WORLD BANK GROUP
Health, Nutrition & Population

2018 SKILLS BUILDING PROGRAM
BIG DATA, ARTIFICIAL INTELLIGENCE AND DECISION SCIENCE IN HEALTH AND NUTRITION

Allocative efficiency analysis and an introduction to Optima TB

In partnership with

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iDSI — Better decisions. Better health.
GHCC — Global Health Cost Consortium
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Types of health system efficiencies

1. **Allocative inefficiency**: not distributing resources to the combination of programs that would yield maximum health impact using available resources
   a. **Pareto inefficiency**: health system could provide additional benefit to one person without disadvantaging another
   b. **Productive inefficiency**: not using an equally effective but lower cost intervention

2. **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)

3. **Dynamic inefficiency**: no incentive to become technologically progressive, i.e. not using or investing in new products, production methods, services and/or service delivery modalities)

4. **'X' inefficiency**: no incentive for managers to maximize output (typically, uncompetitive markets)

What is 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 maximizes health outcomes for a given resource level.

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How do you improve allocative efficiency?

- Mathematical models can be useful tools to identify the efficiencies in resource allocation
  - can address some of the limitations of cost-effective analysis.

- The Optima TB model, is an allocative efficiency tool that can be used to support decision making towards maximizing health outcomes, especially in settings with constrained budget.

Optima TB

What is it?

How does it work?

How will it fit my needs?

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What is Optima TB?

Effective interventions and service delivery

Optima TB 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 **tuberculosis** 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

Using evidence from an **Optima TB** analysis to meet objectives

- What **impact** can be achieved if resources are optimally allocated?

- For example, how many:
  - existing and new TB **infections**
  - TB-related **deaths**

  can be averted?

Common objectives that can be addressed using by Optima TB

1. What will the projected TB epidemic look like under most recent funding?

2. What can be achieved through allocative efficiency gains?

3. What funding amount and allocation will be required to achieve the National Strategic Plan targets?

4. What is the expected future impact of different funding scenarios?

How does Optima TB work?

Optima TB is a model

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

How much further will this plane fly when spending is **optimized**?

Scenario analysis: what if we scaled up the size of wings?

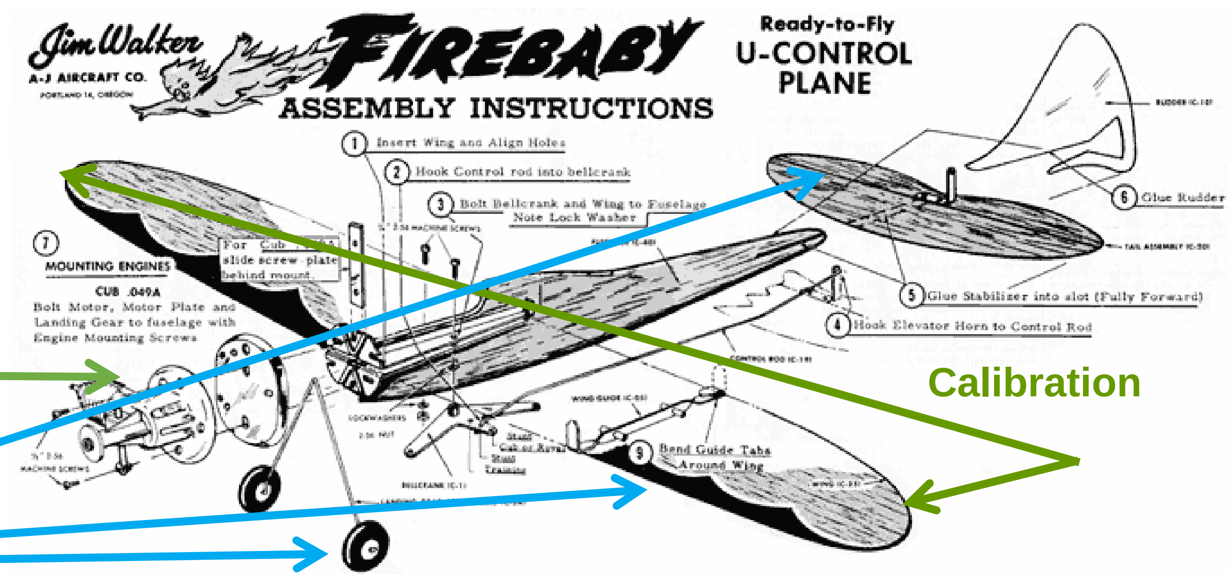
Populations: passenger groups

Programs: piloting, flight service, maintenance, etc.

Spending: part costs

Epidemic model

Optimization of $



Calibration

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Epidemiological component

- Optima TB is a dynamic compartmental population-based model

- The population is divided into compartments based on:
  - age, risk-factors, comorbidities, location, etc.
  - health states (susceptible, infected (active or latent), vaccinated, recovered)

- At each point in time people can move between health states (i.e. model compartments)

- The Optima TB model includes default values related to disease. Default values assume:
  - No testing or treatment
  - No comorbidity

- Within a completed application, the model will be informed using country specific data.

Optima TB terminology

- Susceptible
- Latent TB
  - “Early” latent (infections within the last 5 years)
  - “Late” latent (older infections)
- Smear
  - SP = Smear positive
  - SN = Smear negative
- Strain
  - DS = Drug susceptible (or sensitive)
  - MDR = Multidrug resistant
  - XDR = Extensively drug resistant

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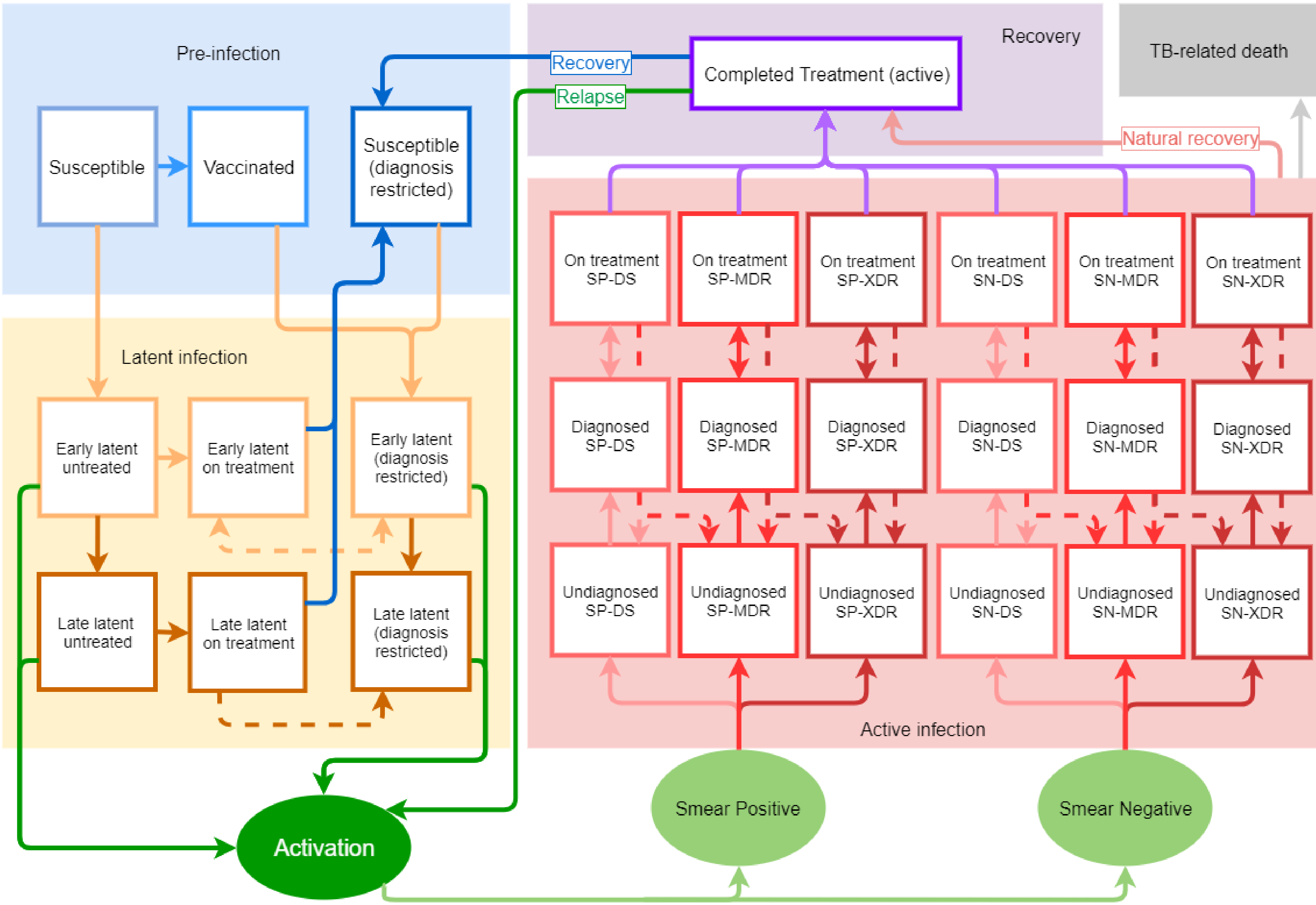
Optima TB terminology

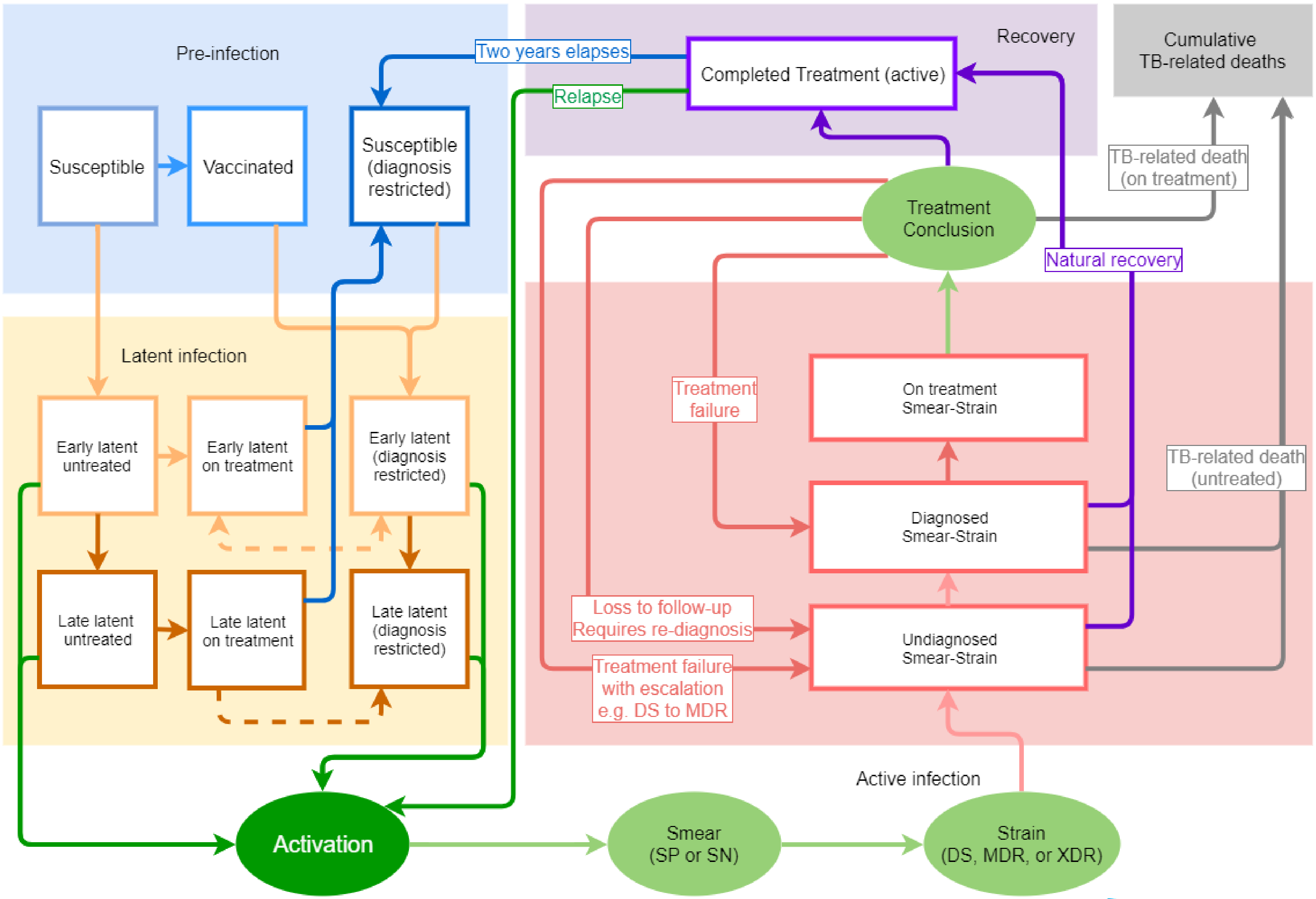
- Compartment
  - Also known as a “stock”
  - Every person in the entire population should be in exactly one compartment at each point in time, e.g. 15-64 year olds with currently undiagnosed SP-DS TB

- Transition
  - Also known as “flow”
  - Every time step in the model, people have a chance to move from one compartment to another through a “transition”
  - Transitions can be based on average durations, probabilities, or proportions

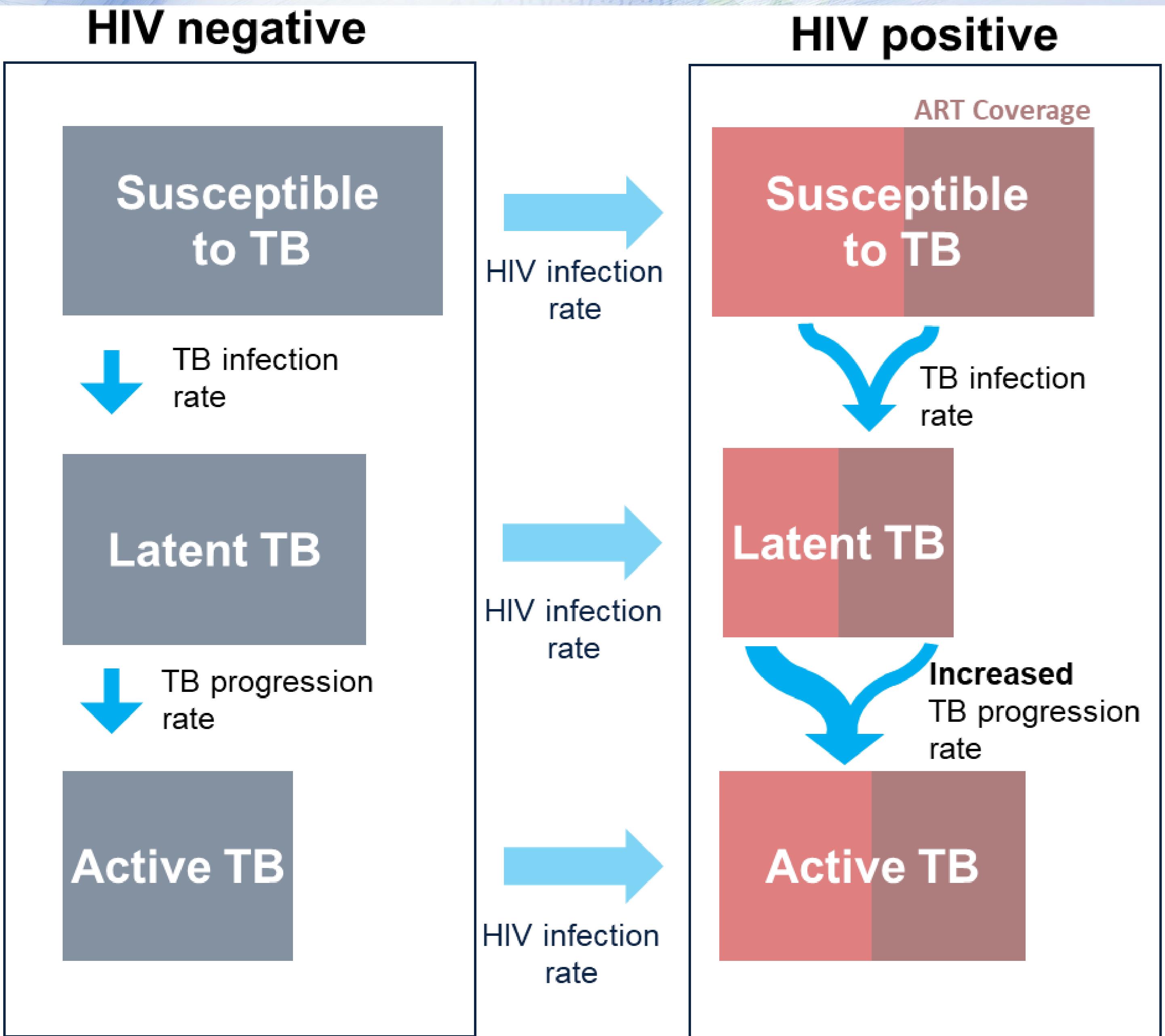
Optima TB disease model



Optima TB disease model with focus on treatment



Handling TB-HIV co-infection in the Optima TB model



Informing the TB epidemic component

Epidemic data is collated in an Optima TB databook (spreadsheet)

- Define populations
  - General populations by age and sex
  - Key populations
  - Coinfections and comorbidities

- Demographic data
  - Population size
  - Birth rate
  - Non-TB-related death rate
  - Transitions between population groups
  - Migration

Population groups, an example
Children aged 0-4 years
Children aged 5-14 years
Adults aged 15-64 years
Adults aged 65 years and older
Prisoners
Coinfected and comorbidities
People living with HIV (PLHIV)
Diabetics

Minimum epidemiological data requirements

- For each population group:
  - TB notifications by:
    - Drug-resistant strain
    - Smear status, if known
  - Number of treatment initiations
  - Treatment outcomes by cohort or year
- If available, estimates for:
  - Active TB prevalence*
  - Active TB incidence
  - Latent TB prevalence
  - TB-related deaths

Minimum data requirement:
3 years of recent annual data including the year program spending available

Example 1: 2010, 2012, 2016 (spending for 2016)

Example 2: 2015, 2016, 2017 (spending for 2017)

* Derived from estimates of incidence and average length of time to treatment initiation

Summary of data entry in the Optima TB databook

- Flexible for including populations of interest
- Requires setting-specific data and/or estimates
- Optima TB model contains disease-specific defaults

The more comprehensive, high-quality the data,
The more representative and informative output

Calibration

The Optima TB model is calibrated to reflect the TB epidemic in a given setting

Why is calibration necessary?

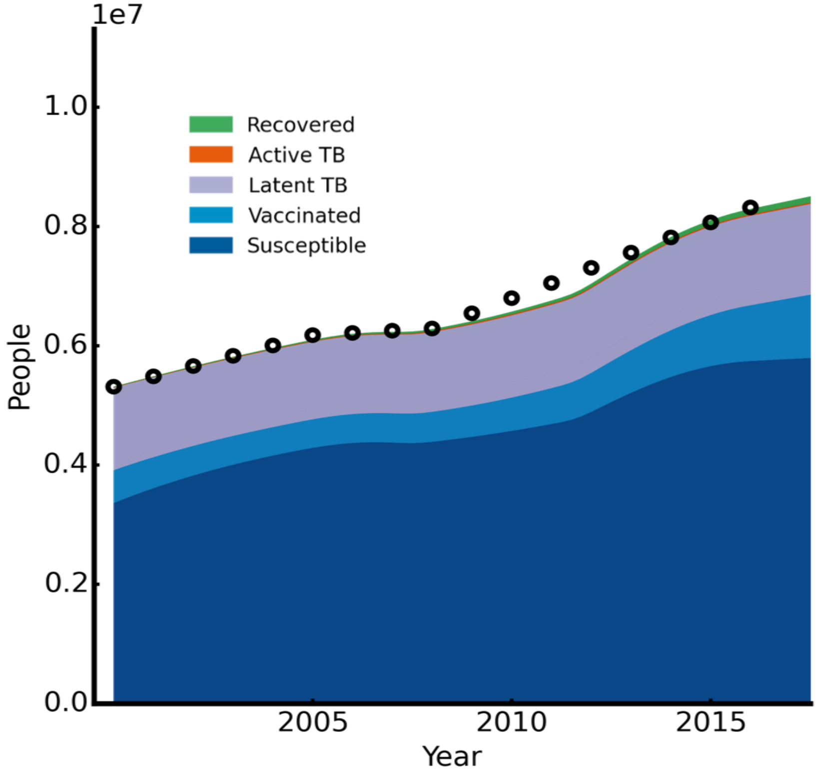
- **Calibration** is the process of adjusting model parameters to best match the observed TB epidemic

- Ideally
  - The model structure would perfectly reflect the real-world epidemic
  - All data and estimates would be consistent and comprehensive
  - Uncertainties and biases would be minimal

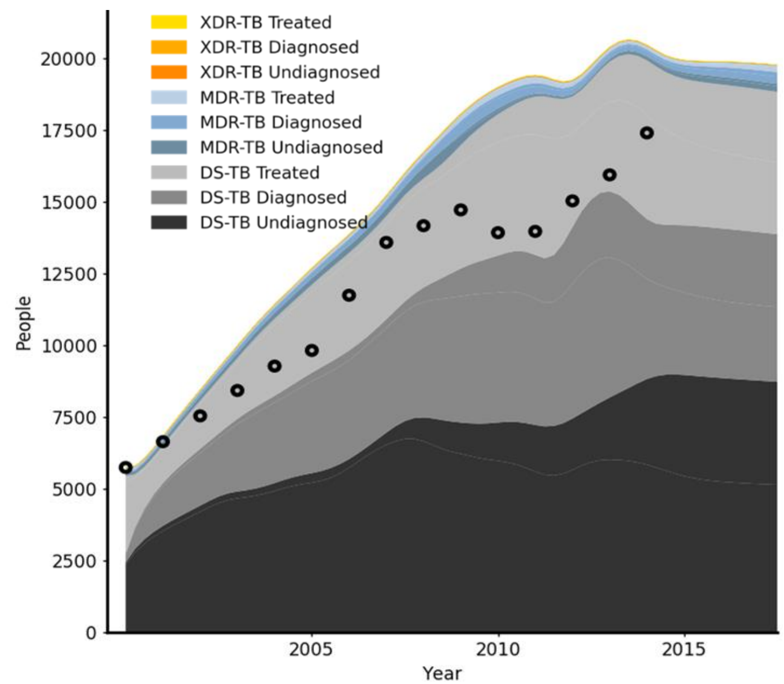
- In practice
  - The model makes simplifying assumptions (e.g., population homogeneity)
  - Epidemiological and behavioral data may not be consistent
  - There are uncertainties (especially for historical data) and biases

Epidemic outputs from the model calibration

Cross-section number of 15-64 HIV- population in each health state



Number of all active-TB (15-64 HIV-) infections by care-status



Why is the model predicting more cases of active TB than the data?

Review of assumptions and default values

Something missing from the model?

- Death rates could be slightly higher for people with TB
  - Adjust SP to SN ratio (higher mortality in SP)
- Latent infection rates could be slightly lower
  - Adjust population vulnerability factor
  - Adjust (other) population infectiousness factor(s)
- Progression from latent to active TB could be slightly lower for long term infections
  - Adjust late latent departure rate
- ...many other options

Which change is appropriate will depend on discussion and consultation – **every change should be justified**

TB program costs and coverage

Overview of TB programs

- Optima TB can accommodate programs that:
  - Directly target TB (i.e. diagnostic, treatment, prevention)
  - Less directly target TB (i.e. behavioral, awareness campaigns)
  - Do not directly target TB, these are included in the budget but not considered within the optimization (i.e. management)

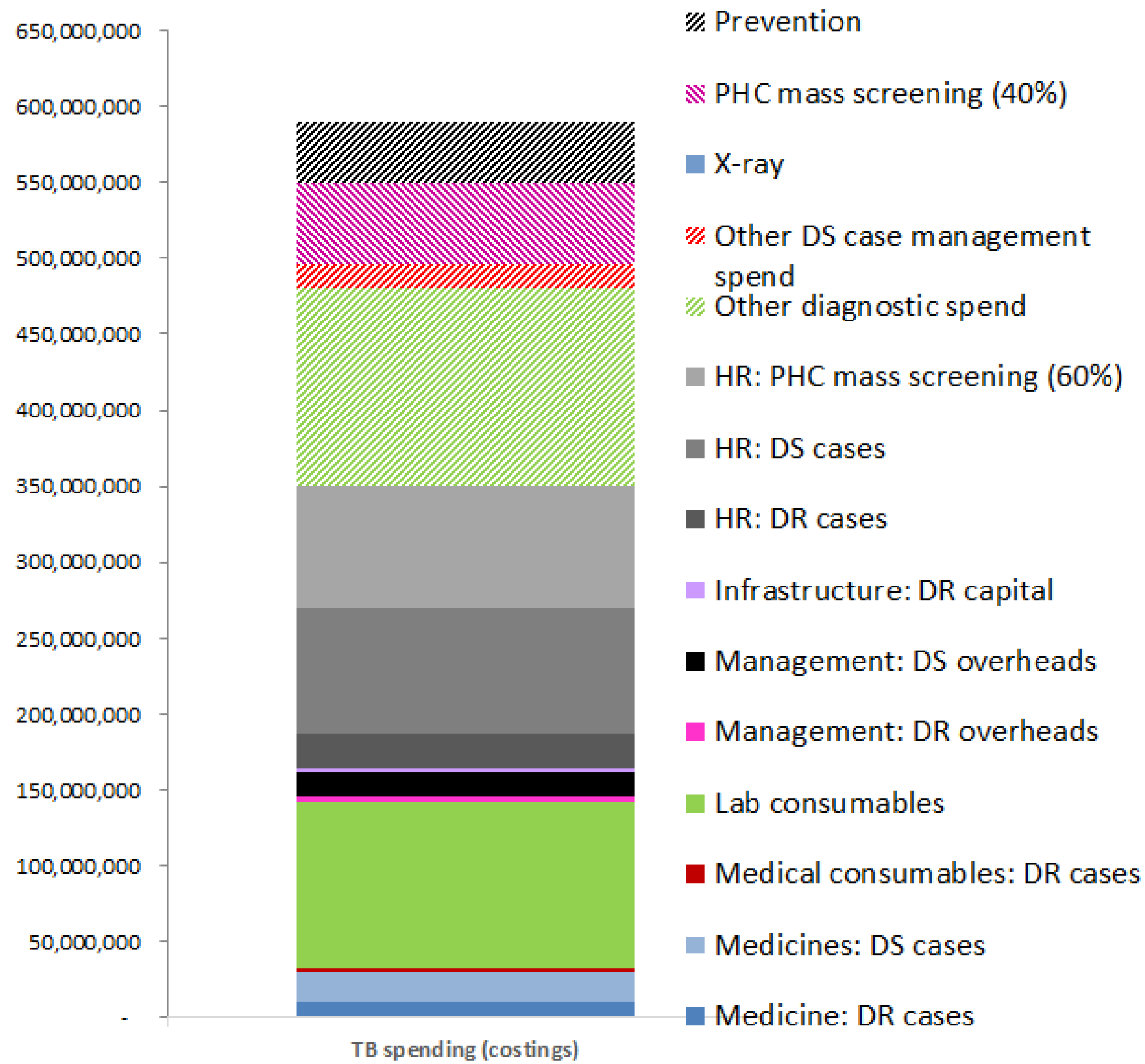
- For each program, the minimum data requirements are:
  - Spending
  - Coverage (number of people reached)
  - Unit cost
  - Capacity constraints

- TB programs not currently implemented, but planned for future implementation can be included in the Optima TB model

TB program spending

- Can be reported directly (top-down costing)
- Alternatively, can be reconstructed from unit costs and program coverage (bottom-up costing)
- Valuable to do both if possible

Example: total TB spending 590 million (2016)

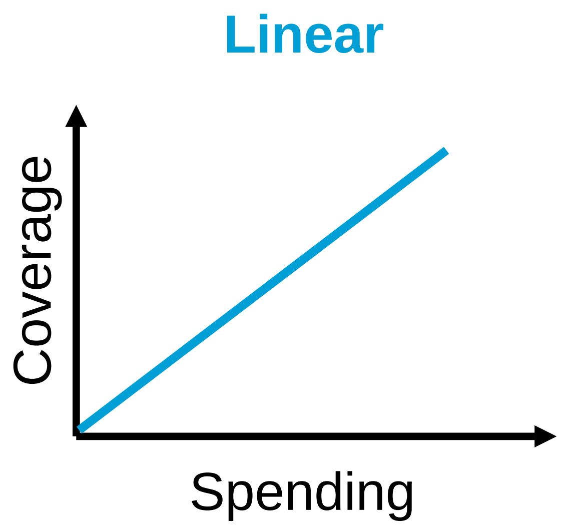


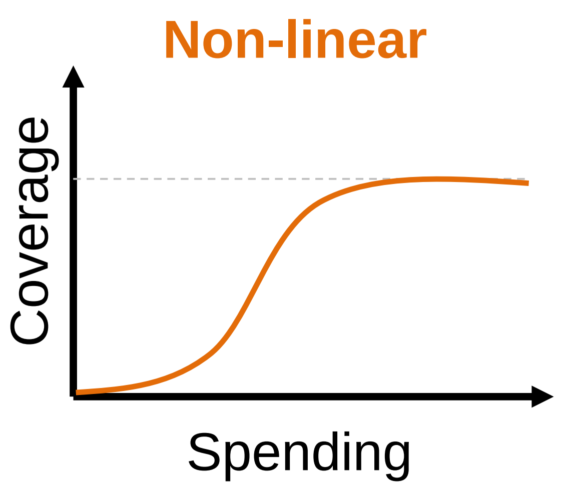
Cost functions

Cost functions relate program costs to population coverage and outcomes.

Cost-coverage curves

- Relates program spending to program coverage
- Cost-coverage curves can be:
  - **Linear**: slope represents a single unit cost, or
  - **Non-linear**: slope represent scale-up, stable implementation, and increasing effort in reaching additional people
- In the absence of data to inform non-linear cost-coverage curves, linear cost-coverage curves are assumed





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Reconciliation

- **Historical values are input directly** for treatment outcomes, number of cases diagnosed, etc
- **Future values are determined by spending** and program effectiveness for each program

- Example
  - Notified diagnoses in 2017 equal to **1000 people** (databook)
  - Program spending in 2017 only enough to **diagnose 800 people** (program book)
  - There is an inconsistency and there will be a sharp jump in the project output
- Reconciliation may require reviewing the databook and program book to determine which is accurate and ensuring they are aligned

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Scenario Analysis

ASKING 'WHAT IF?'

Overview of selected scenarios

- Scenario analysis allows examination of:
  - the epidemiological impact and cost implications of changing coverage levels and/or prevention, diagnosis, and treatment programs or modalities, and
  - the impact of varying budget levels.
- Specifically:
  - Changing rates (i.e. testing and treatment; proportion of MDR cases)
  - Changing coverage, or
  - Changing program budget
- Scenario analysis is **flexible** and can be tailored to address context **specific questions**
- May require: additional information, eg, reduced budget or target coverage level in scenario arm

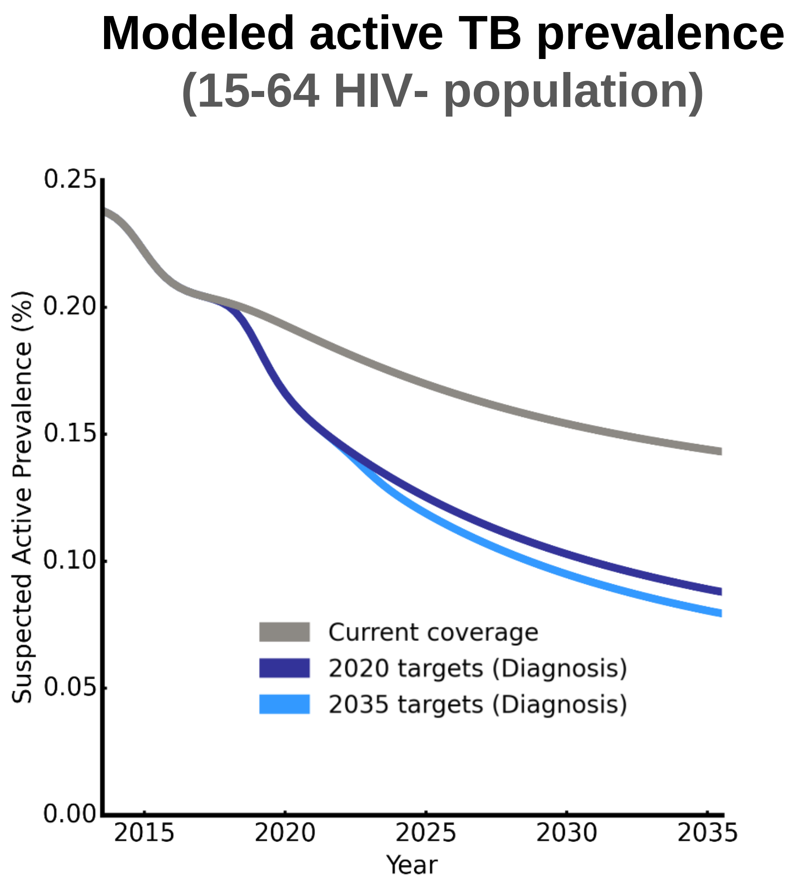
Scenario example: impact of improved testing coverage

What is the projected impact of the TB epidemic if the 2020 and 2035 targets are achieved?

Scenario: Improved testing	Most recent conditions	2020 targets	End TB 2035 targets
Case diagnosis for DS-TB among HIV negative population	67%	90%	95%
Case diagnosis for MDR-TB among HIV negative population	67%	90%	95%
Case diagnosis for XDR-TB among HIV negative population	67%	90%	95%

Scenario example: impact of improved testing coverage

- If testing targets were achieved, it is estimated that there would be a reduction in active TB cases



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Scenario possibilities

- The website offers the most commonly used “budget” scenario where funding allocations for different programs are varied.
- What other scenario questions would you want to explore?

Optimization analysis

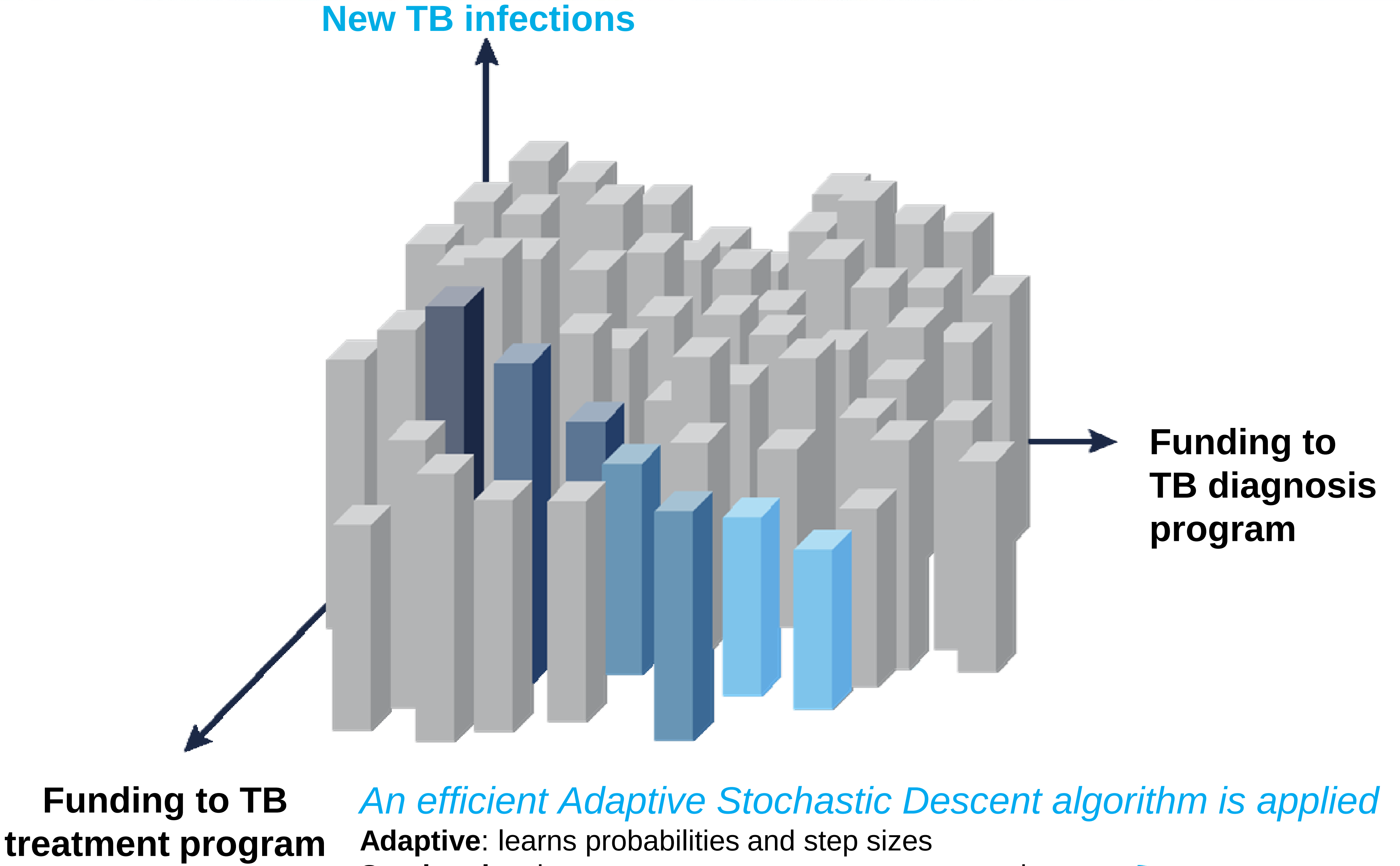
OPTIMIZING RESOURCE ALLOCATION

Optimizing resource allocation: What does it mean?

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

Optimal allocation redistributes budgets to the most efficient, targeted programs

Optimization between just two programs



An efficient Adaptive Stochastic Descent 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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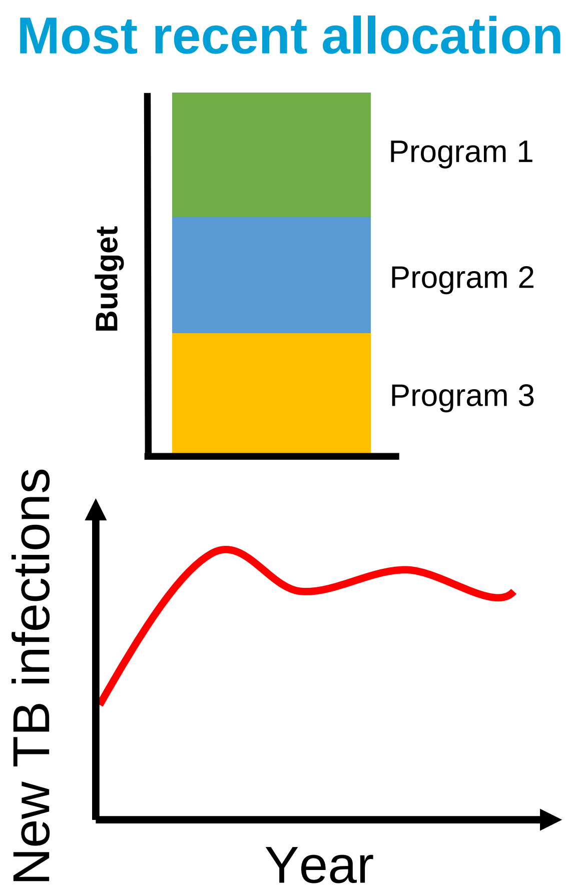
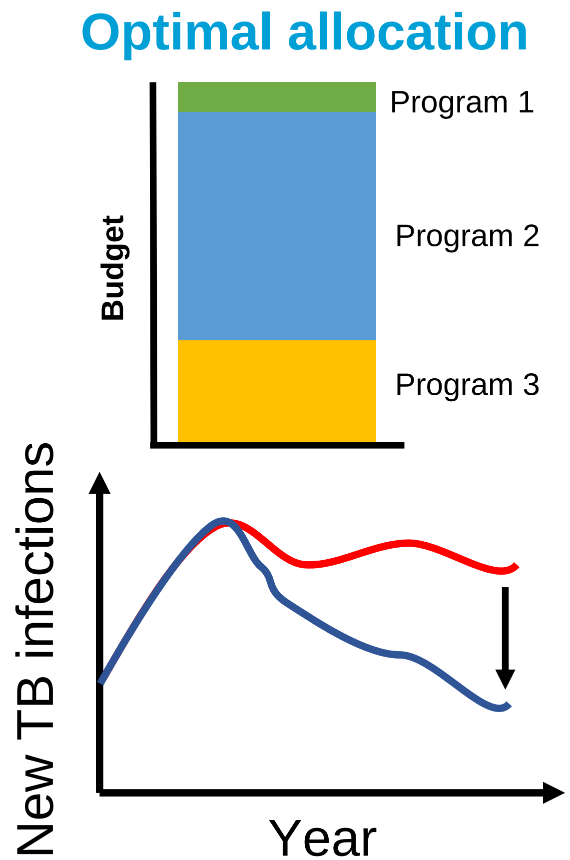
Kerr et al. 2018

Optimizing resource allocation: What does it do?

Optimal allocation redistributes budget to the most cost-effective combination of programs



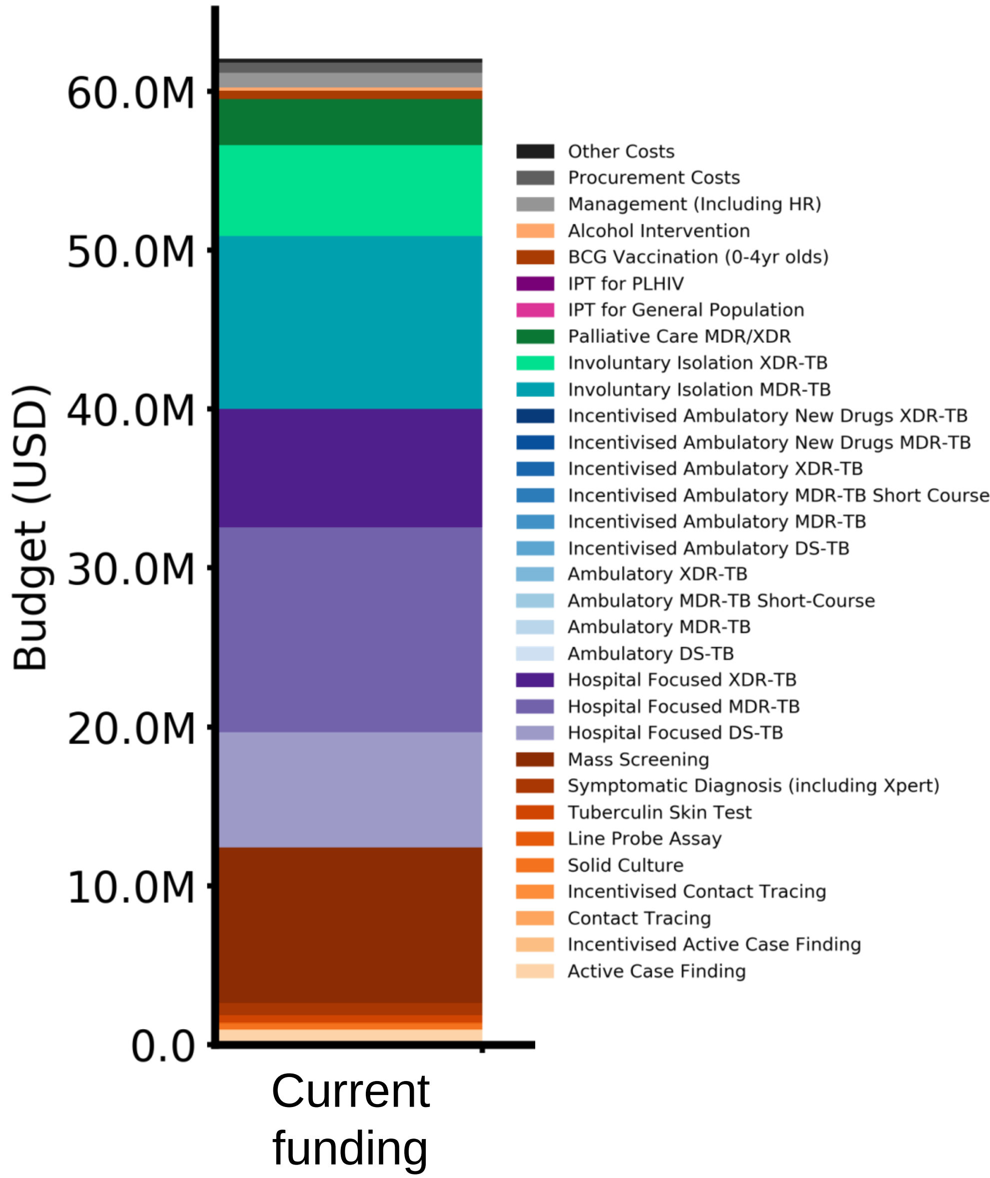


Optimization aims to identify the best combination of investment in programs to minimize new TB infections and/or TB-related deaths

Example from Belarus - Optimizing allocation

- Most recent funding (2015): ~$61M
- Could a different allocation of the 2015 budget:
  - Avert more new infections?
  - Further reduce prevalence?
  - Prevent additional TB deaths?
  - Decrease the number of MDR/XDR cases?
- Movement towards 2020 and 2035 targets

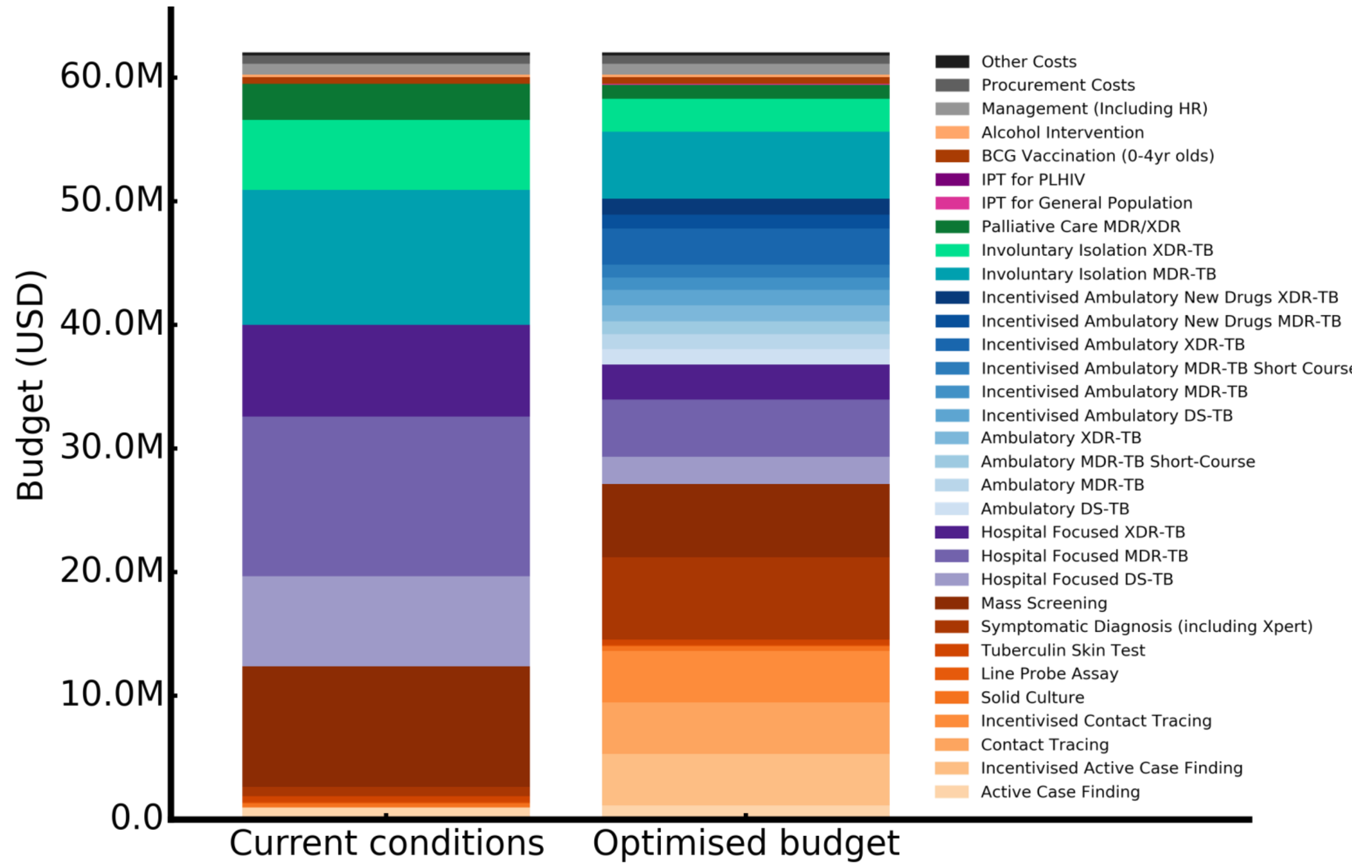
Objective can be to minimize infections or deaths, or both



Example from Belarus - Optimizing allocation

Optimized budget allocation to minimize TB infection and TB-related deaths:

- Doubles the budget for testing programs, with a marked shift towards **active case finding** and **contact tracing** while reducing mass screening
- Shifts funding from hospital-based to **ambulatory treatment modalities**



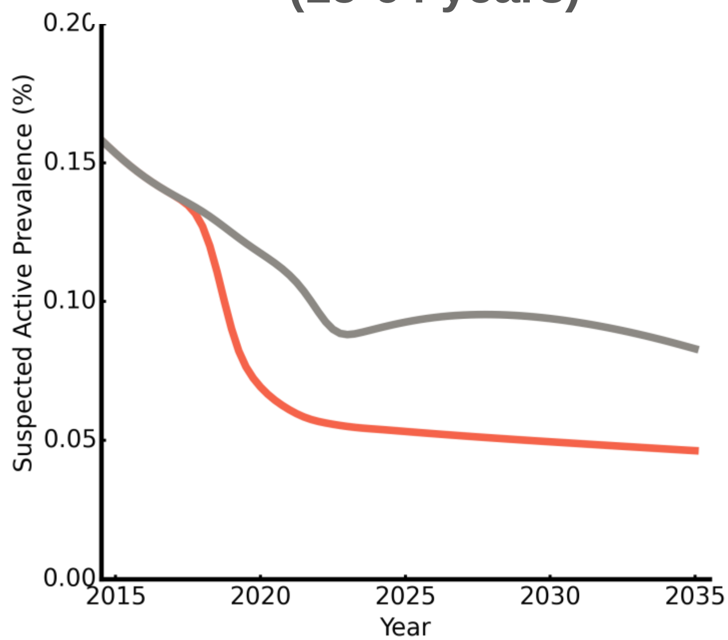
Example from Belarus - impact of optimized budget on the general population

The annual budget is assumed to be constant at $590 million until 2035

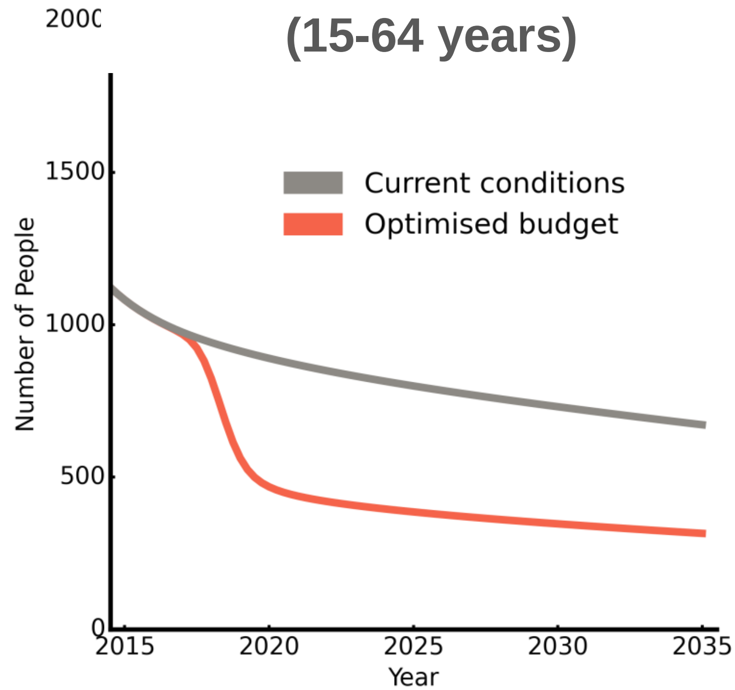
An optimized budget allocation could result in a:

- Relative reduction of adult TB prevalence by 45% in comparison to current funding, to 0.05% of the adult population by 2035
- Reduction of TB-Deaths by 60% relative to the most recent funding allocation, and 70% of 2015 levels, by 2035

Active TB Prevalence (15-64 years)



TB-related death rate (15-64 years)



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How will Optima TB fit my needs?

GROUP DISCUSSION

QUESTIONS?

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