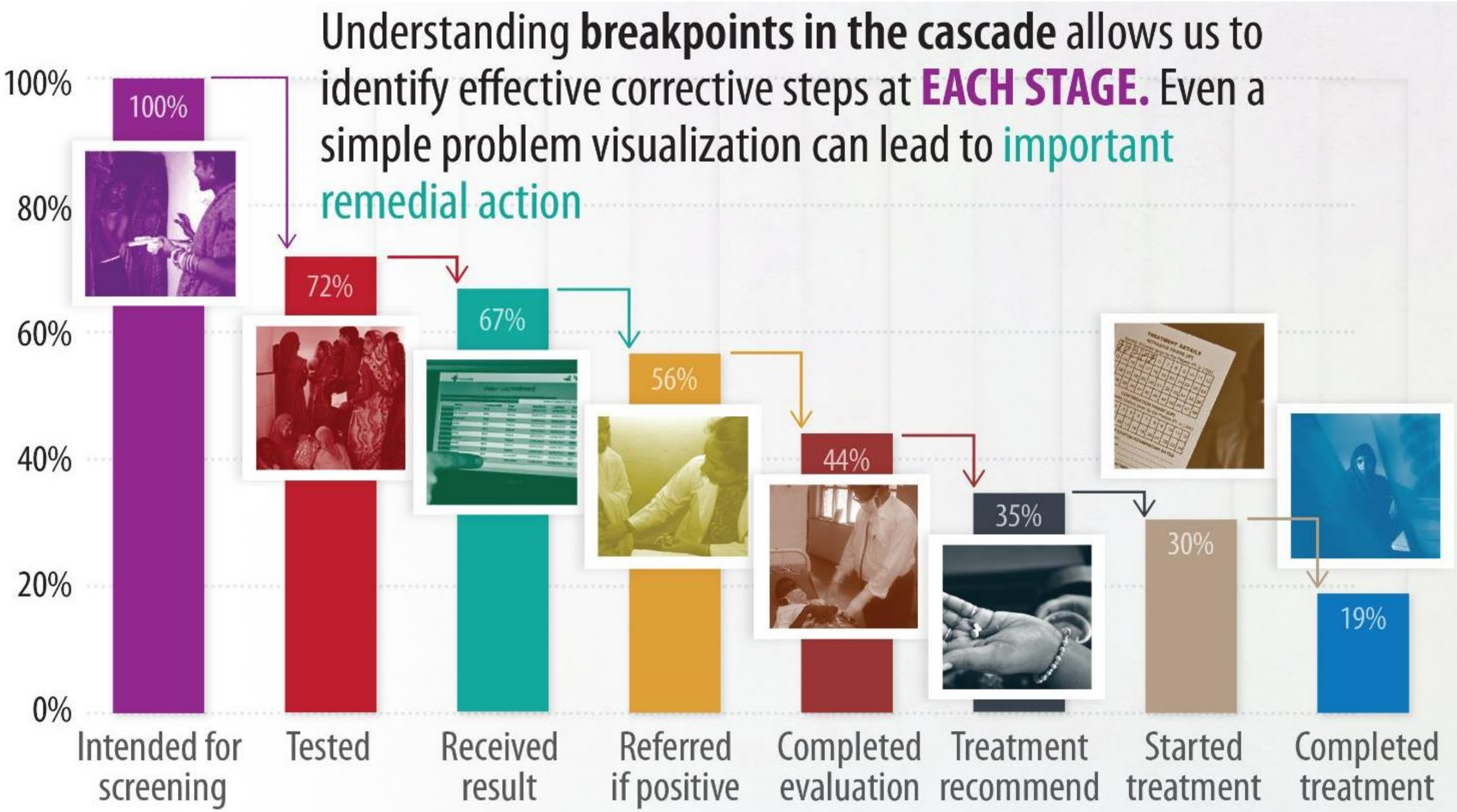
- Framework that outlines the sequential steps or stages of medical care that people go through from initial diagnosis to achieving disease control
- Initially used for HIV, especially in PMTCT; now increasingly use for other infections/ conditions like TB, NCDs (and also for prevention)
- Both terms “care cascade” and “treatment cascade” are used interchangeably
- For many years, the “continuum of care” term was used and referred to the same concept of successive stages in somebody’s diagnosis-care-treatment journey, and the importance of a person to keep moving through these stages

Better health outcomes requires that one identifies bottlenecks and chokepoints along the cascade

- Bottlenecks and chokepoints are points along critical path to effective service delivery
- Better health outcomes require that we find and fix these chokepoints

Cascades can help to identify and address bottlenecks

Example of cascade: India TB



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Both supply-side and demand-side barriers need to be addressed

- Individuals who want to prevent a specific disease or who already live with a medical condition need access to a **continuum of services** to achieve disease control—with each service in the delivery cascade **conditional on having received the previous one**
- But: people can experience **barriers** to getting tested, linking to or staying in care, and starting/adhering to treatment
- Need to address supply side and demand side gaps in order to improve cascade, improve quality and coverage, and health outcomes

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Bottleneck Analyses is not a new concept

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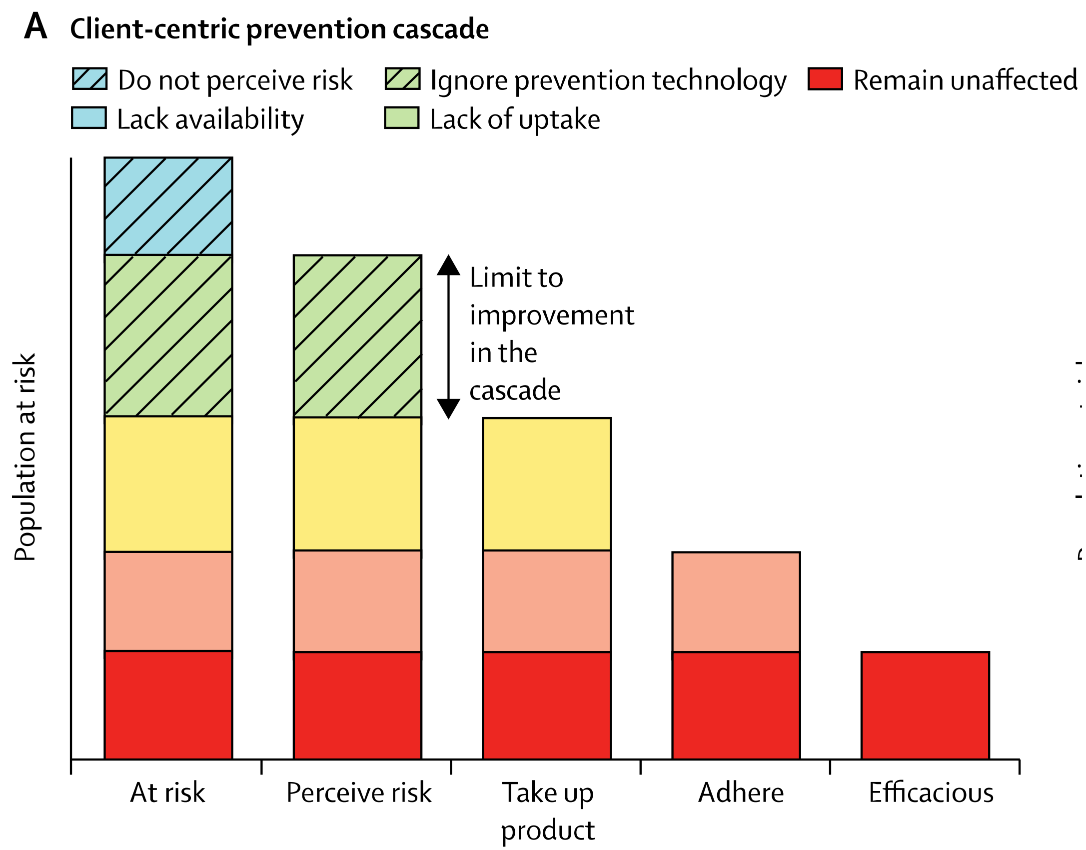
Client-centric: how can those at risk of infection avoid it?

- Assumes intervention is available



Source: Garnett et al. 2016. HIV Prevention Cascades: Identifying Gaps in the Delivery of HIV Prevention Interventions. https://spiral.imperial.ac.uk/bitstream/10044/1/43765/2/Geoff_cascadesposter_2016.pdf

London School of Hygiene & Tropical Medicine

Centre for Evaluation

Imperial College London

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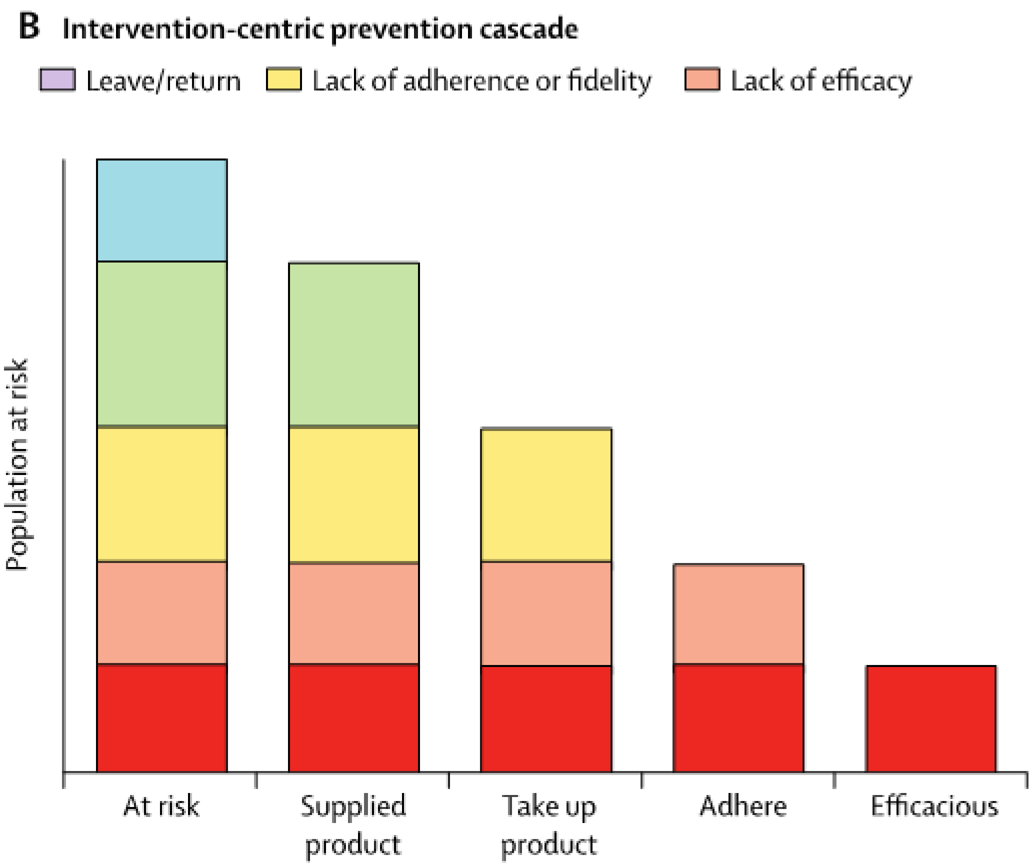
Intervention-centric: programme perspective

- Programme staff:
  - Identify target population
  - Make intervention available
  - Observe uptake
  - Observe appropriate use
  - Observe efficacy
- Denominator = persons **at risk** of infection over a given time period



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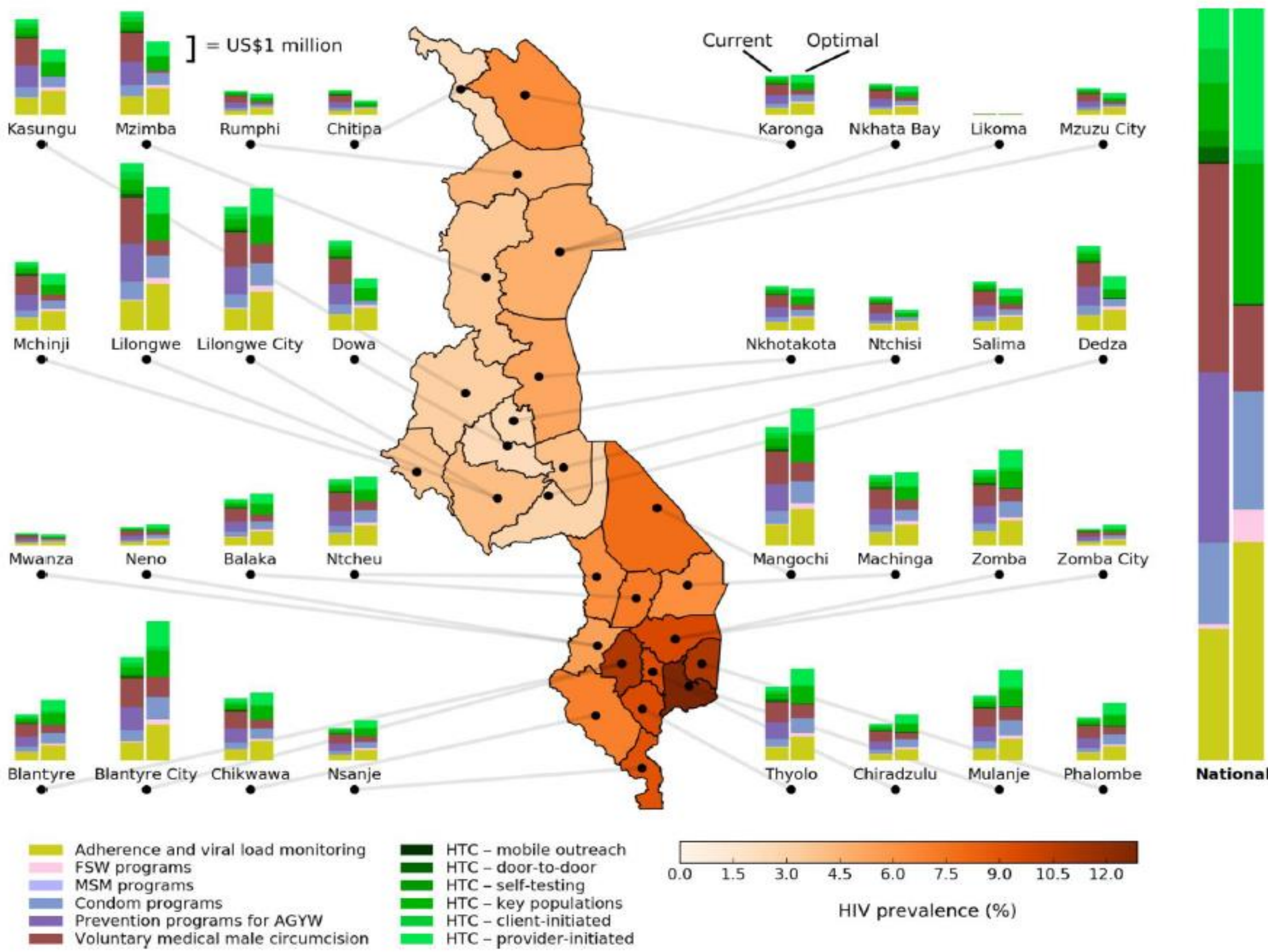
Geographical optimization - Malawi



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The World Bank. 2017. Improving the allocative efficiency of Malawi's HIV response: Findings from a mathematical modelling analysis. Washington DC: World Bank.

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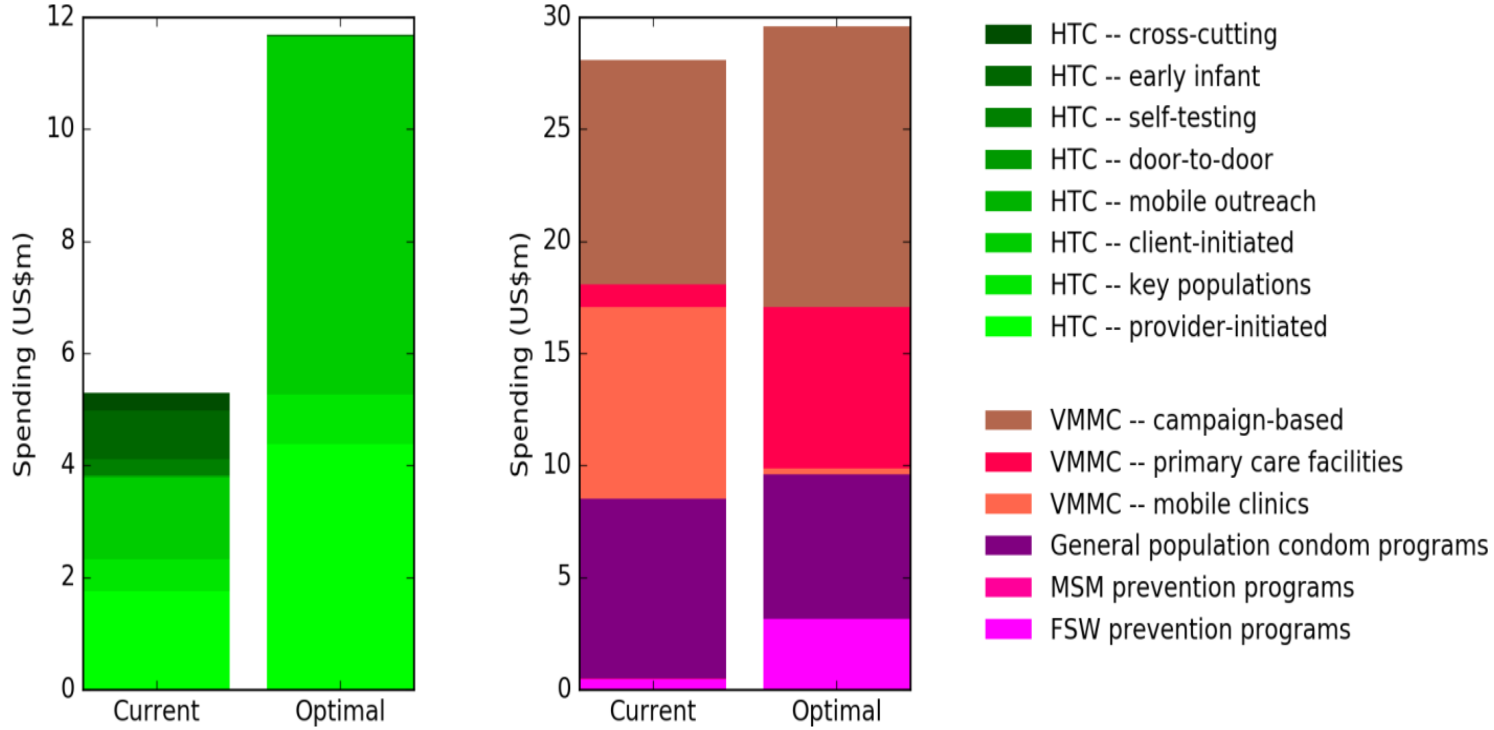
HIV: improve implementation efficiency by choosing the best service delivery modalities

Comparison of current and optimal allocations in:
Spending on HCT (left) and prevention (right)



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Types of inefficiency in health systems

- Allocative inefficiency
- Pareto inefficiency
- Productive inefficiency
- Social inefficiency
- Dynamic inefficiency
- ‘X’ inefficiency

QUESTIONS?

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2018 SKILLS BUILDING PROGRAM

BIG DATA, ARTIFICIAL INTELLIGENCE AND DECISION SCIENCE IN HEALTH AND NUTRITION

Introduction to Optima HIV and Optima HIV interface

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Burnet Institute — Medical Research. Practical Action.
UCL
techemergence
symphony
University of Copenhagen
Machine Intelligence Institute of Africa — Transform Africa through Machine Intelligence
iDSI — Better decisions. Better health.
GHCC — Global Health Cost Consortium
UNDP
Bill & Melinda Gates foundation

Learning objectives

- Introduction to Optima HIV and tour of Optima HIV interface
- Brief demonstration of a complete analysis from beginning to end

SOURCE: Chisholm, D and Evans, D. 2010. Improving health system efficiency as a means of moving towards universal coverage. *World Health Report (2010) Background Paper, No 28.* World Health Organization

Optima

What is it?

How will it fit my needs?

How does it work?

Where do I get it?

Tour of the interface

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What is Optima HIV?

Effective interventions and service delivery

Optima HIV aims to support countries to make the best possible investment **decisions**

Support demand for and **delivery of services** to the best feasible **standards:**

- for the right **people**
- in the right **places**
- at the right **time**
- in the right **ways**

For the greatest **HIV** and **health impact**

While moving early and urgently to **institutionalize** and **sustain services**

The Optima approach

Burden of disease

- Epidemic model
- Data synthesis
- Calibration / projections

Programmatic responses

- Identify interventions
- Delivery modes
- Costs and effects

Objectives and constraints

- Strategic objectives
- Ethical, logistic, and/or economic constraints

Scenario analysis

Optimization

Projected health and economic outcomes

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Addressing objectives using Optima

- What health benefits can be achieved if resources are optimally allocated?
  - For example: how many new HIV infections or HIV-related deaths can be averted?
- Optima analysis can help inform strategies to achieve HIV-related objectives
  - Optima HIV is an efficiency analysis tool
  - Optima HIV is *not* a budgeting tool

Which model for which purpose?

How does Optima HIV compare with other models?

Comparison of HIV epidemic model characteristics	Approach	Populations	Purpose	Inputs	Outputs
EPP	Fits four parameters to a simple model; written in Java	MSM, PWID, FSW, male SW, CSW, and low-risk (separated into urban and rural)	Estimate and project adult HIV prevalence and incidence	Size of subpopulations; HIV prevalence among subpopulations; treatment data	Current number of HIV infections; HIV infection trends (5-year projections)
AEM	Semi-empirical process model; written in Java	PWID, direct FSW, indirect FSW, MSW, CSW, and MSM	Provide a policy and planning tool for Asian countries	Size of subpopulations; HIV and STI prevalence; risk behavior data; average duration in each population	Trends of HIV infections; impacts on AIDS cases, ART needs, deaths, etc. (long term projections)
MOT	Risk equations; written in Excel	PWID, FSW, MSM, and low-risk (separated into males and females)	Calculate expected number of infections over coming year	HIV prevalence; number of individuals with particular exposure; rates of exposure	Incidence (HIV acquisition) per risk group
Goals / Spectrum	Compartmental rate-based model; written in Visual Basic	MSM and high, medium, and low-risk groups	Estimate costs and impact of different interventions	Sexual behavior by risk group; demographic data; base year human capacity	Costs; HIV prevalence and incidence (5- year projections)
Optima	Compartmental rate-based model; versions available for MATLAB and Python	Flexible; unlimited but usually around 8-20 groups, including key affected and general populations and different age groups	Analyze and project HIV epidemics; determine optimal resource allocations	Size of population groups; HIV and STI prevalence; risk behavior data (e.g. condom use); biological constants (e.g. background death rates)	HIV prevalence and incidence trends; healthcare costs; deaths; optimal resource allocations

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SOURCE: Kerr et al. (2015) Optima: A Model for HIV Epidemic Analysis, Program Prioritization, and Resource Optimization, JAIDS, 69(3): 365-76.

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How does Optima HIV work?

Optima HIV is a model

Outcome: how many people can we safely fly in this plane?

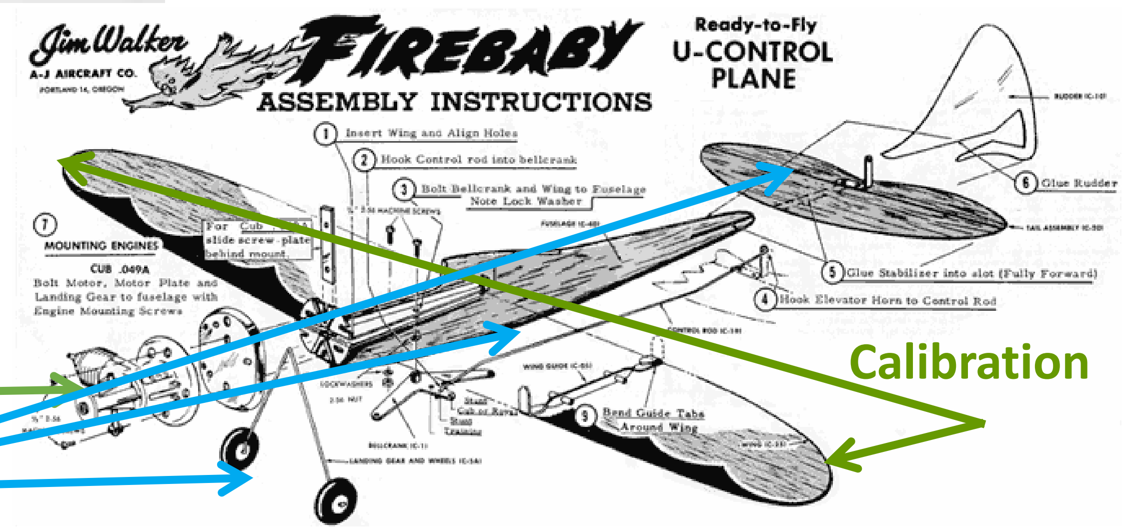
How much further will the plane fly when program $ allocation is **optimized**?

Scenarios: what if we scaled up the size of wings?

Populations: passenger groups

Programs: piloting, flight service, maintenance, etc.

Spending: part costs $



Epidemic model

Optimization of $

Calibration

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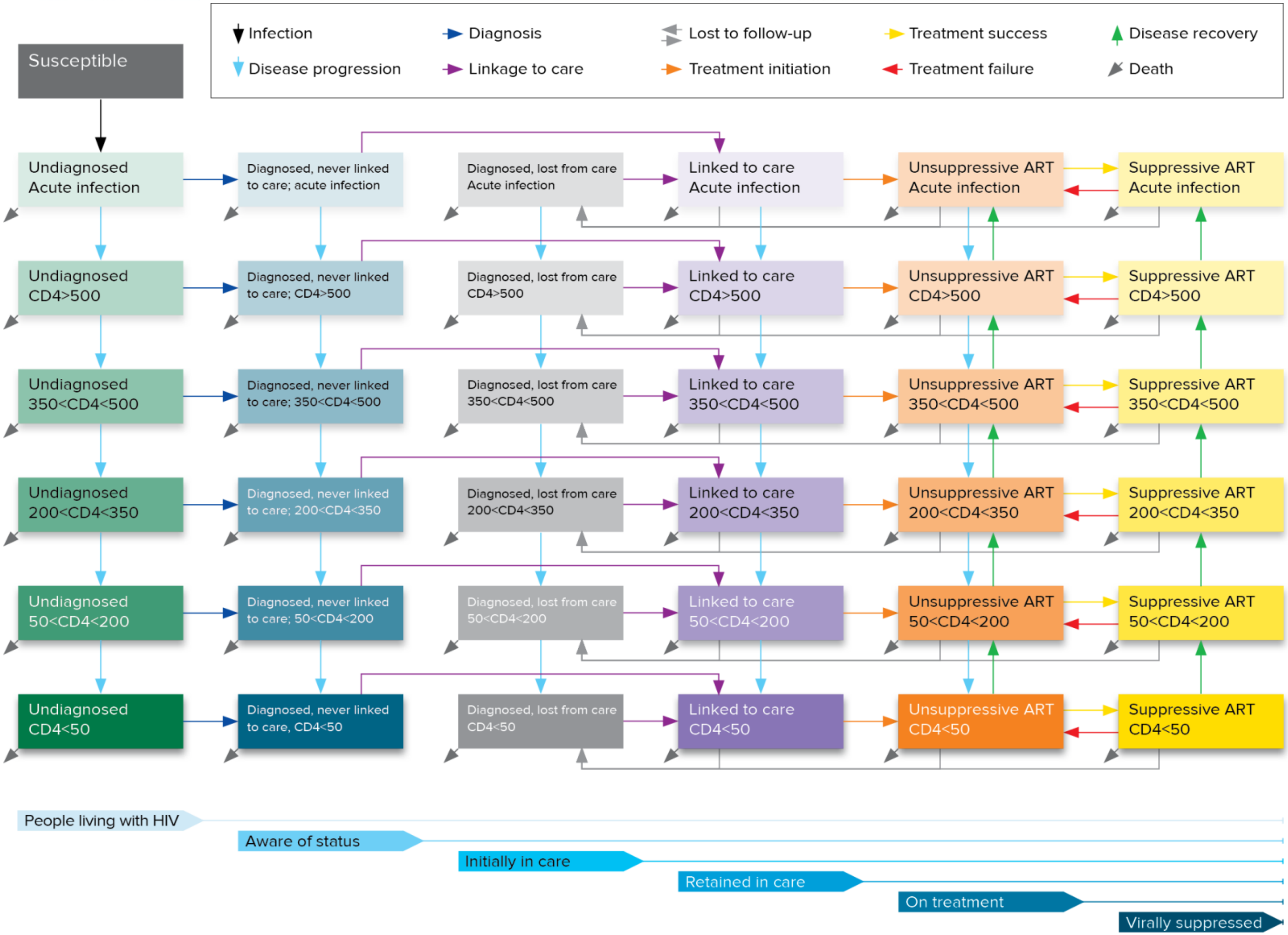
Epidemiological component

- Optima HIV is a **dynamic compartmental population-based** model
- The population is divided into compartments based on:
  - User-defined criteria
    - Age, sex, risk behavior, location, etc.
  - Health states across HIV cascade
- At each point in time, people can move between health states (i.e. compartments)

Compartmental model structure



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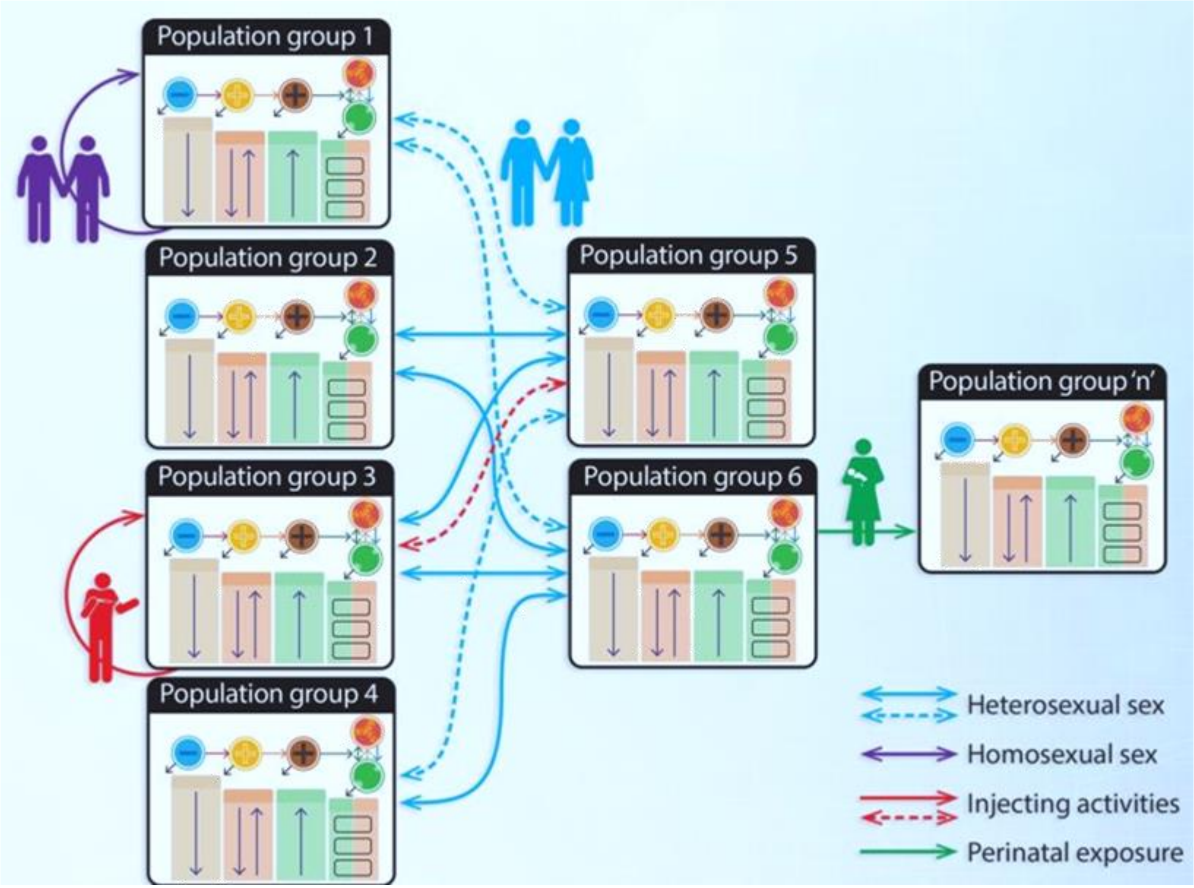
Compartmental model structure

- Tracks disease progression for each population group
- And viral transmissions between populations (i.e. partnerships)



How does Optima model HIV transmission?

- **Force of infection**

- Transmission for each population group

- Incidence depends on:
  - Risk-related interaction with others
  - Type of risk events (sexual, injecting, mother-child)
  - Prevalence of HIV among sexual and/or injecting partners
  - Viral load in partners
  - Frequency of risk events and types
  - Was protection used, e.g. condoms, clean needle-syringes?

What is the probability of transmission of HIV in a discordant partnership?

- **N** number of risk events (e.g. average number of interaction events with HIV-infected people where HIV transmission may occur
- **P** transmission probability of each event

Force of infection

$$\mathbf{F} = 1 - (1 - \mathbf{P})^{\mathbf{N}}$$

SOURCE: Kerr et al. (2015) Optima: A Model for HIV Epidemic Analysis, Program Prioritization, and Resource Optimization, JAIDS, 69(3): 365-76.

Programs in Optima HIV

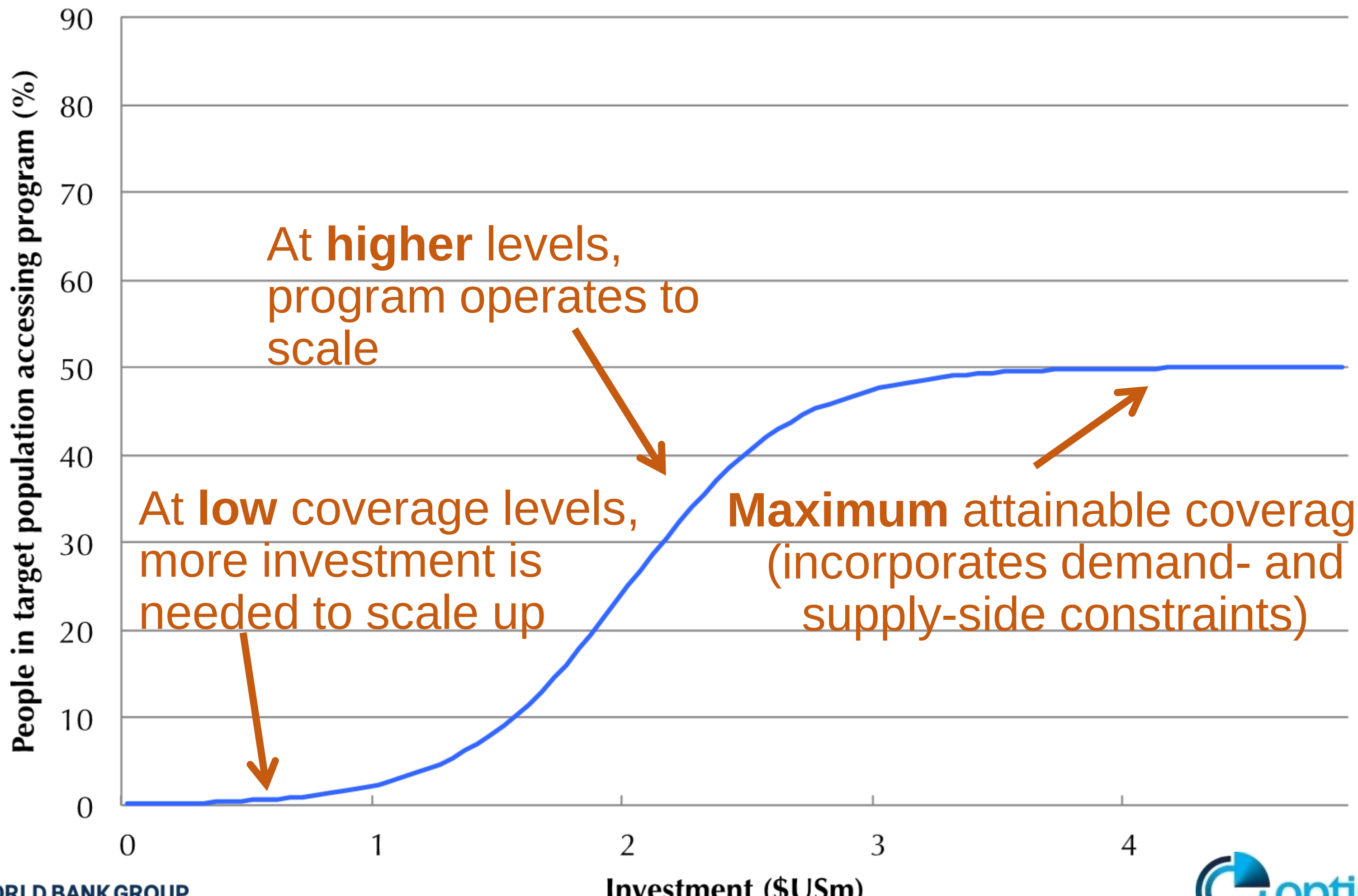
- HIV programs can be:
  - Targeted programs: direct impact on the epidemic
  - Non-targeted programs: indirect impact on the epidemic, not considered in the optimization

- Collate program cost (spending and unit costs) and coverage data (or make assumptions, as necessary)

- Cost functions link:
  - program spending to program coverage
  - program coverage to program outcome

Cost function curve: spending versus coverage

Cost functions define relationships between investment and coverage (coverage and outcome relationships are also defined)



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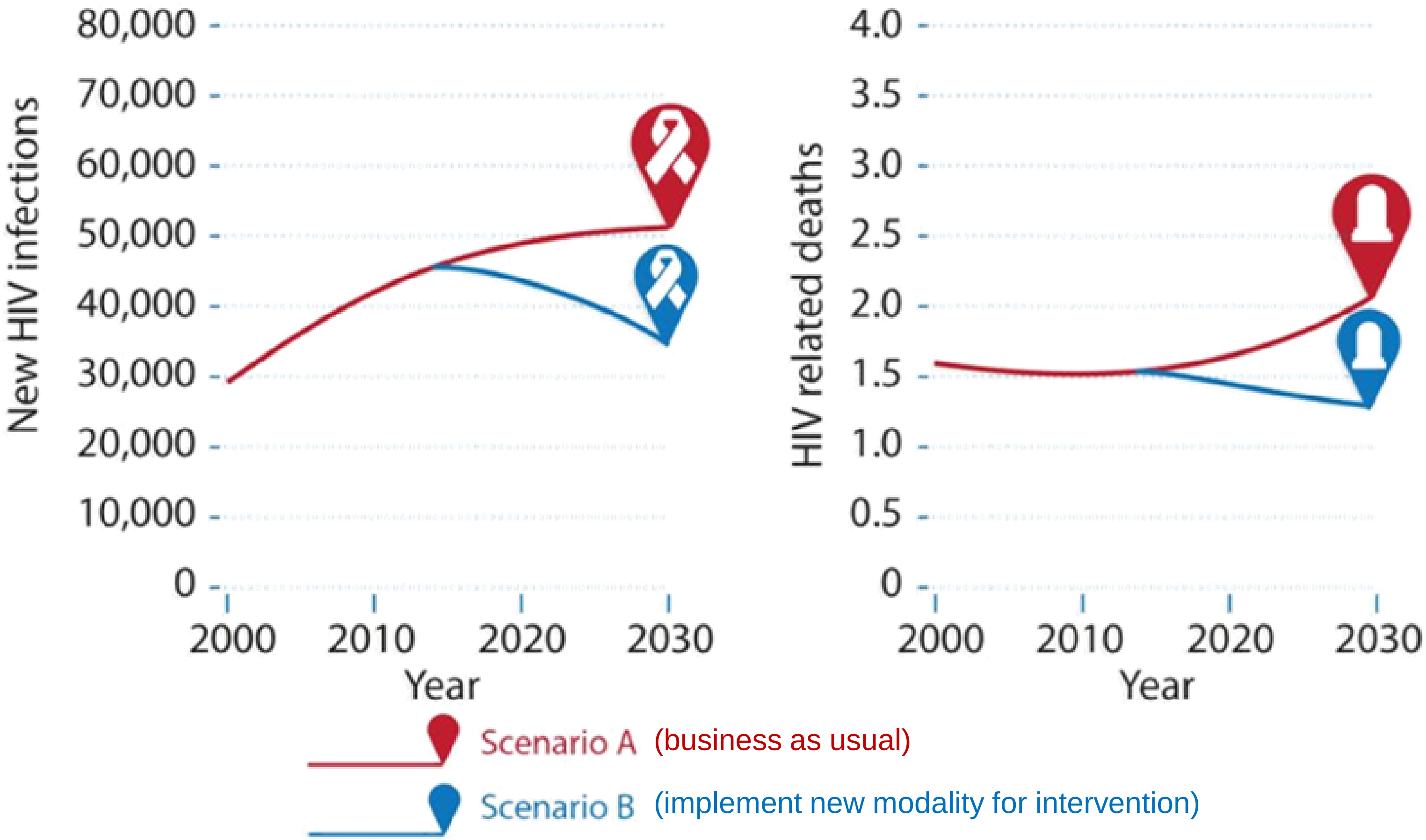
Scenario analysis



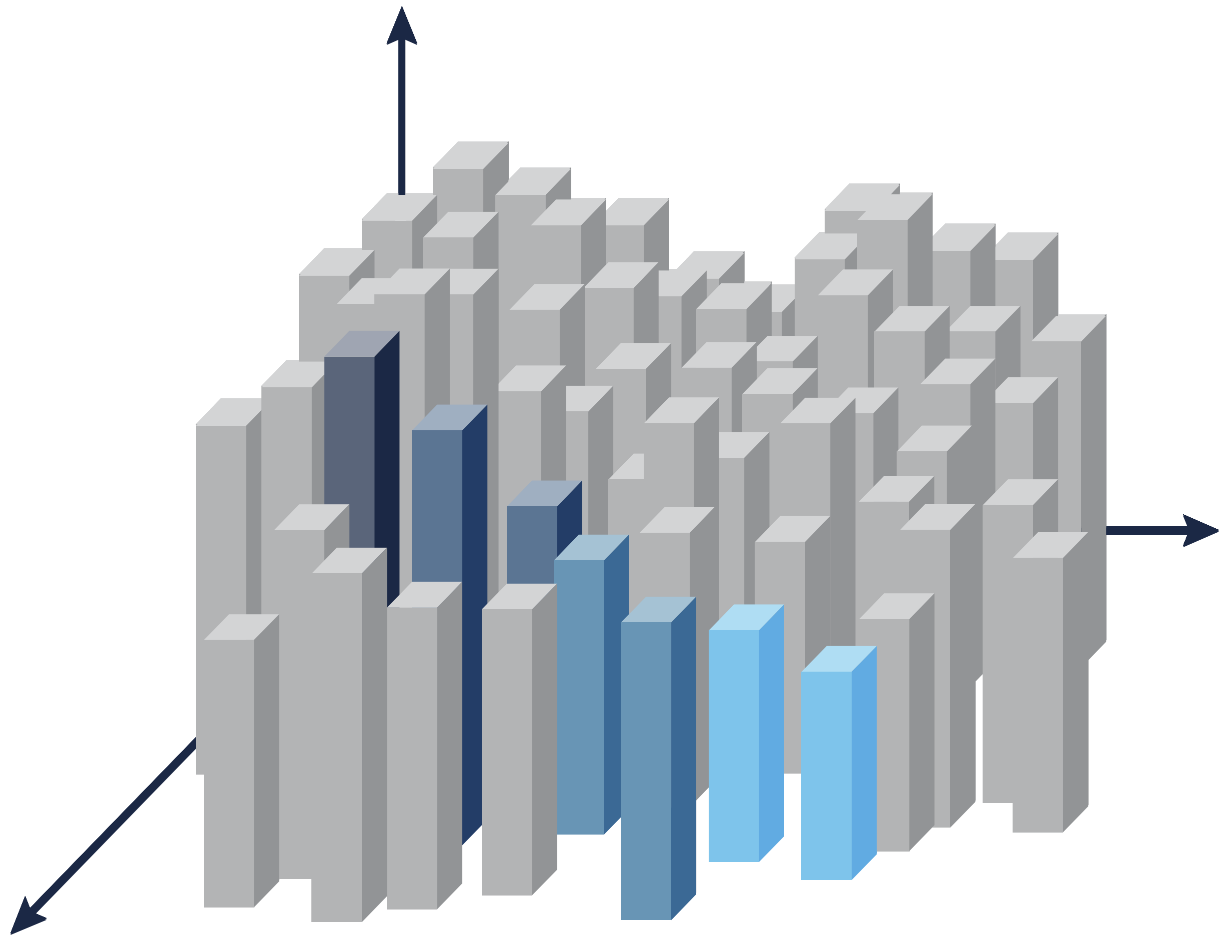
(business as usual)

(implement new modality for intervention)

Optimize resource allocation to best meet objectives

How should the budget be allocated amongst these ‘n’ programs, modalities, and delivery options, considering their interactions with synergies and limitations?

Optimization: **consider just two dimensions**



An efficient **A**daptive **S**tochastic **D**escent algorithm is applied

Adaptive: learns probabilities and step sizes
Stochastic: chooses next parameter to vary at random
Descent: only accepts downhill steps

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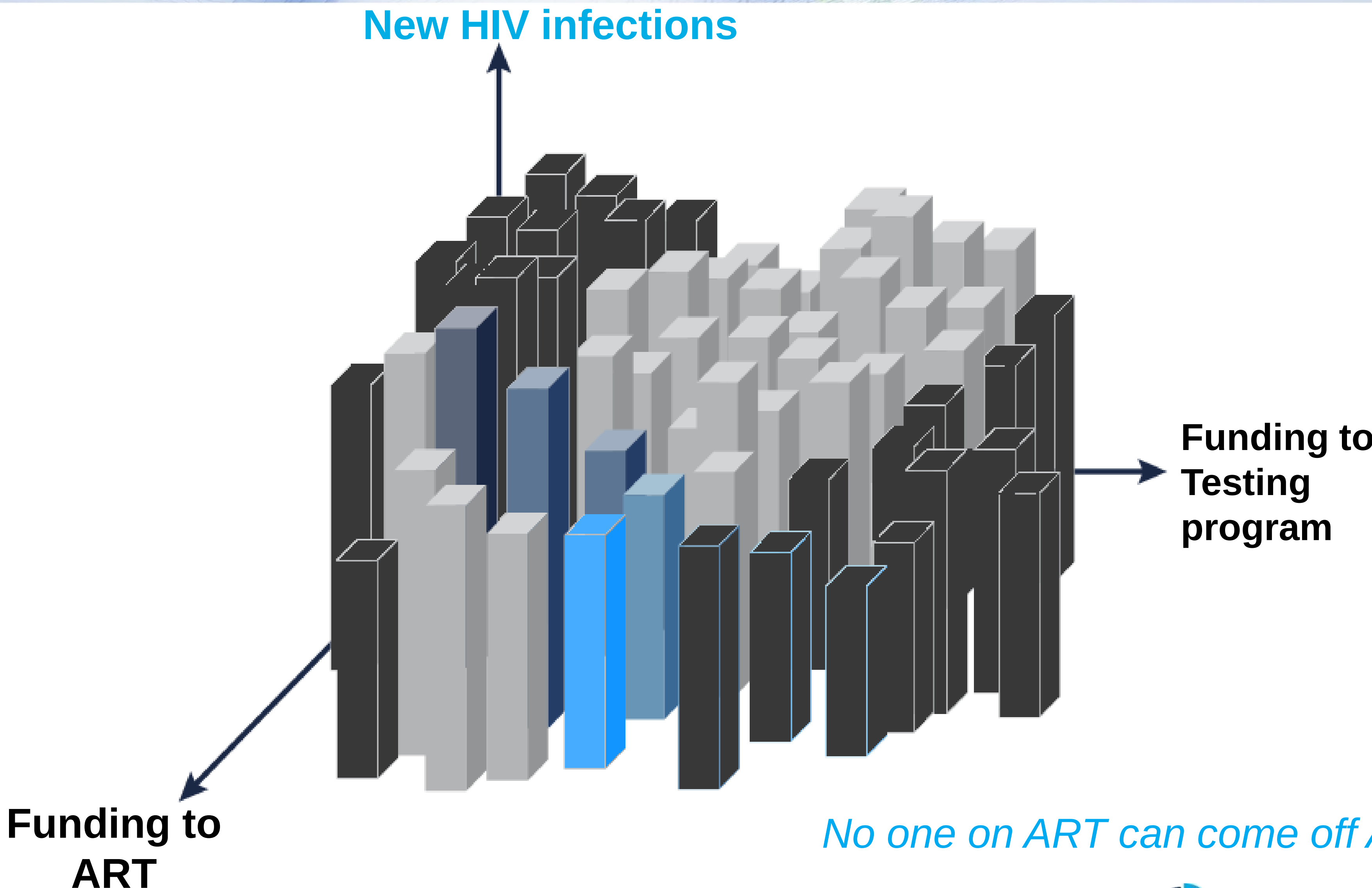
SOURCE: Kerr et al. (2015) Optima: A Model for HIV Epidemic Analysis, Program Prioritization, and Resource Optimization, JAIDS, 69(3): 365-76.

Constraints: ethical, economic, logistic, political

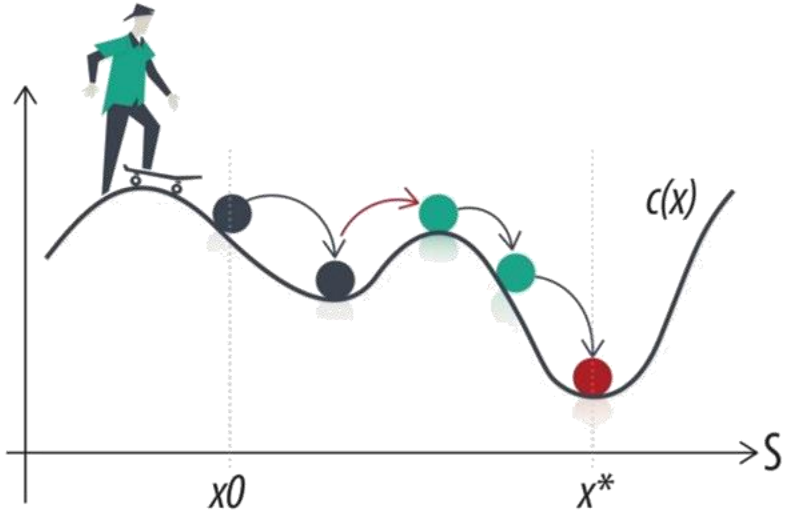


No one on ART can come off ART

SOURCE: Kerr et al. (2015) Optima: A Model for HIV Epidemic Analysis, Program Prioritization, and Resource Optimization, JAIDS, 69(3): 365-76.

Which optimization algorithm?

- Traditional algorithms (e.g., simulated annealing) require many function evaluations—slow



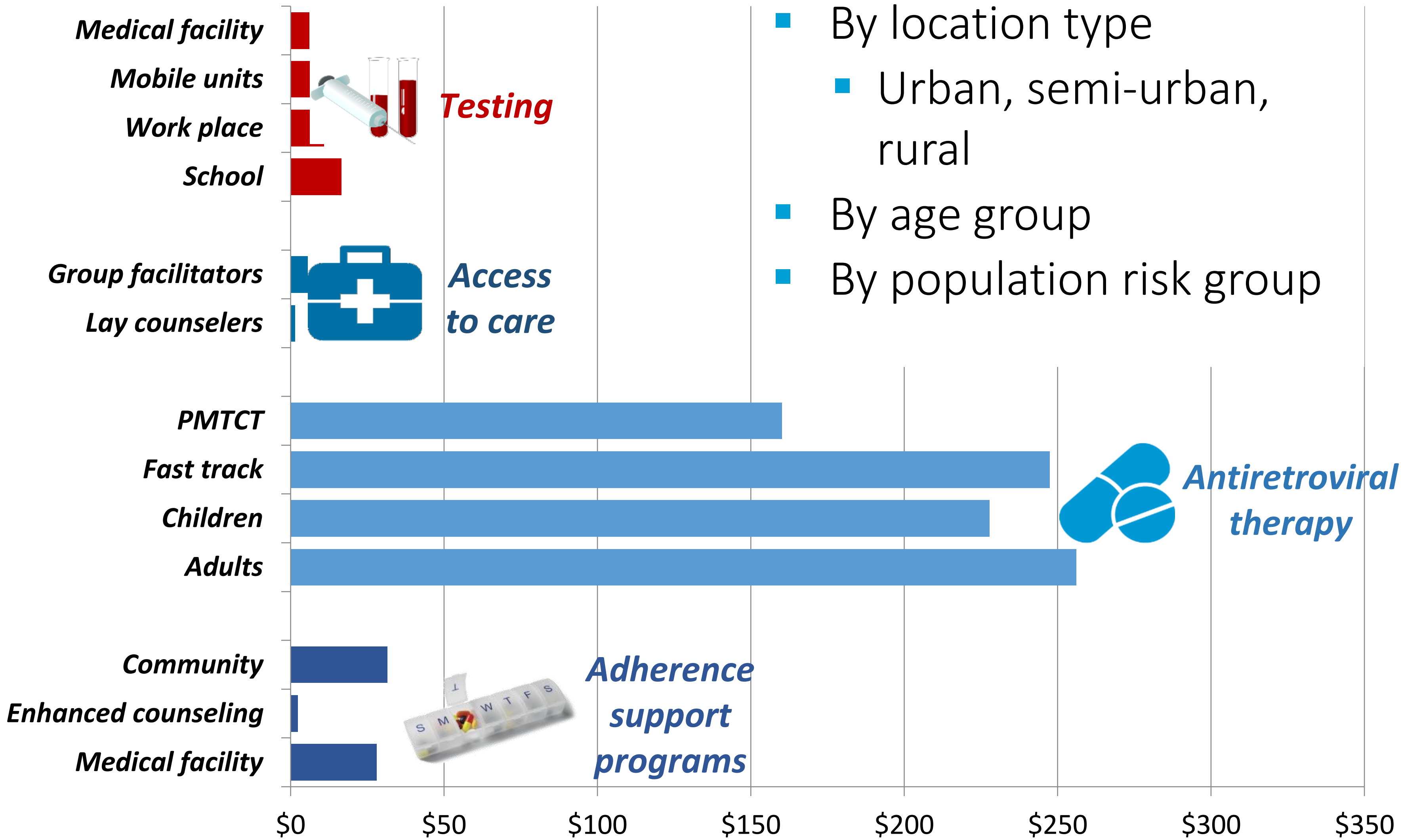
Optima's optimization algorithm

Adaptive **s**tochastic **d**escent

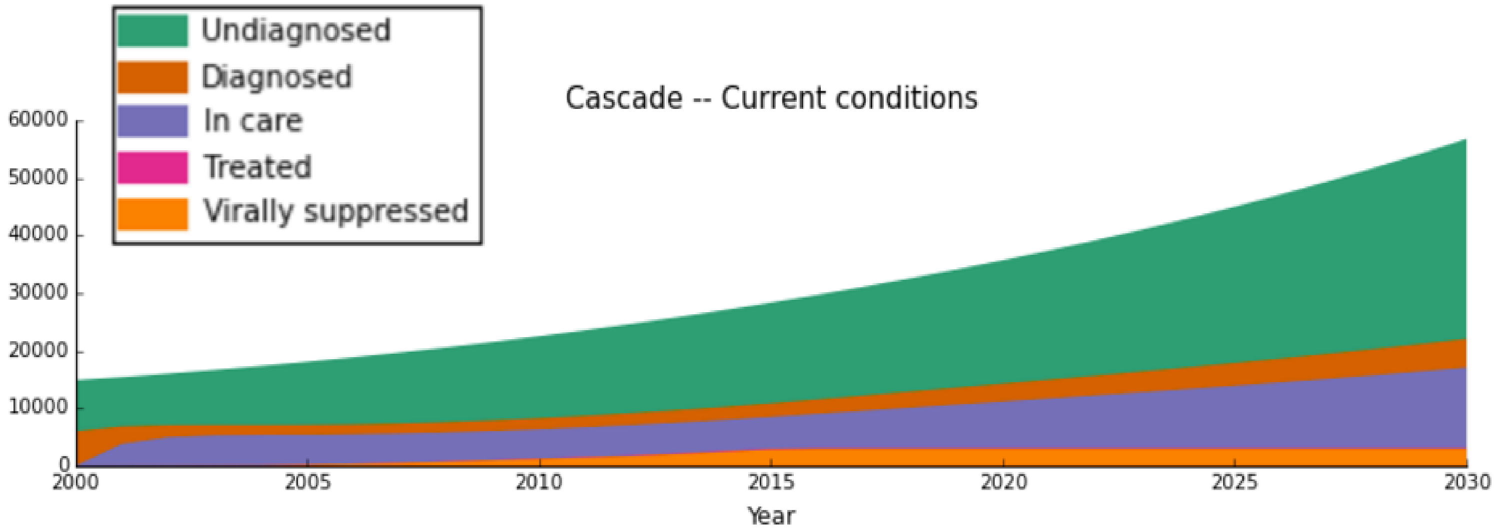
- **Adaptive**: learns probabilities and step sizes
- **Stochastic**: chooses next parameter to vary at random
- **Descent**: only accepts downhill steps

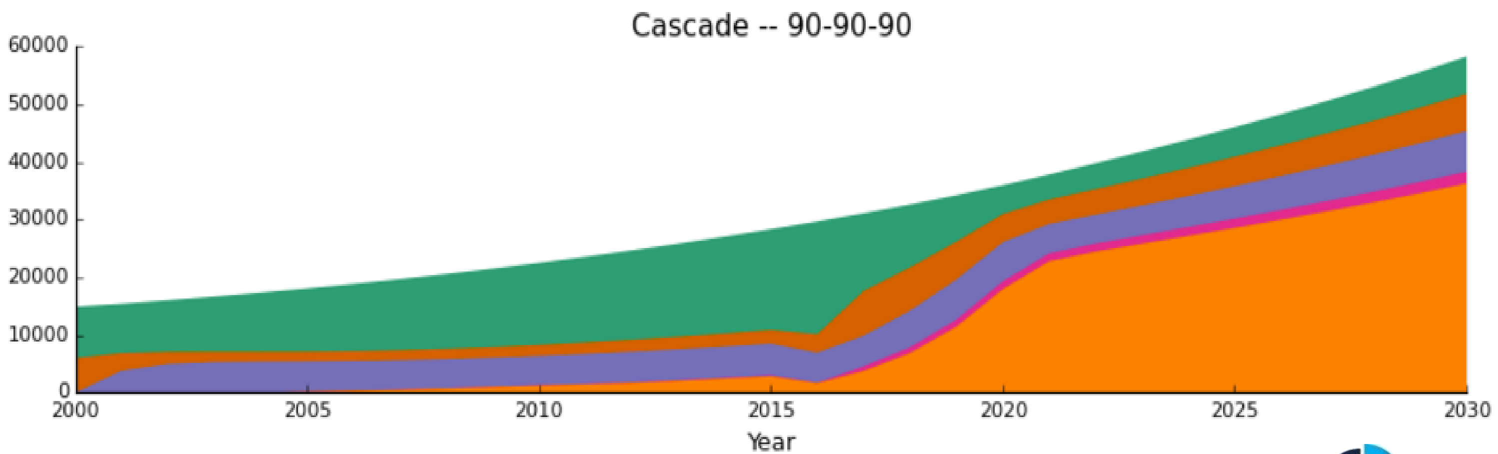
Implementation and allocative efficiency

- By location type
  - Urban, semi-urban, rural
- By age group
- By population risk group



Towards 90-90-90





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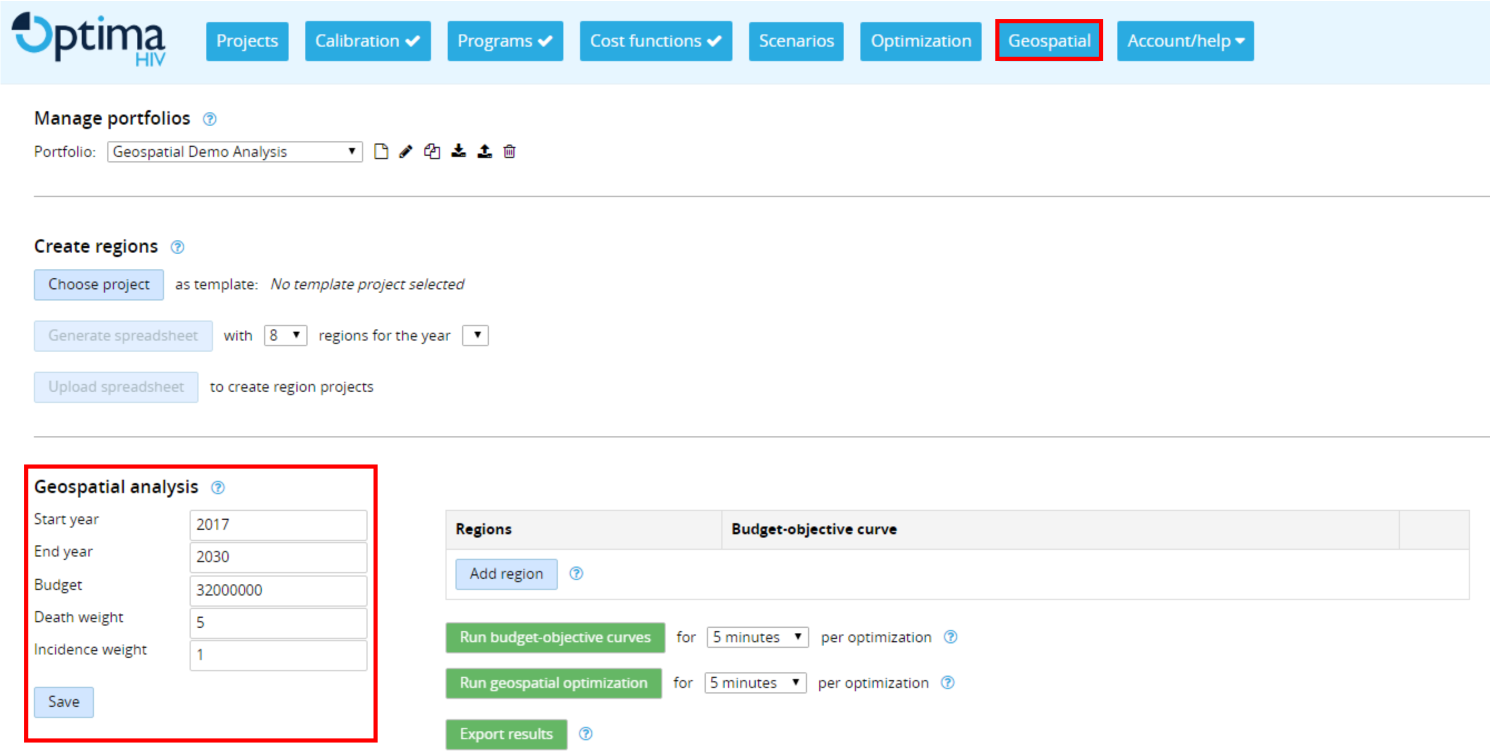
Geospatial analysis

- For conducting analyses across two or more settings (regional, subnational, district or facility level)



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QUESTIONS?

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Scope of Work and Analytical Framework

In partnership with

datasciencedojo — data science for everyone
Burnet Institute — Medical Research. Practical Action.
UCL
techemergence
symphony
University of Copenhagen
Machine Intelligence Institute of Africa — Transform Africa through Machine Intelligence
iDSI — Better decisions. Better health.
GHCC — Global Health Cost Consortium
UNDP
Bill & Melinda Gates foundation

Session objectives

1. What is a scope of work and why is it needed
2. An understanding of the key issues to specify in the scope, in particular concerning the analytical framework and timeline

What is a Scope of Work (SOW) and why is it needed?

- The SOW is an agreement document in which the analysis to be performed is described
- It should be specific and detailed, so that:
  - The study team has clear guidance
  - The stakeholders are clear on what to expect from the analysis
- The SOW should contain:
  - Any deliverables and end products that are expected to be provided by the study team
  - A time line for all deliverables
  - The roles and responsibilities within the study team and other parties involved in supporting or overseeing roles

Elements of a SOW (table of contents)

- Background (or Problem Statement) - *Brief description of the Program/Service, challenges and opportunities; include relevant strategies, program objectives, operational plans, targets or key performance indicators, and any available budget or expenditure information*
- Rationale *why the analysis is proposed and how it links to Government policy*
- Objectives – *analysis questions to be answered*
- Specifications for the analysis – *next slide*
- Deliverables – *detailed description of expected outputs*
- Implementation and Coordination – *roles and responsibilities and any coordination mechanisms*
- Timeline – *All milestones and deliverables*

TYPICAL ANALYTICAL FRAMEWORK

Overview of typical analyses

PREPARE → **1. Descriptive analyses of epidemiological, program, budget and cost data** (inputs to model parameterisation)

EPI ANALYSES → **2. Epidemiological curve fitting (to historical data) and future epidemiological projections** (under current program coverage and budget allocations)

OPTIMISATION ANALYSES → **3. Optimisation of funding allocations to programs:**

3.1 Optimisation within *current* funding volume

3.2 Optimisation with *higher or lower* funding volumes

3.3 *Geographical optimisation* of funding within & between sub-national levels of Govt

OPTIMISATION/ SCENARIO ANALYSES → **4. Estimation of minimum funding needed** to achieve strategic plan targets

SCENARIO ANALYSES → **5. Scenario analyses** to assess impact of changes to the program, coverage, service delivery modalities or unit costs

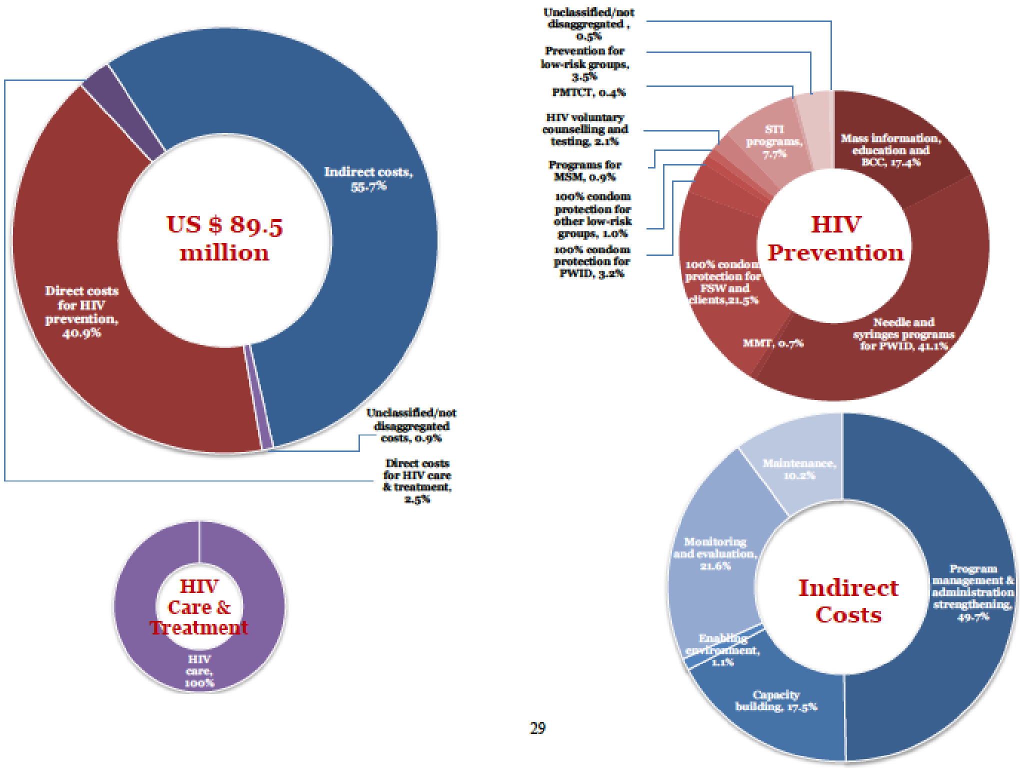
HISTORICAL ANALYSES → **6. Impact** of historical funding allocations

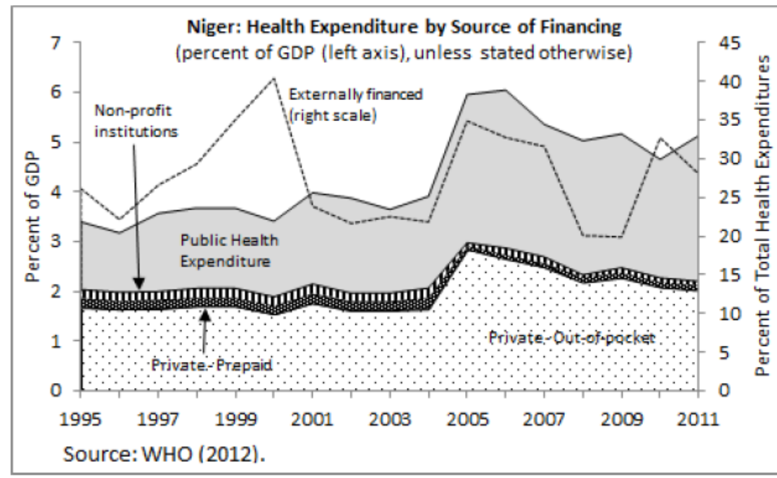
Analysis 1: Descriptive analyses of epidemiological, program, budget and cost data with which to parameterise the mathematical model

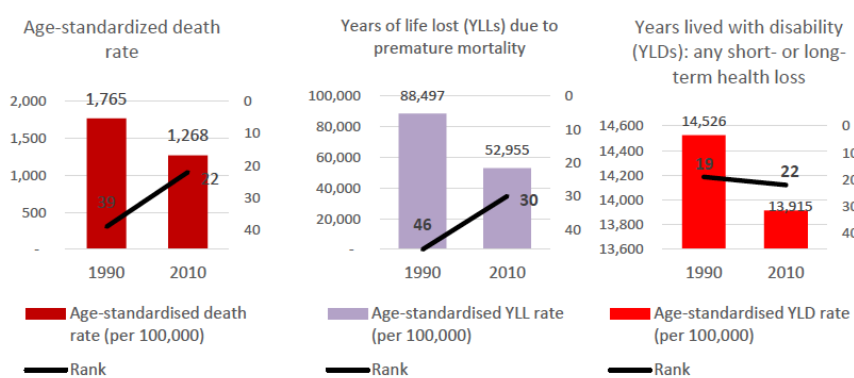
Analysis of:

Epidemiological data
Overall funding
Current program expenditure
Unit costs
Program coverage

Examples







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Analysis 2

Fit to historical epidemiological data and project future HIV epidemiological trends

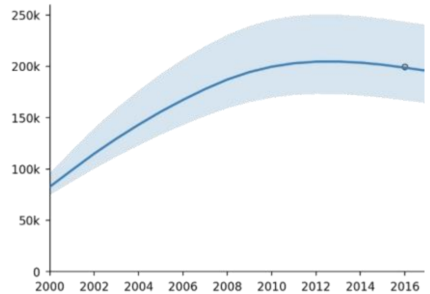
Epidemiological curve fitting (to historical data) and future epidemiological projections

Unit costs / cost functions	Funding volume	Funding proportionate allocation	Coverage	Program target outcomes	Epidemiological outcomes
Fixed	Current funding	Current allocation	Current allocation	N/A	Assess impact

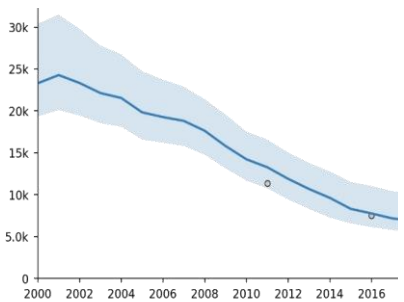
- **Fit to historical epidemiological data**
- **Project future HIV epidemiological trends**
- Estimate HIV prevalence, incidence, AIDS-related deaths as well as outcomes across the HIV care cascade
  - Historically (2000-2017)
  - In the future (2018-2030)
  - **Assuming current % programme coverage and other epidemic determinants (e.g. sexual behaviour) remain constant**
- Total population and by population group
  - Sex, Age, Key populations (e.g. FSW, clients, MSM, PWID)

Examples

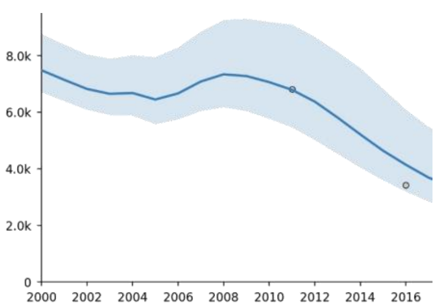
PLHIV

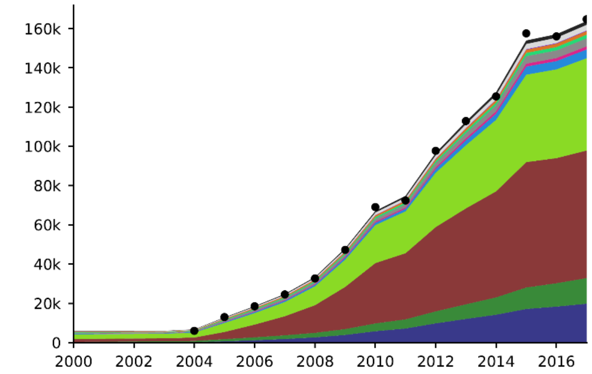


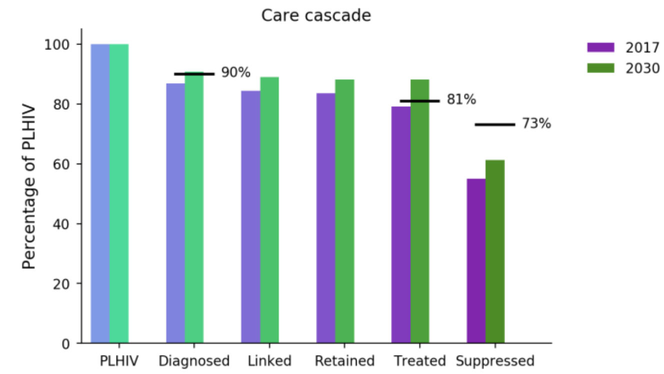
New HIV infections

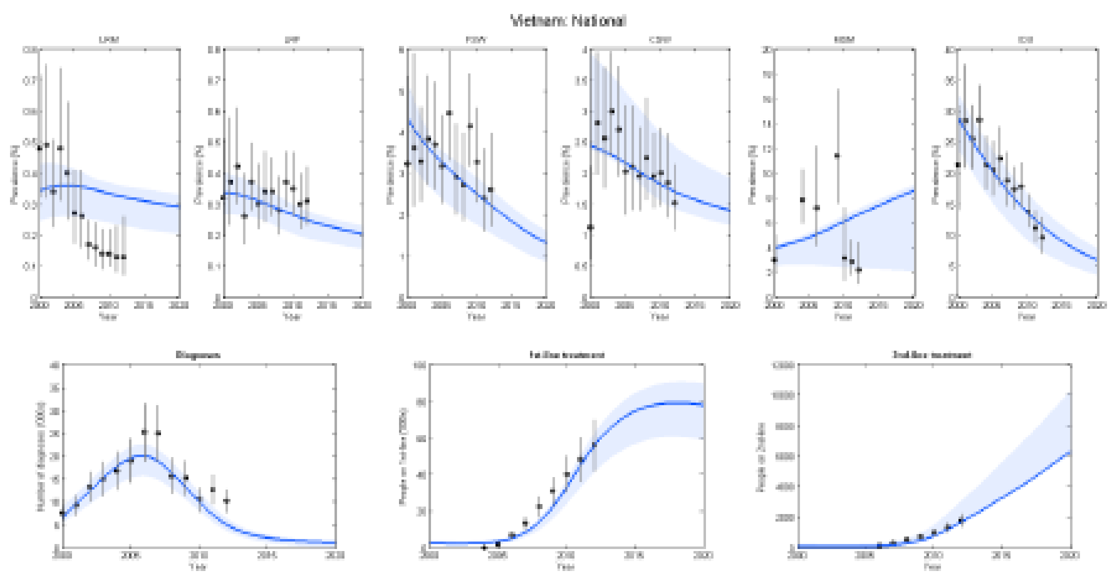


HIV-related deaths









Analysis 3.1

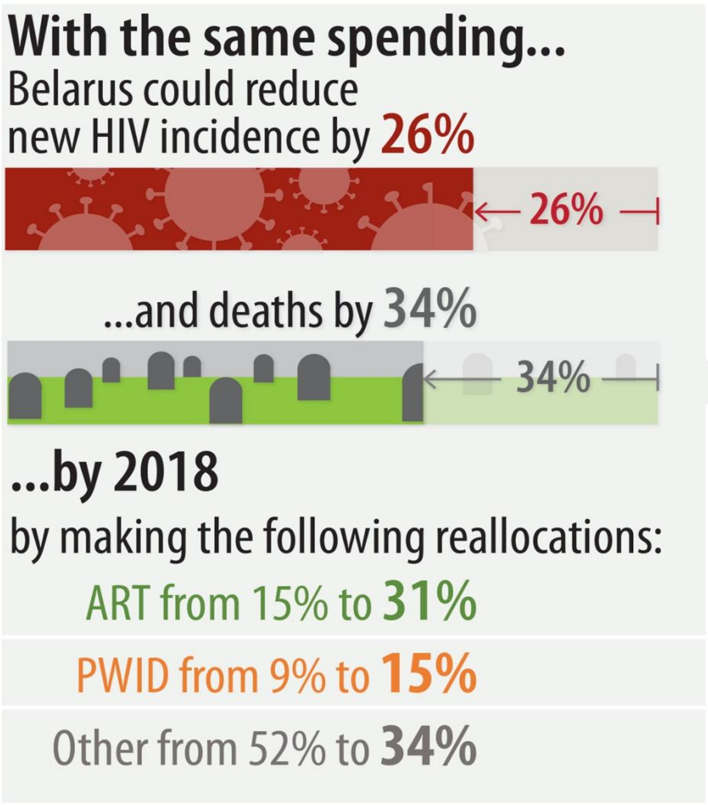
Determine, through mathematical algorithms, optimised funding allocations to programs, within current funding volume

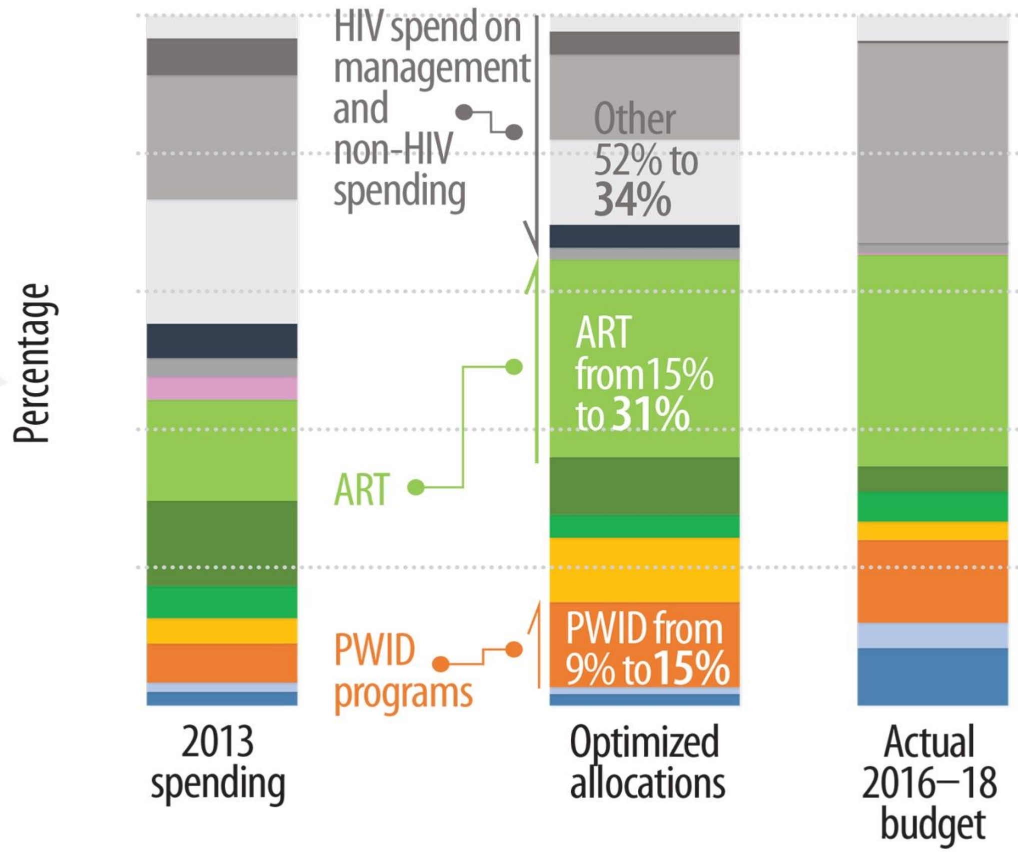
Optimisation within *current* funding volume

Unit costs / cost functions	Funding volume	Funding proportionate allocation	Coverage	Program target outcomes	Epidemiological outcomes
Fixed	Current funding	Optimise	Vary, based on optimisation	N/A	Assess impact

- **Quantify program objectives** and determine the objective function
- Determine, through mathematical algorithms, **optimised funding allocations**
- Project **future trends** of the HIV epidemic with **optimised allocation** of resources
  - Estimate the future number of new infections and HIV-related deaths if the current funding for HIV programmes was allocated optimally throughout:
    - The remaining national strategic plan period (20XX to 20XX)
    - The time period for achieving global HIV targets (2030 SDG & End AIDS targets)

The case of Belarus





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Analysis 3.2

Determine, through mathematical algorithms, optimised funding allocations for different levels of funding

Optimisation with *higher or lower* funding volumes

Unit costs / cost functions	Funding volume	Funding proportionate allocation	Coverage	Program target outcomes	Epidemiological outcomes
Fixed	Fixed volume (either higher or lower than current volume)	Optimise	Vary, based on optimisation	N/A	Assess impact

- **Quantify program objectives** and determine the objective function
- Determine, through mathematical algorithms, **optimised funding allocations for different levels of funding**. Typically:
  - With reduced funding to 50-90% of current HIV spending
  - With increased funding to 100-200% of current HIV spending
- Project **future trends** of the HIV epidemic with **optimised allocation** of resources
  - Estimate the future number of new infections and HIV-related deaths if the current funding for HIV programmes was allocated optimally throughout:
    - The remaining national strategic plan period (20XX to 20XX)
    - The time period for achieving global HIV targets (2030 SDG & End AIDS targets)

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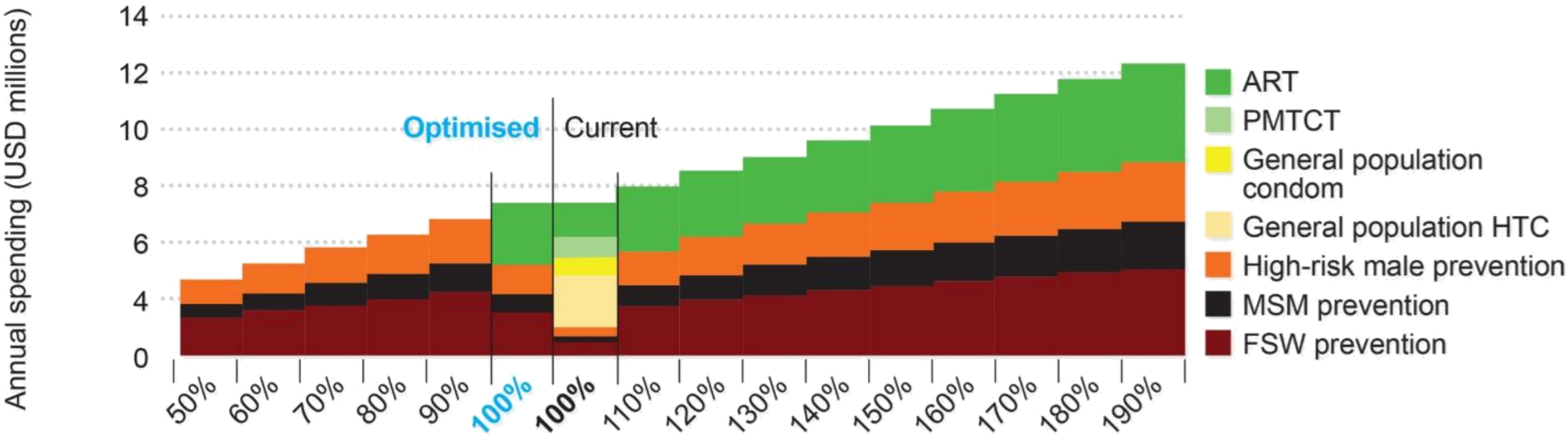
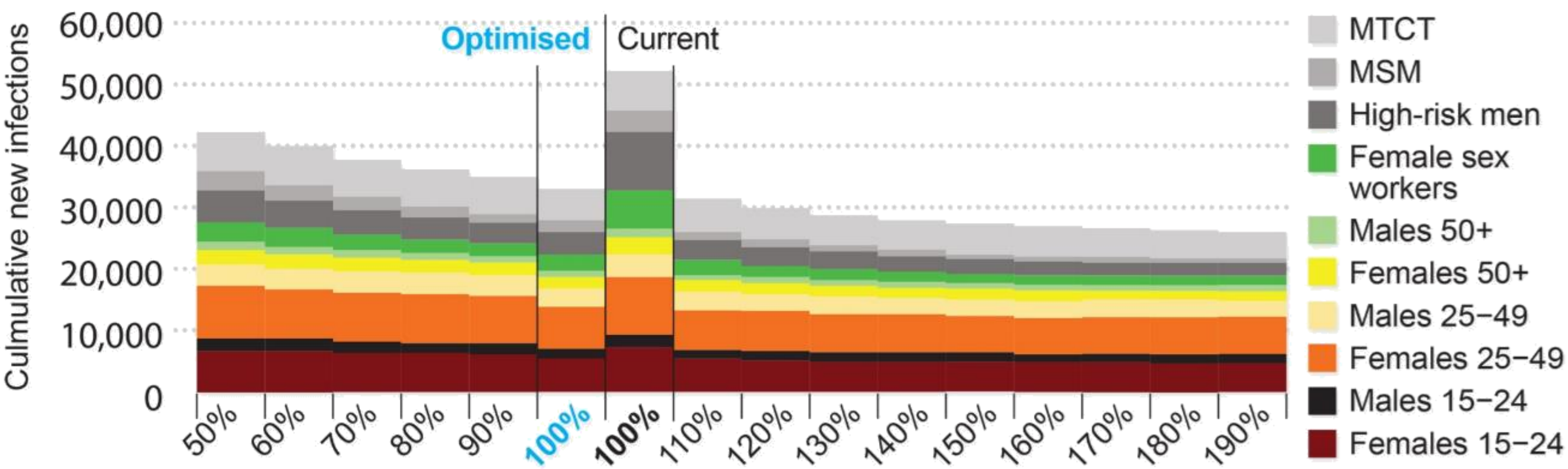
Example of using a mathematical model to improve HIV allocative efficiency in HIV in Sudan





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Analysis 3.3: Geographical optimisation

Determine, through mathematical algorithms, optimised funding allocations between and within sub-national entities (e.g. regions, districts or facilities)

Optimisation of funding to programs in specific geographic units

Unit costs / cost functions	Funding volume	Funding proportionate allocation	Coverage	Program target outcomes	Epidemiological outcomes
Fixed (for each sub-national entity)	Current or different funding (for each sub-national entity)	Optimise (to and within sub-national entities)	Vary, based on optimisation	N/A	Assess impact (for each sub-national entity)

- **Quantify program objectives** and determine the objective function
- Determine, through mathematical algorithms, **optimised funding allocations between and within sub-national entities**
- Project **future trends** of the HIV epidemic with **optimised allocation** of resources **for each sub-national entity**
  - Estimate the future number of new infections and HIV-related deaths if the current funding for HIV programmes was allocated optimally throughout:
    - The remaining national strategic plan period (20XX to 20XX)
    - The time period for achieving global HIV targets (2030 SDG & End AIDS targets)

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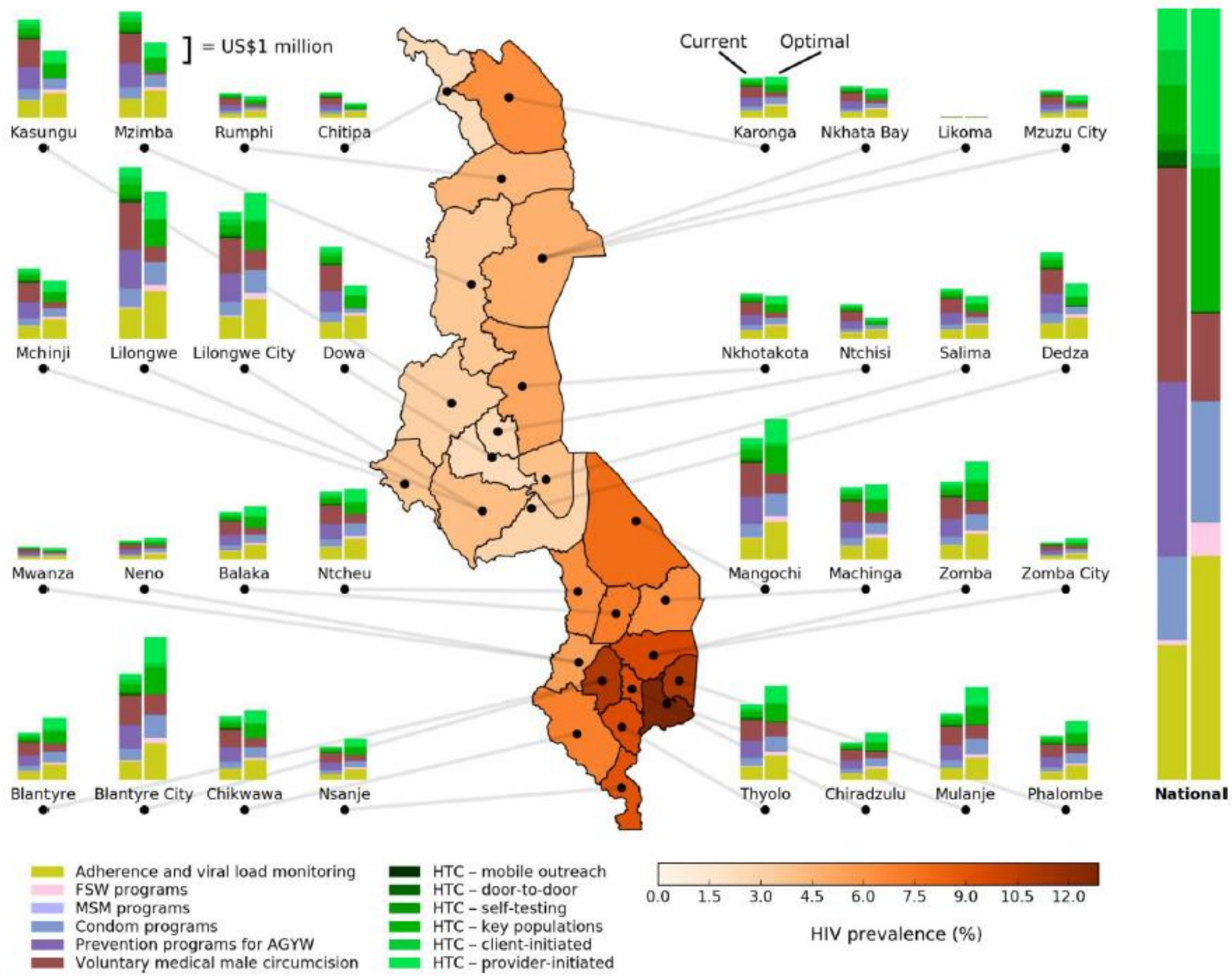
Malawi: geographical optimisation



Analysis 4

Estimate the minimum financial resources – if optimally allocated – required to achieve HIV response targets

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Minimum funding needed to achieve strategic plan targets

Unit costs / cost functions	Funding volume	Funding proportionate allocation	Coverage	Program target outcomes	Epidemiological outcomes
Fixed	Optimise	Optimise	Vary, based on optimisation	Vary, based on optimisation	Fixed, based on strategy

- Estimate the amount of funding required to achieve targets and determine how the resources should be allocated across different HIV response interventions:
  - To reduce HIV incidence by x % and AIDS-deaths by y% by 202x (national targets)
  - To reduce HIV incidence and AIDS-deaths by 90% by 2030 (from 2010) (End AIDS targets)

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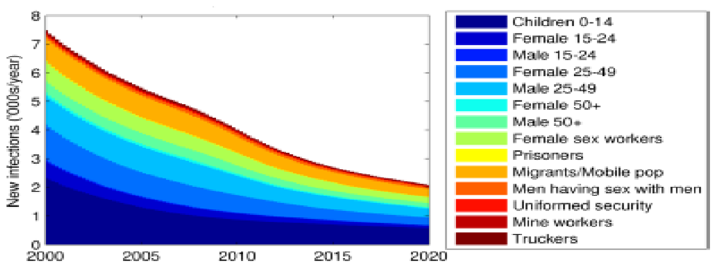
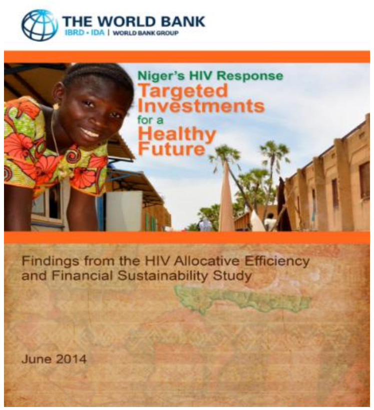
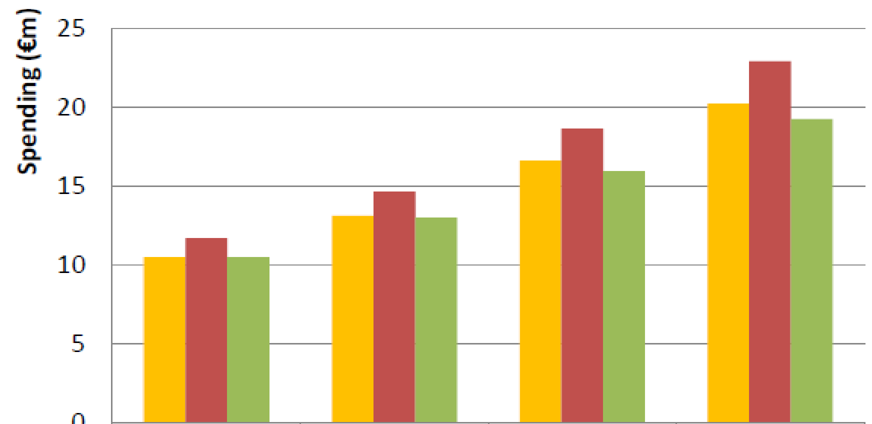
Achieving National Strategic Plan targets in Niger

- Reduce HIV incidence by 50% and scale-up ART to at least 80% of eligible people (2013-2017)





Minimum budgets required to meet NSP coverage targets, Niger 2013–17



	2014	2015	2016	2017
Default (€m)	10.5	13.1	16.6	20.2
Higher CD4 threshold	11.7	14.7	18.6	22.9
Lower management costs	10.5	13.0	16.0	19.2

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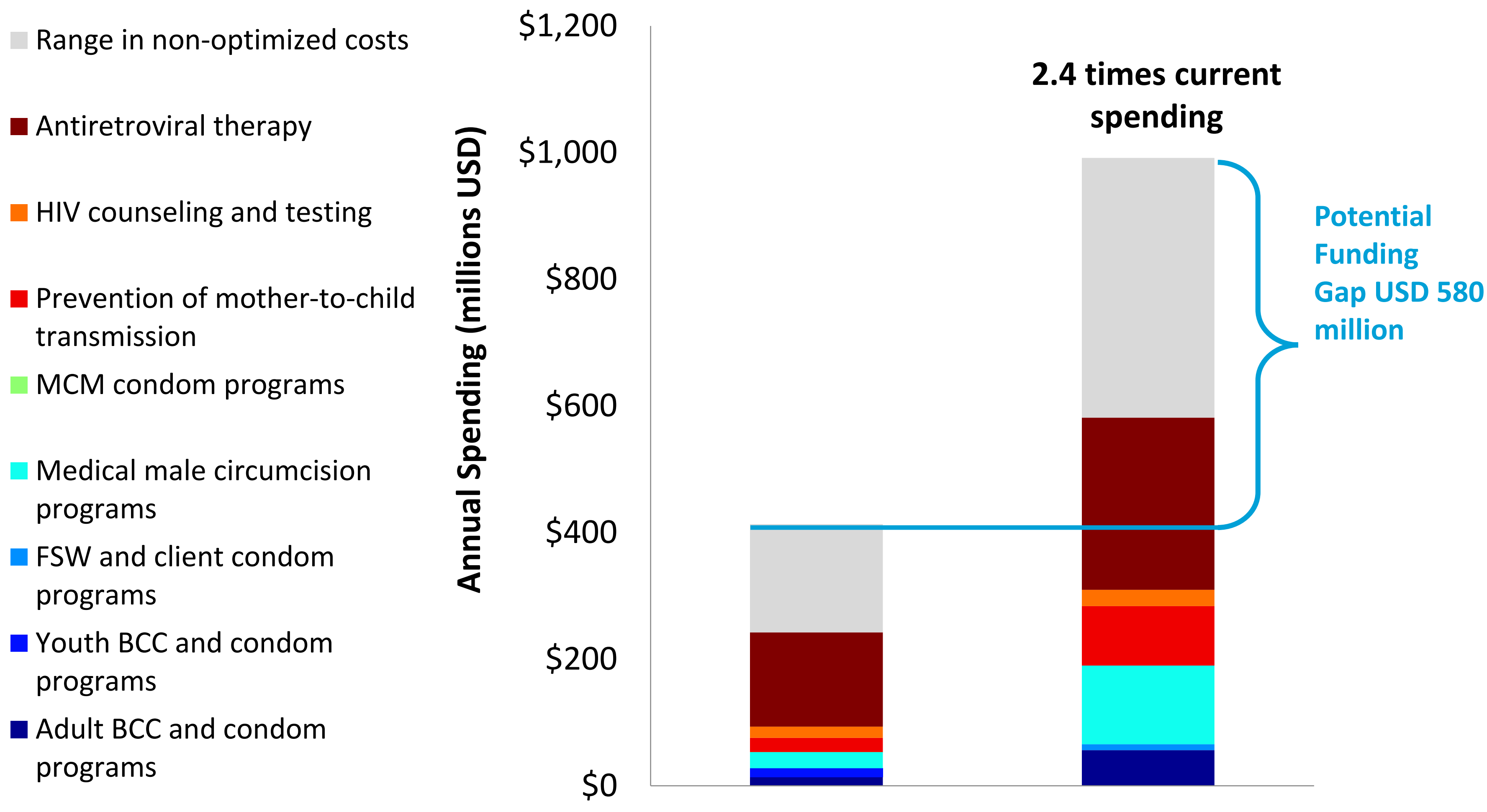
Spending required for ambitious targets in Zambia
“Reality check”



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Scenario Analyses:

Estimate how the future HIV epidemic would be influenced by specific changes to the status quo conditions

Implementation scenarios

Unit costs / cost functions	Funding volume	Funding proportionate allocation	Coverage	Program target outcomes	Epidemiological outcomes
Vary as per analysis requests	Vary as per analysis requests	Vary as per analysis requests	Vary as per analysis requests	Vary as per analysis requests	Vary as per analysis requests

- Estimate the future number of new HIV infections and AIDS-deaths if program specific changes were achieved through implementation of the following actions (examples):
  - Scaling up coverage of testing, treatment and adherence programmes to achieve 90/90/90 targets
  - Achieving other programme coverage targets
  - Defunding key population non-ART prevention programmes

Implementation scenarios are typically defined based on country priorities and can involve some of the examples above, but potentially a range of other analyses.

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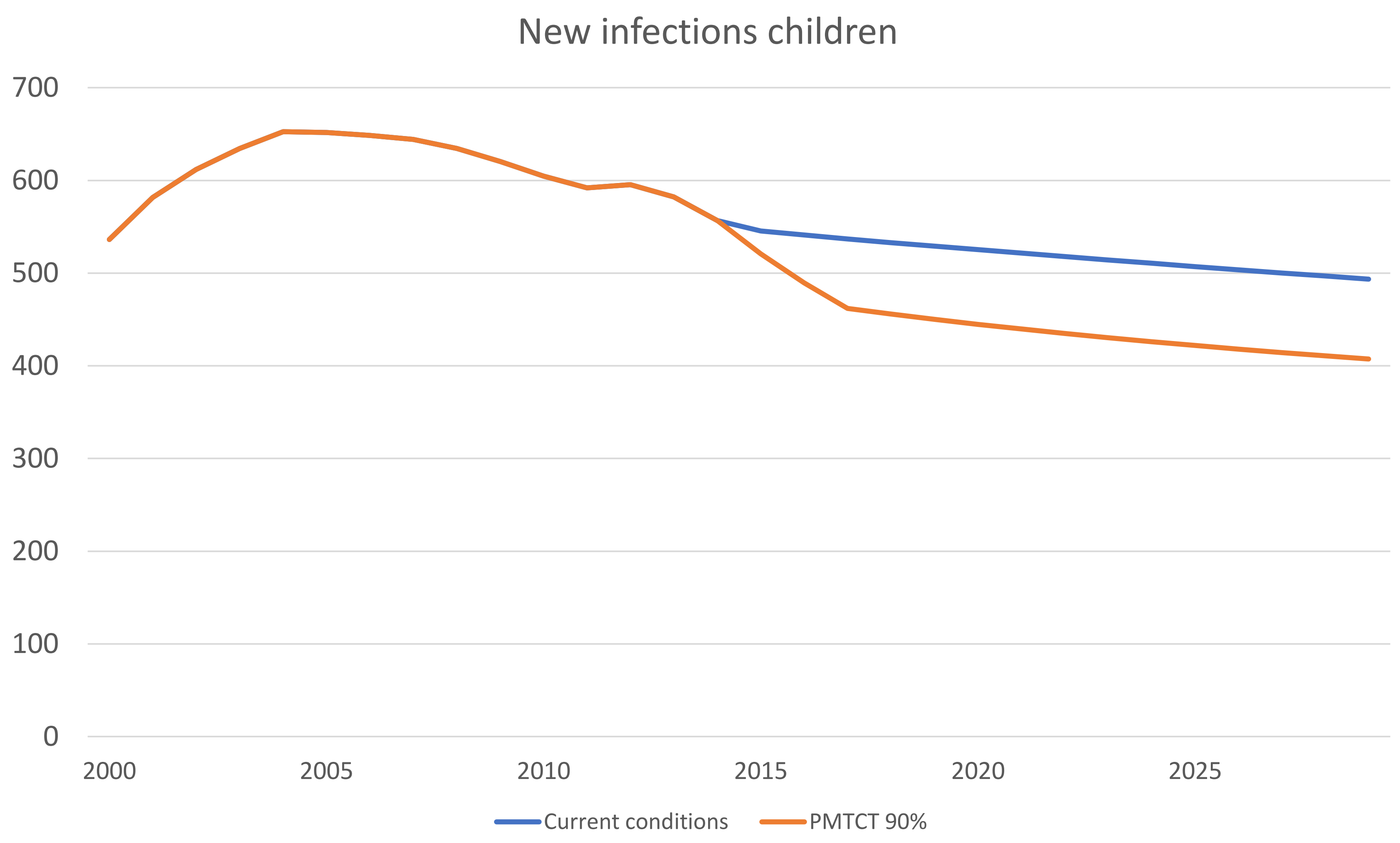
Example: Impact of scaling up PMTCT coverage



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Analysis 6: Impact of historical funding allocations

Estimate the epidemiological impact and cost-effectiveness of the past HIV response funding as spent and with historical changes in coverage levels

Impact of historical funding allocations

Unit costs / cost functions	Funding volume	Funding proportionate allocation	Coverage	Program target outcomes	Epidemiological outcomes
Fixed	Past funding	Past allocation	Past allocation	N/A	Assess impact

- Estimate the number of additional new HIV infections and AIDS-deaths that would have occurred had investment not been made in (examples):
  - Any component of the last National Strategic Plan (20xx-20xx)
  - PWID programs (needle and syringe programs and OST)
- Based on investment and estimated number of new HIV-infections and AIDS-deaths averted, estimate the cost-effectiveness of the past response

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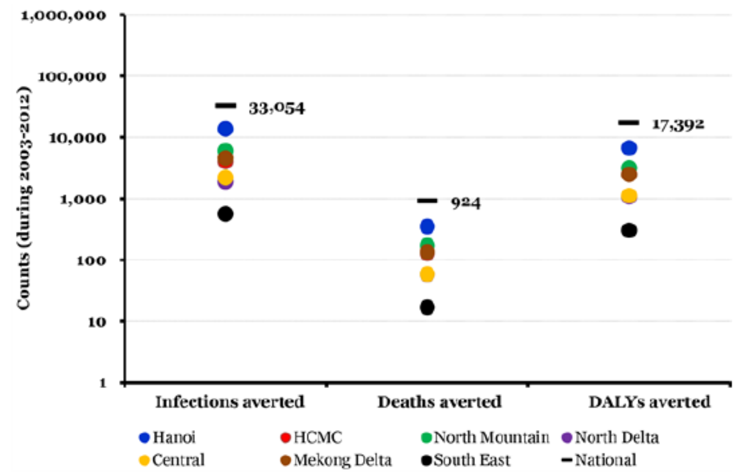
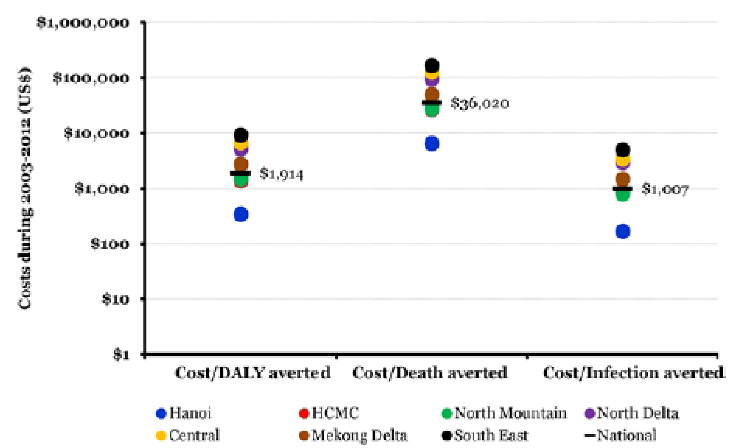
Example: Evaluating a decade of DFID and WB supported HIV/ AIDS programmes in Vietnam (2003-2012)

- It was estimated that the **DFID/WB programmes averted ~33,000 HIV infections, 924 HIV-related deaths, and 17,392 DALYs**
- Most of the health benefits were attributed to NSPs for PWID.
- Programme costs amounted to an estimated (2003-2012):
  - US $1,007 per HIV infection averted
  - US $36,020 per HIV-related death averted
  - US $1,914 per DALY averted
- According to standard willingness to pay thresholds, these values indicate that the programmes are **good value for money.**
- For every $ spent on NSPs, the estimated rate of return in healthcare costs saved was US $1.93.





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Specifications for the Analysis ("Analysis Framework")

- Time horizons (reference year, etc.)
- Populations and sub-populations
- Interventions/ Modalities
  - Target groups
  - Characterization of each intervention
  - Parameters (and/or cascade stage(s)) affected
  - Baseline coverage in target populations
  - Saturation
  - Effectiveness
  - Cost (unit or marginal)
- Definition of scenarios/optimisations
- Constraints applied in modelling
- Model constants, parameters, assumptions (e.g. for base case)
- Critical data gaps and strategies to fill them
  - Additional data collation, secondary data or sensitivity analysis etc.

2018 SKILLS BUILDING PROGRAM

BIG DATA, ARTIFICIAL INTELLIGENCE AND DECISION SCIENCE IN HEALTH AND NUTRITION

Collating data and populating the Optima HIV databook

In partnership with

Learning objectives

- Key data needs and sources
- Interpreting data sources and considerations for model parameters
- Handling data uncertainties

SOURCE: Chisholm, D and Evans, D. 2010. Improving health system efficiency as a means of moving towards universal coverage. *World Health Report (2010) Background Paper, No 28.* World Health Organization

Optima HIV data requirements

- Demographic, epidemiological and behavioural data are to be collated in the Optima HIV databook.
  - Once collected, databook is uploaded directly to Optima HIV model

- Costing, coverage and cost-coverage values are entered in the Optima HIV interface.

Minimum data requirements for Optima HIV databook: demographic, epidemiological, and behavioral values

Sheet	Indicators	Mandatory or optional
Populations	Populations by age, sex, risk	Mandatory
Population size	Population sizes by population	Mandatory
HIV prevalence	HIV prevalence by population	Mandatory
Other epidemiology	Background mortality, prevalence of STIs, TB prevalence by population	Mandatory
Testing & treatment	HIV testing rates by population, probability of a person with CD4 <200 being tested per year, on ART, covered by ARV-based prophylaxis (PrEP, PEP) by population, on PMTCT, birth rate by female population, percentage of HIV-positive women who breastfeed	Mandatory
Optional indicators	Tests, diagnosis, modelled estimates (infections, prevalence, PLHIV, HIV-related deaths), initiating ART, PLHIV aware of status, diagnosed in care, in care on treatment (%), pregnant women on PMTCT (%), on ART with VS (%)	Optional
Cascade	Time to be linked to care by populations, time to be linked to care for people with CD4<200, lost to follow-up by population, people with CD4<200 lost to follow-up (%/year), VL monitoring, proportion of those with VL failure who are provided with effective adherence support or a successful new regimen, treatment failure rate	Optional*
Sexual behavior	By population: number of regular, casual, commercial acts and condom use by partner type, and circumcisions by male population	Mandatory
Injecting behavior	Frequency of injection and needle-syringe sharing by populations, number on OST	Mandatory
Partnerships & transitions	Interactions for sexual and injecting partners, occurrence of births specified from which female population to youngest general population by sex where applicable, age- and risk-related movement between populations	Mandatory
Constants	Parameters (transmissibility, efficacy, disease progression, mortality, etc.)	Only edit where context values available

*Recommend entering values for these two indicators within the cascade sheet:
(1) time take to be linked to care, if left blank everyone diagnosed will immediately be linked to care, and
(2) loss to follow up, if left blank no one would be lost to follow-up

if left blank will be **interpreted as zero** by the model, the model will run, but the outcome will not be realistic

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Common data sources

For demographic, epidemiological and behavioural values:

- UNAIDS Global AIDS Monitoring (GAM) reports
- Integrated Bio-behavioural Surveillance (IBBS) reports
- Demographic and Health Survey (DHS)
- Annual M&E progress reports
- Multiple Indicator Cluster Surveys (MICS)

Model estimates for ‘Optional indicators’ sheet in databook:

- National HIV estimates produced using EPP/Spectrum

Consult the **Optima HIV User Guide Vol. IV - Indicator Guide**

https://docs.google.com/document/d/1AayY5PmIkmt-rwkjawWjg56omDPZ9Igv7qiNB7wifbo/edit#heading=h.kn3gck778icg

Create project and download spreadsheet (databook)

Create projects ⓘ

Choose a demonstration project from our database:

Concentrated (demo) ▼ Add this project

Or create/upload a new project:

Create new project Upload project from file Upload project from spreadsheet

☐	Children	Children	Edit	Copy
☐	Infants	Infants	Edit	Copy
☐	Other males	Males	Edit	Copy
☑	Other females	Females	Edit	Copy
☐	Other males [enter age]	Other males	Edit	Copy
☐	Other females [enter age]	Other females	Edit	Copy

Add population

Create project & download data entry spreadsheet ⓘ

Entering data in the Optima HIV databook

- Demographic, epidemiological and behavioral data is entered in an excel data entry spreadsheet template (Databook)
  - for the total population or by population group*,
  - by year or as an assumption value, and
  - for certain indicators, for the best value, as well as low and high bound values (bound values are optional)

HIV prevalence										
			2000	2001	2002	2003	2004	2005	2006	2007	2008
	FSW	high	5.00%					7.00%			
	FSW	best	3.50%					4.40%			
	FSW	low	2.00%					3.00%			
	Clients	high									
	Clients	best									
	Clients	low									
	MSM	high									
	MSM	best				2.16%		2.65%			3.62%
	MSM	low									

*When entering in the databook - key population size values are subtracted from the general population values to ensure that the total population is the total for that particular setting

Entering data in the Optima HIV databook – only in designated areas of the databook

- In the databook note the following:
  - Do not alter values in columns A (indicator), B (population names), X (“OR”) or Y (Assumption)
  - Extra rows may be added, but do not move existing text and cells shaded in blue
  - New sheets can be added for additional data or calculations

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Percentage of people who die from non-HIV-related causes per year																								
2			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020		Assumption
3		FSW																						OR	1%
4		Clients																						OR	1%
5		MSM																						OR	1%
6		Males 0-9																						OR	1%
7		Females 0-9																						OR	1%
8		Males 10-19																						OR	1%
9		Females 10-19																						OR	1%
10		Males 20-24																						OR	1%
11		Females 20-24																						OR	1%
12		Males 25-49																						OR	1%
13		Females 25-49																						OR	1%
14		Males 50+																						OR	1%
15		Females 50+																						OR	1%
16																									

Partnerships and risk transitions

- Interactions between regular sexual partners:
  - Entered from left column for male populations to their corresponding partners
  - Rows for female populations should be left <u>blank</u>
  - Weighting values relate to each other within population group
  - Cells left blank are interpreted as 0 (i.e. no interaction)

Interactions between regular partners

	FSW	Clients	MSM	Males 0-9	Females 0-9	Males 10-19	Females 10-19	Males 20-24	Females 20-24	Males 25-49	Females 25-49	Males 50+	Females 50+
FSW													
Clients							1		5		5		
MSM			1										
Males 0-9													
Females 0-9													
Males 10-19							5		3		1		
Females 10-19													
Males 20-24							1		5		3		
Females 20-24													
Males 25-49							1		3		5		3
Females 25-49													
Males 50+									1		3		5
Females 50+													

Partnerships and risk transitions

- Risk transitions
  - The average number of years those at risk spend in that risk group before moving back to the general population
  - If only 1 risk population → general population, enter average number of years before transition, e.g., 10 years for clients
  - Risk population transitioning to more than one general population group, use the simple calculation

$$\frac{1}{(1/60 + 1/20)} = 15 \text{ years on average}$$

Risk-related population transitions (average number of years before movement)								
	Males 20-24	Females 20-24	Males 25-49	Females 25-49	Males 50+	Females 50+		Average
FSW		60		20				15
Clients	50		17		50			10

... Testing & treatment | Optional indicators | Cascade | Sexual behavior | Injecting behavior | **Partnerships & transitions** | Constants

Considerations

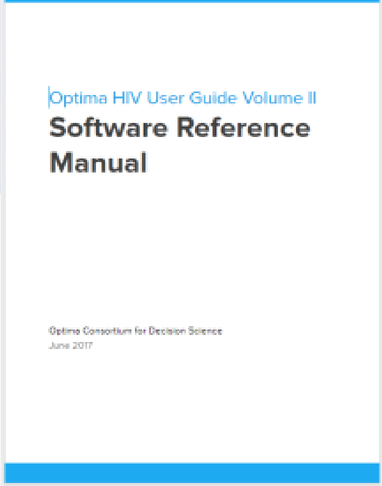
- Data availability (or lack thereof)
  - **Population sizes** for key populations may be difficult to estimate where not reported
    - **Assumptions** may need to be made, for example, estimating the population size for clients of FSW as three-times the pop size of FSW
  - Limited data on sexual and injecting behaviour. IBBS (Integrated Bio-behavioural Surveillance) reports are one possible source for these values.
  - Variation in the reliability of data values must be assessed and handled together with the modelling team on a case-by-case basis as necessary.

Considerations

- Data inconsistencies
  - For example, there may be discrepancies in the number of sexual acts reported by men and by women who are sexual partners

- Data, estimates and assumptions used to inform the model must be carefully reviewed by the country team together with the modelling team.

Support for Optima users on data entry


Optima HIV User Guide Volume II
Software Reference Manual
Optima Consortium for Decision Science
June 2017

- User **training**, including practical exercises
- User guide
- **Indicator guide**: with mapping to UNAIDS GAM and NASA, PEPFAR, and GF indicators
- Data spreadsheets undergo several **reviews** by Optima HIV team together with country M&E team
- Optima HIV (Burnet and WB) **support team** provides online support

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Practice

Review of Optima HIV databook and uploading a completed Optima HIV spreadsheet

QUESTIONS?

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2018 SKILLS BUILDING PROGRAM

BIG DATA, ARTIFICIAL INTELLIGENCE AND DECISION SCIENCE IN HEALTH AND NUTRITION

Optima HIV model calibration

In partnership with

datasciencedojo — data science for everyone

Burnet Institute — Medical Research. Practical Action.

UCL

techemergence

symphony

University of Copenhagen

Machine Intelligence Institute of Africa — Transform Africa through Machine Intelligence

iDSI — Better decisions. Better health.

GHCC — Global Health Cost Consortium

UNDP

Bill & Melinda Gates foundation

Learning objectives

- What is calibration?
- Data sources for calibration
- Steps for calibrating and what to look for in a calibration

What is calibration?

- **Calibration:** *is the process of adjusting the parameters of the model to get the best possible match to all available data*
- Ideally:
  - The model structure would perfectly reflect the real world
  - All data would be self-consistent
  - Uncertainties and biases would be minimal
- In practice:
  - The model makes simplifying assumptions (e.g., population homogeneity)
  - Epidemiological and behavioral data are not consistent
  - Data (especially historical) have large uncertainties and biases

Data sources for calibration

- All data entered can be used for calibration

- In practice, the most reliable data for the model are (in order):
  - Number of people on treatment
  - Prevalence estimates
  - Other cascade data (proportion diagnosed, proportion virally suppressed, etc.)
  - Estimates of new HIV infections, HIV-related deaths, etc. (typically from Spectrum or another model)

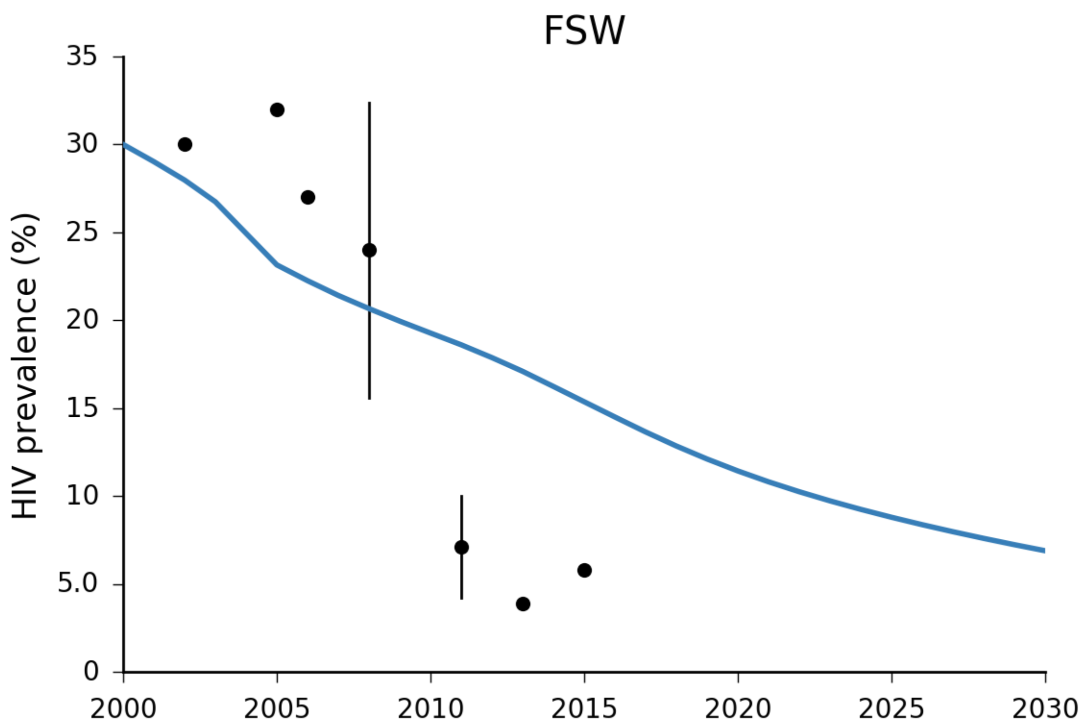
Are the data points consistent?

- Examine trends over time
- Examine all data sources to identify the most reliable source(s) and value(s)
- Consider values across populations who are sexual partners. For example, sexual behaviours (acts, condom use) between FSW and their clients. Are they balanced?
- Consider values as to their contribution to the status of the national epidemic. For example, prevalence for each population multiplied by population size, for an estimate of the total number of PLHIV. Does this seem reasonable?

Does the data make sense?

- Data that come from different sources may not be consistent
- Methodologies, sites, etc. can change from year to year

- For example: **Does this seem realistic?**



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How to calibrate in Optima HIV

1. Run an auto-calibration

2. Adjust using manual calibration as necessary

Most common parameters to adjust, by population group:

- Initial HIV prevalence
- Force of infection (unitless, rule: <10, > 0.01)

Other parameters

- Inhomogeniety (by how much the curve “bends” away from current trajectory or changes over time) (unitless)
- Death rate, failure rate

Calibration is an iterative process to fit the model to the epidemic

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Additional notes for calibration

- When **calibrating** the model, you have the option to pay *more attention to some data points than others*
- Optima will **automatically correct for most data inconsistencies** (e.g. by balancing the number of sexual acts, interpolating missing values for population size)

Practice

Calibrating a model

QUESTIONS?

Overview of steps for Optima HIV modelling

1. Access & resources: login and logout, user guide, demo project instructions, and help
2. Projects: start a new project and define programs
3. Data: create project & download spreadsheet
   a. Enter data in spreadsheet: ensure completeness, model needs *at least one* data *or* assumption value for each population for: population size, prevalence, behaviour, etc.)
4. Upload complete spreadsheet to project
5. Calibration
   a. Automatic calibration
   b. Manual calibration: adjust as necessary
6. Define programs and enter costs and coverage
7. Cost functions
   a. Define cost functions
   b. Define outcome functions
8. Analyses
   a. Scenario
   b. Optimization
9. Analyze results, generate slides and report, disseminate results
10. In future: update the project & regenerate results in consultation with the Optima team

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