Integrated Health Tool for planning and costing (IHT)

Tuberculosis module

Statistical impact model

Department for HIV, Tuberculosis, Hepatitis and
Sexually Transmitted Infections

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World Health Organization

Integrated Health Tool for planning and costing

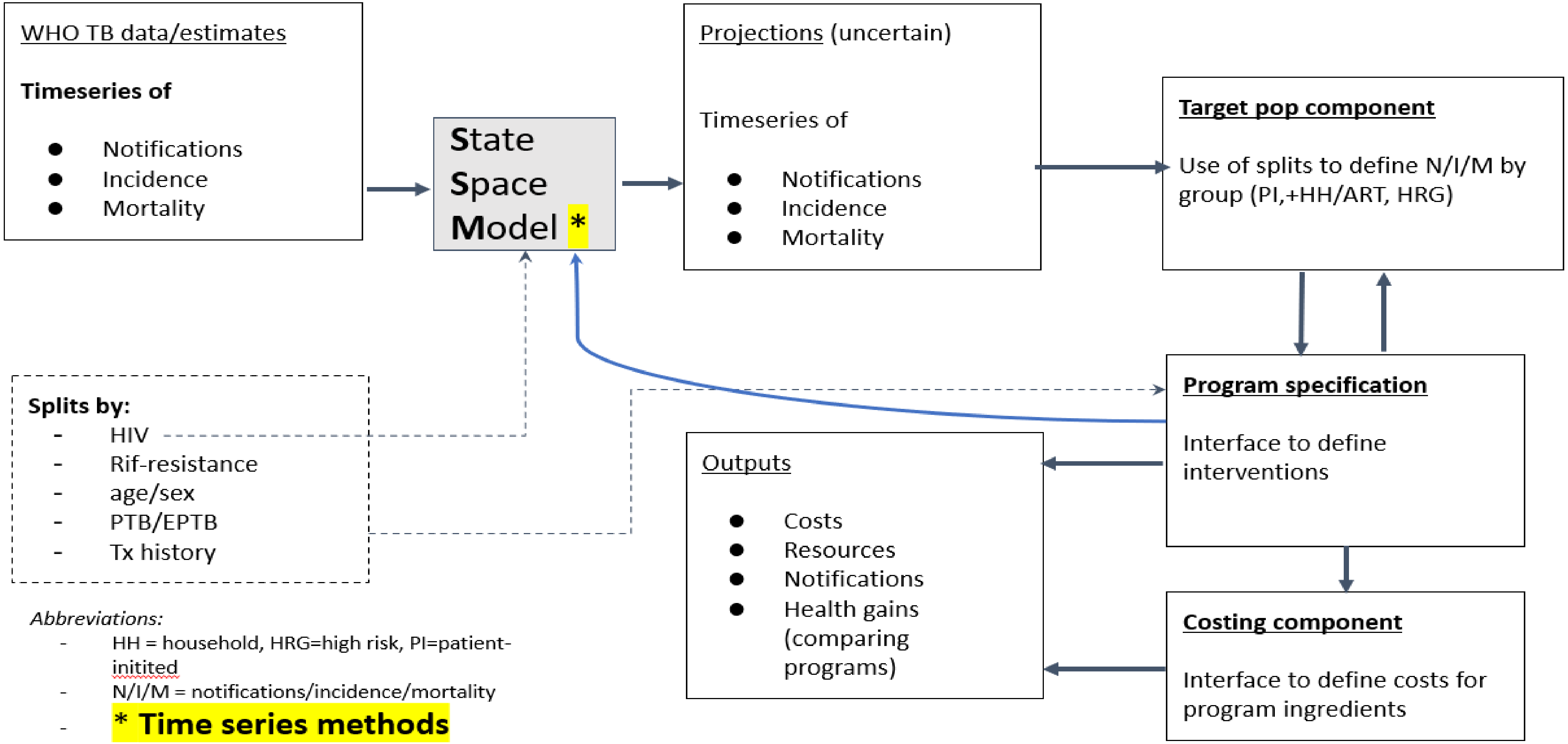
END TB

Outline

1. How the statical model works
2. How impact can be estimated with the statistical model
3. An example of health impact following notification scale-up
4. Discussion and note on exercise materials

1. How the statical model works

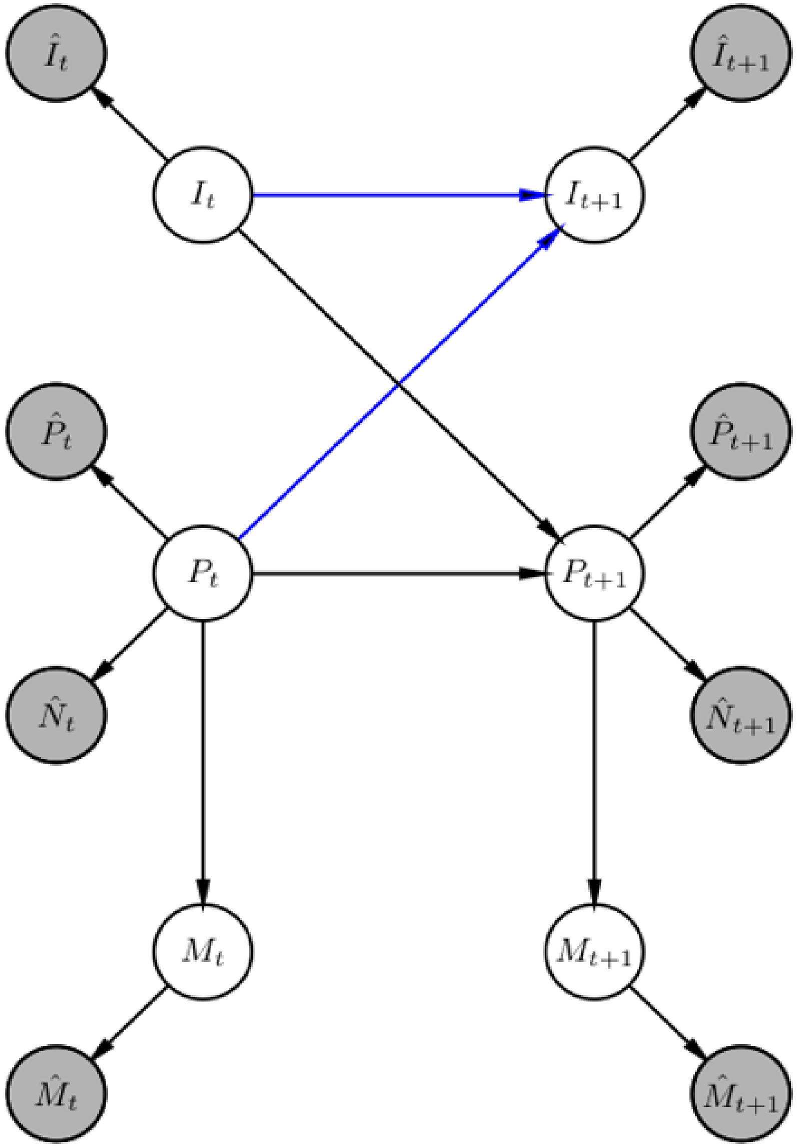
Outline of the statistical model



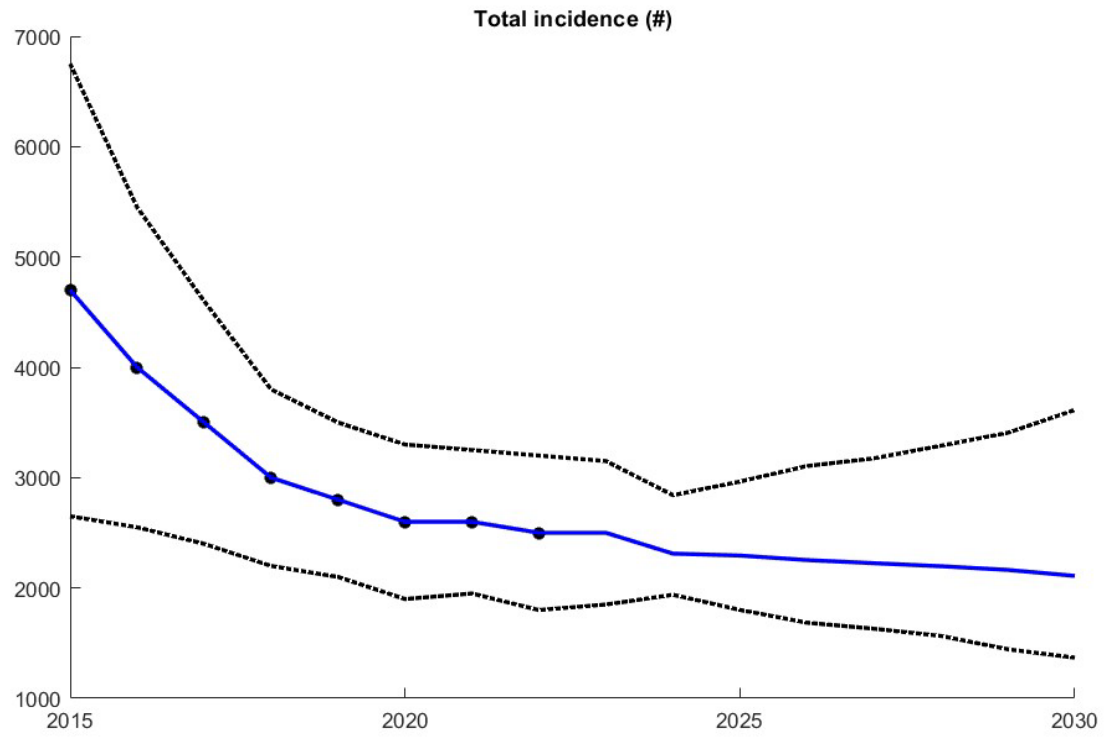
Semi-mechanistic time-series model

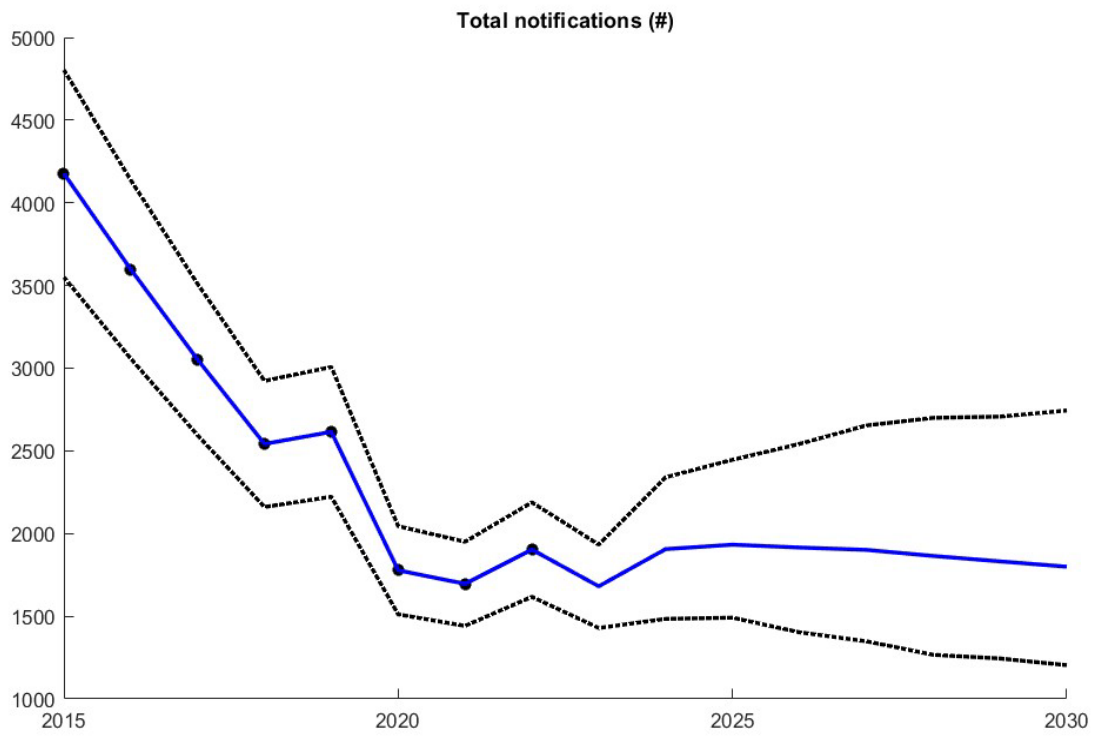
Semi-mechanistic time series

- Model observed quantities (*P, I, N, M*) as ***uncertain*** measurements of underlying variables/states (*P,I,M*) produced by a noisy statistical process
- ***Mechanistic*** model of (*P,M*) given rest
- ***Statistical*** model of *I* (blue)
  - It has a mechanistic interpretation of (P→I) and captures intervention effects stemming from pathways to (I,N)
- ***State space model:*** inference on states



Projection of TB incidence and notifications





2. How impact can be estimated with the statistical model

Estimating impact of a strategy

There are three **impact elements** in the statistical model:

- Increase notifications and probability of being detected
- Decrease the risk of TB disease
- Decrease risk of mortality for those receiving treatment

How to use these in a statistical model which don’t have explicit intervention mechanisms?

Hazard rates of a given scenario: baseline or scale-up

- **Hd**= total number of notifications
  - Impacts notification rate: Prevalence -> Notification
- **Hi**= average degree of protection
  - Impacts risk for TB disease: Susceptible -> Infected
- **Ht**=average treatment success
  - Impacts mortality: Notified -> Mortality/death

Hazard ratios between scenarios: baseline (0) and scale-up (1)

- **HRd=Hd1/ Hd0**,
  - Example with Hd0=10,000, Hd1=20,000
  - HRd =20,000 / 10,000 = 2.00 ->100% increase in N
- **HRi=(1-Hi1)/(1-Hi0)**
  - Example: HRi =(1-10%)/(1-5%) = 94.7% ->5.3% reduction in S->I (i.e. incidence)
- **HRt=(1-Ht1)/(1-Ht0)**
  - Example: HRt =(1-90%)/(1-84%) = 62.5% ->37.5% decrease in N->M (i.e. TB mortality)

Hazard ratios between scenarios: baseline (0) and scale-up (1)

Impact is derived directly from these three impact ratios which are calculated from the Target Population elements between a baseline and a scale-up scenario/file. Note that while the impact estimation process is maximally simplified, the user still plays a critical role in producing reliable impact estimates.

For example, the user must ensure that coverage levels in the baseline and scale-up are compatible with the impact produced. To get reliable impact:

- Baseline coverage is constant
- Baseline coverage <= scale-up coverage, generally matching only in the base year of analysis
- Baseline Notification < Scale-up Notification,
- The algorithms between baseline and scale-up scenarios should match – this alignment process is outlined in the exercise.

3. An example of health impact following notification scale-up

From configured projections to hazard rates

Each configured projection/scenario has a set of hazard rates that are calculated as part of running/calculating Target Population component:

- **The total number notified (Hd)**
  - Uses the **Total Notification i**nput which is based on inputs that the determine the probability of being screened, i.e. the screening algorithms for the various patient groups in patient or provider-initiated programs.
  - Inputs that determine the probability of being diagnosed (sensitivity).
  - Early detection is implicitly handled via systematic screening programs.
  - Upfront DST can also be quantified from the TP component. More relevant to dynamical model where it can be used explicitly for MDR impact.
  - In patient and provider-initiated programs

From configured models to hazard rates

- **Reduction in population-level risk for TB disease (adjusted for higher risk in population groups receiving TPT) (Hi)**
  - Inputs that expand the TPT eligible pool, including increased screening
  - In provider-initiated programs only
  - Inputs to expand TPT initiation among those eligible including TPT coverage (presumptive or following testing) and linkage to preventive treatment.
  - For those receiving TPT we assume 70% protection against disease for those receiving TPT.
- **Treatment success rate for new and relapse cases. (Ht)**
  - This is a direct user input which implicitly depends on factors that reduce LTFU, like DST and appropriate and timely treatment.
  - Also depends on adherence mechanisms and appropriate treatment monitoring elements.

From Hazard Rates to Hazard Ratios

- **Baseline/counterfactual scenario**
  - Any impact analysis needs a counterfactual to which outcomes are compared for impact, i.e. relative to which impact is measured.
  - Prepare the **Baseline scenario** and go to [**6. Results**] to run the model.
  - Three hazards will be calculated: Hd0, Hi0 and Ht0.
- **Scale-up scenario (or Current scenario in the editor)**
  - Continuing from a prepared **Baseline scenario**, set notification targets and scale-up various interventions according to NSP objectives.
  - Three hazards will be calculated: Hd1, Hi1 and Ht1
- **Each scenario uses its referenced counterfactual to calculate three Hazard Ratios:**
  - **HRd=Hd1/ Hd0, HRi=(1-Hi1)/(1-Hi0), HRt=(1-Ht1)/(1-Ht0)** which are sent to the Statistical or Dynamical model to estimate impact for the current scenario

Flow of impact information

1	**Baseline or counterfactual scenario**	**Scale-up or current scenario**
2	Base year intervention configuration. **No intervention(s) scale-up** for all years.	Base year intervention configuration. **Scale-up intervention(s) to reach NSP targets** in final year.
3 **copy:** **calc:**	**Impact Editor** Counterfactual hazards: Hd0, Hi0 and Ht0 Scenario hazards: Hd0, Hi0 and Ht0	**Impact Editor** Counterfactual hazards: Hd0, Hi0 and Ht0 Scenario hazards: Hd1, Hi1 and Ht1
4	**Hazard Ratios** HRd=Hd0/Hd0=1 HRi=(1-Hi0)/(1-Hi0)=1 HRt=(1-Hto)/(1-Ht0)=1	**Hazard Ratios** HRd=Hd1/Hd0=increased detection HRi=(1-Hi1)/(1-Hi0)=increased protection HRt=(1-Ht1)/(1-Ht0)=improved outcomes
5	Statistical or Dynamical model adjustment No impact	Statistical or Dynamical model adjustment NSP impact
***calc**	**requires [6. Results to be run]**	This triggers a model run and a Hazard Rate calc

Make a copy of baseline hazards (1/2)

Hazards in the bottom section are calculated. Hazards in the top section are copies for reference in the calculation of impact ratios (slide 10). **We put the calculated baseline hazards in the top section.**

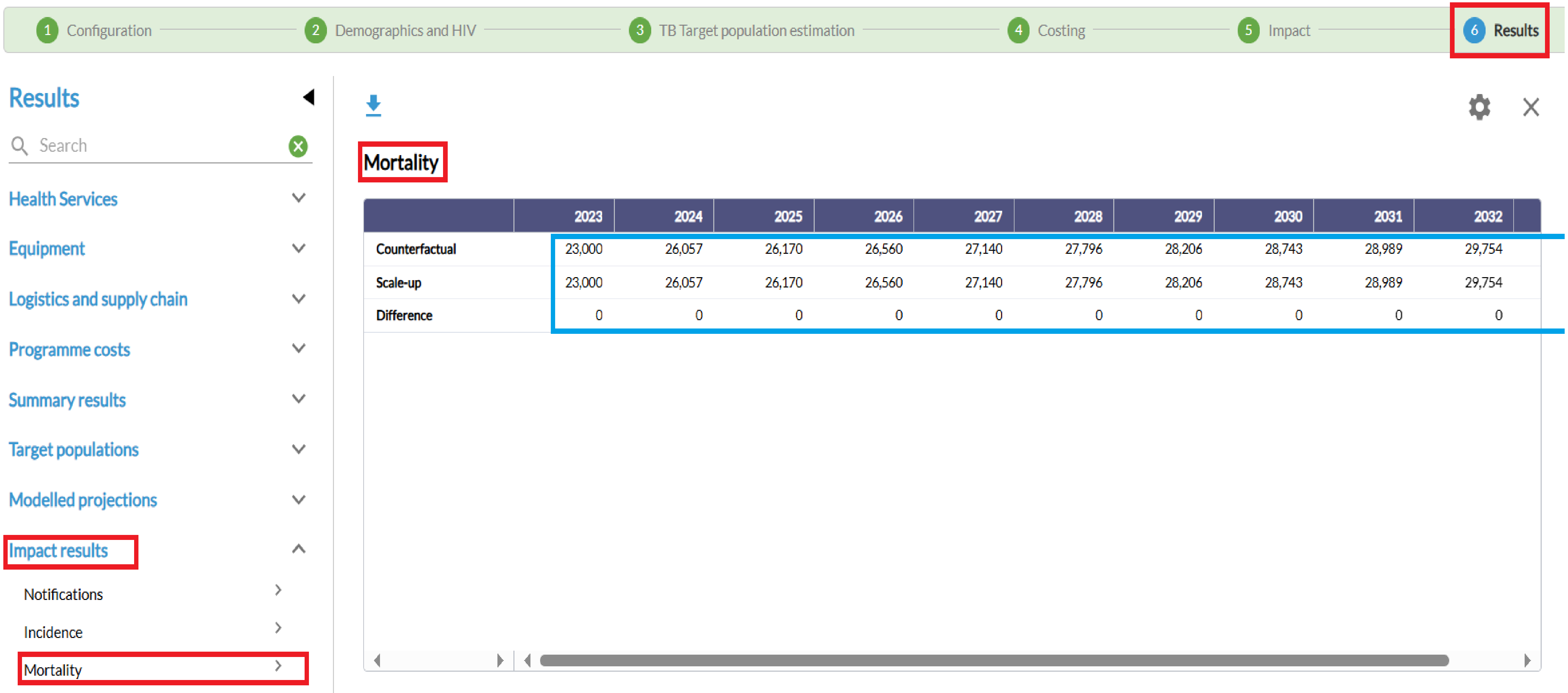
1 Configuration — 2 Demographics and HIV — 3 TB Target population estimation — 4 Costing — 5 **Impact**

Impact ratios

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Counterfactual (Baseline)										
Total cases notified (#)	97,126	95,894	98,033	100,246	102,050	104,414	106,402	107,448	109,772	110,51
Reduction in population-level risk for TB disease (adjusted for higher risk in population groups receiving TPT) (%)	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6
Treatment success rate for new and relapse cases (%)	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0
Current scenario (Scale-up)										
Total cases notified (#)	97,126	95,894	98,033	100,246	102,050	104,414	106,402	107,448	109,772	110,51
Reduction in population-level risk for TB disease (adjusted for higher risk in population groups receiving TPT) (%)	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6
Treatment success rate for new and relapse cases (%)	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0

Make a copy of baseline hazards (2/2)

Go to 6) Results/Impact. Impact for the baseline file should be 0 since the hazard ratios are all 1.



Mortality

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Counterfactual	23,000	26,057	26,170	26,560	27,140	27,796	28,206	28,743	28,989	29,754
Scale-up	23,000	26,057	26,170	26,560	27,140	27,796	28,206	28,743	28,989	29,754
Difference	0	0	0	0	0	0	0	0	0	0

Make a copy of baseline file and do Scale-up (1/3)

This example scenario file has an increased notification target. Here, we doubled estimated baseline notifications in 2027

1 Configuration — 2 Demographics and HIV — 3 **TB Target population estimation** — 4 Costing — 5 Impact

Notification projections

Patient-initiated programs

Provider-initiated programs

Household contacts

PLHIV on ART

High risk groups

Resistance testing and treatment

Prevention of TB infection

Vaccination

Target populations

Projection of total TB notifications | Define TB case type split/distribution

Total cases notification (all forms: new, relapse and retreatment)

Reported notifications

	2023
Reported	97,126

Projected notifications - Baseline

	2023	2024	2025	2026	2027	2028	2029	2030
Baseline	97,126	95,894	98,033	100,246	102,050	104,414	106,402	107,[illegible]

Projected notifications - Target

	2023	2024	2025	2026	2027	2028	2029	2030
Number notified	97,126	123,870	150,613	177,357	204,100	204,100	204,100	204,[illegible]
Proportion notified*	76.3%	91.5%	99.0%	99.0%	99.0%	99.0%	99.0%	99[illegible]

Note: Projection of total TB notifications: all forms from patient and provider initiated programs. *Proportion of estimated TB incidence

Make a copy of baseline file and do Scale-up (2/3)

This will generate an increase in the detection hazard of the scale-up scenario

1 Configuration — 2 Demographics and HIV — 3 TB Target population estimation — 4 Costing — 5 Impact

Impact ratios

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Counterfactual (Baseline)										
Total cases notified (#)	97,126	95,894	98,033	100,246	102,050	104,414	106,402	107,448	109,772	110,51
Reduction in population-level risk for TB disease (adjusted for higher risk in population groups receiving TPT) (%)	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6%
Treatment success rate for new and relapse cases (%)	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%	84.0%
Current scenario (Scale-up)										
Total cases notified (#)	97,126	123,870	150,613	177,357	204,100	204,100	204,100	204,100	204,100	204,10
Reduction in population-level risk for TB disease (adjusted for higher risk in population groups receiving TPT) (%)	0.7%	1.0%	1.4%	1.8%	2.3%	2.3%	2.2%	2.2%	2.1%	2.1%
Treatment success rate for new and relapse cases (%)	84.0%	85.5%	87.0%	88.5%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%

Make a copy of baseline file and do Scale-up (3/3)

Which will generate impact on TB indicators, which can be displayed in a table or a graph

1 Configuration — 2 Demographics and HIV — 3 TB Target population estimation — 4 Costing — 5 Impact — 6 Results

Results

Search

- Health Services
- Equipment
- Logistics and supply chain
- Programme costs
- Summary results
- Target populations
- Modelled projections
- Impact results
  - Notifications
  - Incidence
  - Mortality

Mortality

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Counterfactual	23,000	26,057	26,170	26,560	27,140	27,796	28,206	28,743	28,989	29,754
Scale-up	23,000	25,576	25,568	23,985	21,883	20,161	18,248	17,134	16,288	15,730
Difference	0	481	603	2,575	5,257	7,635	9,958	11,608	12,701	14,024

4. Discussion and exercise

Discussion

- Impact is derived from the comparison of hazards between a scale-up and baseline scenario
  - Ratio of notifications: HRd = Hd1 / Hd0
  - Ratio of average probability of being protected against TB disease: HRi = (1-Hi1) / (1-Hi0)
  - Ratio of average treatment success: HRt = (1-Ht1) / (1-Ht0)

- It is critical to ensure that there is a sensible relationship between the baseline and scale-up scenario:

  - They should be identical in all respects except for the scale-up of interventions according to the objectives of a strategy.

- The dynamical model, discussed on Topic 12 provides a comparator for impact using the statistical model.

Note for exercise material section 4

- Follow the demonstration of:
  - Preparing the Baseline projection.
    - **This projection must represent base year coverage and continued constant coverage after that.**
  - Running the model and making a copy of its Hazard rates in counterfactual section of the baseline file in the Impact editor
  - Making a copy of the Baseline file to create a Scale-up scenario
    - **Scale-up agrees with Baseline in base year, with scale-up to NSP targets thereafter.**
  - Copy the Hazard rates of the baseline projection to the counterfactual section of the scale-up projection
- Create impact in the Scale-up file by increasing:
  - Total notification
  - TB prevention in provider-initiated populations
  - Treatment success in the Impact editor, noting that this input is not explicitly captured in the care cascade, but is assumed to be implicitly captured by increasing DST and appropriate and timely regimen allocation