The University Of Sheffield.

Universal Health Coverage and Tuberculosis modelling: Taiwan

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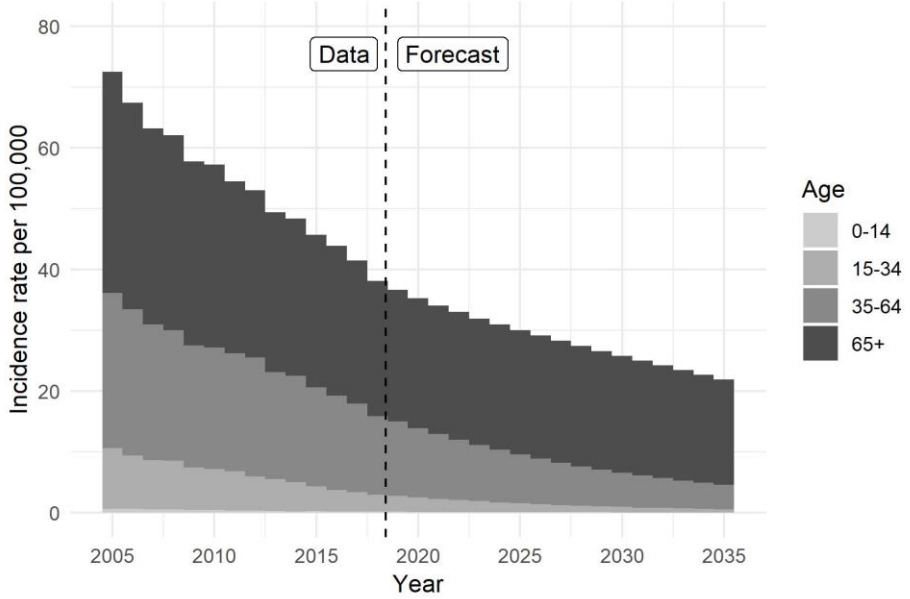
Taiwan

- Western Pacific region
- Population: 23 million
- GDP per capita: 25k USD

Epidemiology of Tuberculosis

Annual incidence
39 per 100,000

EPTB < 5%
MDR ≈ 1%
TB with HIV ≈ 1%



Aged 65 and over
- > 55% in 2018
- > 75% in 2035

Ku and Dodd, 2019

Taiwan

- Western Pacific region
- Population: 23 million
- GDP per capita: 25k USD

National Health Insurance

Full UHC + PPM

From 1995

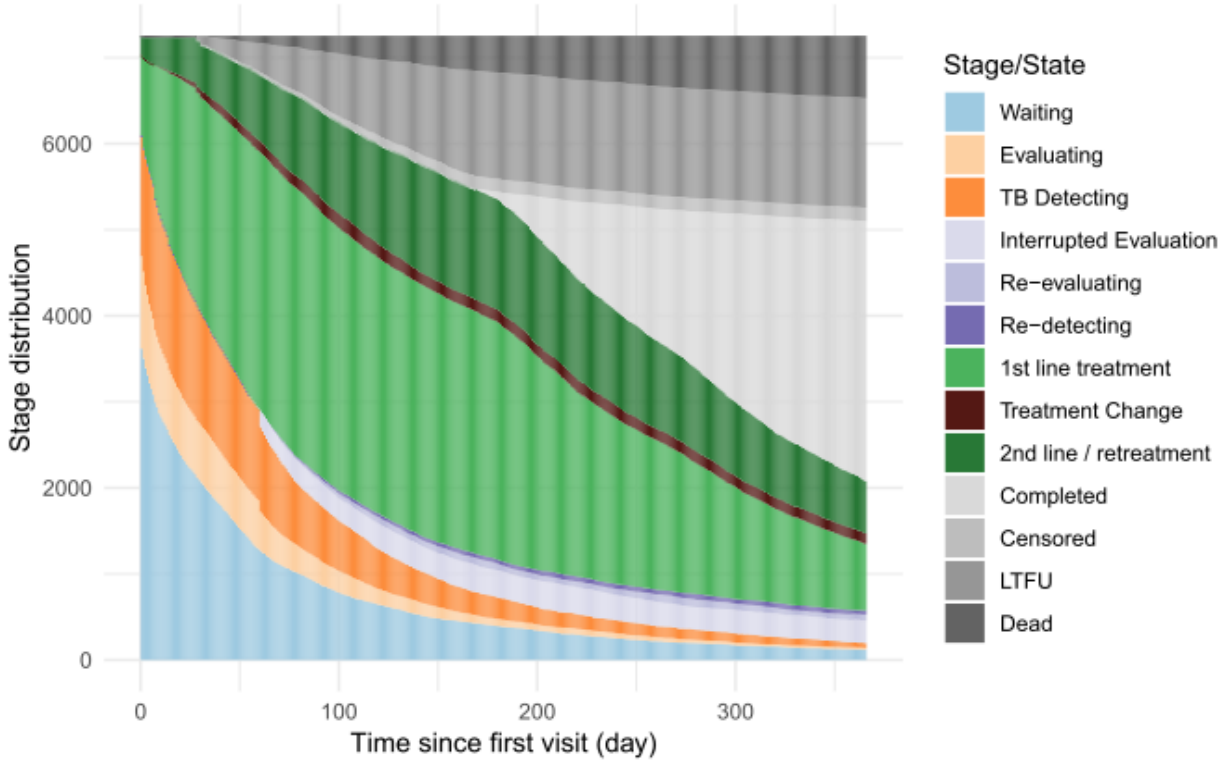
Coverage > 99%

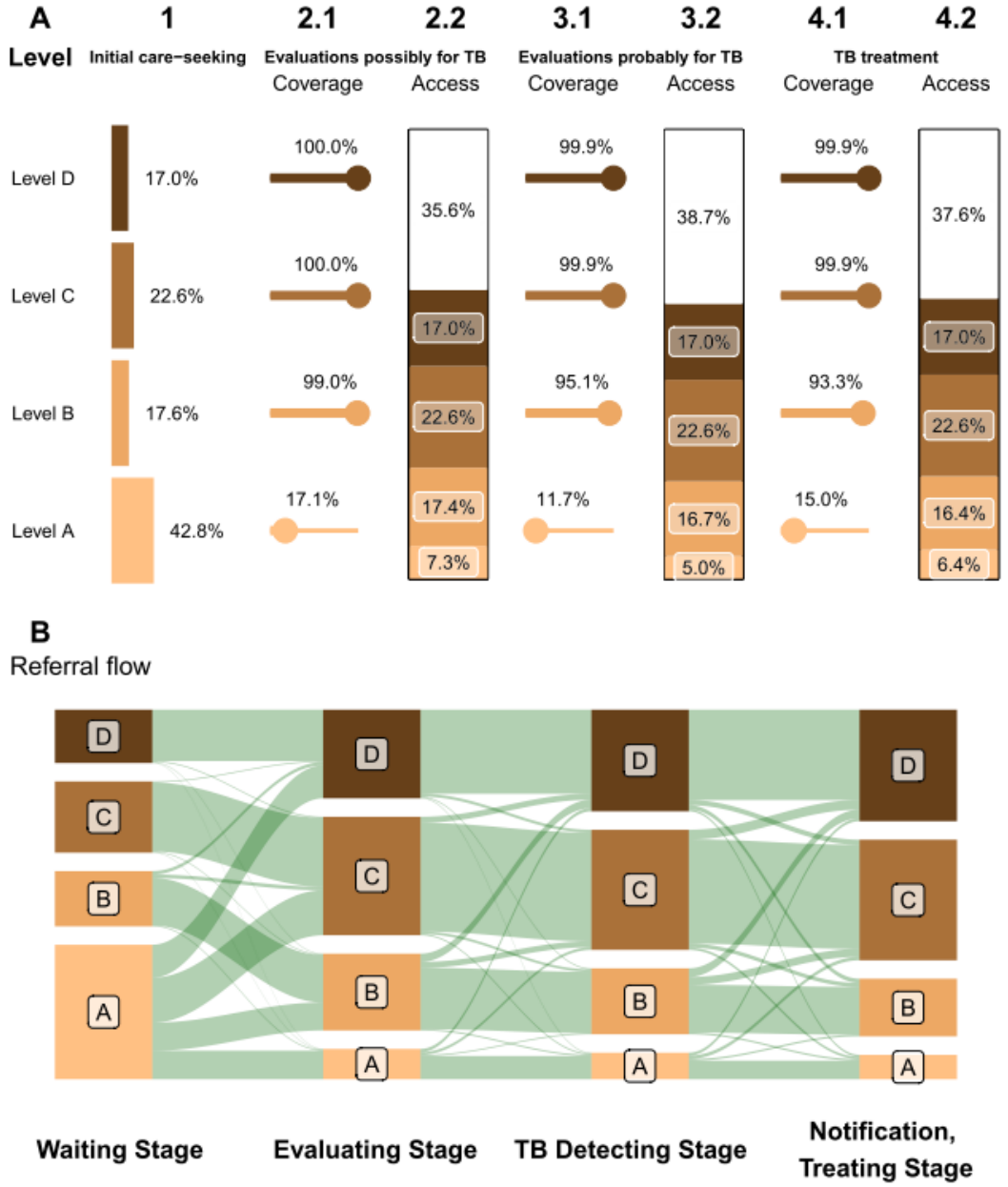
Public + Private healthcare

Healthcare utilisation data for research purpose

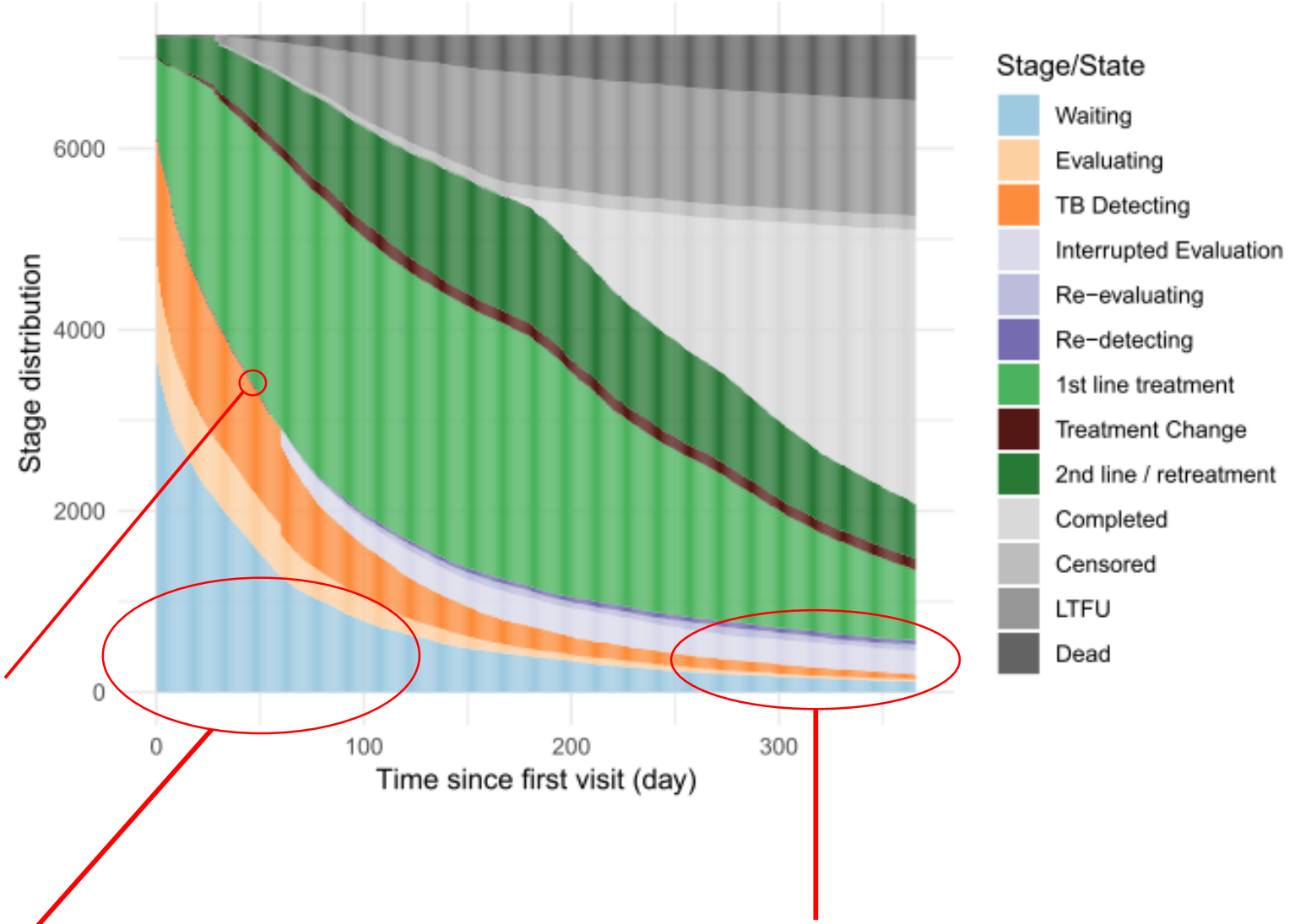
- Patient info.
- Hospital info.
- Healthcare visits
- Medication use

Individual Patient Pathway Analysis





IPPA
Finding 1



Median System Delay: 41 days

Healthcare visit without TB medication

A fat-tail by interrupted evaluation

IPPA
Finding 2

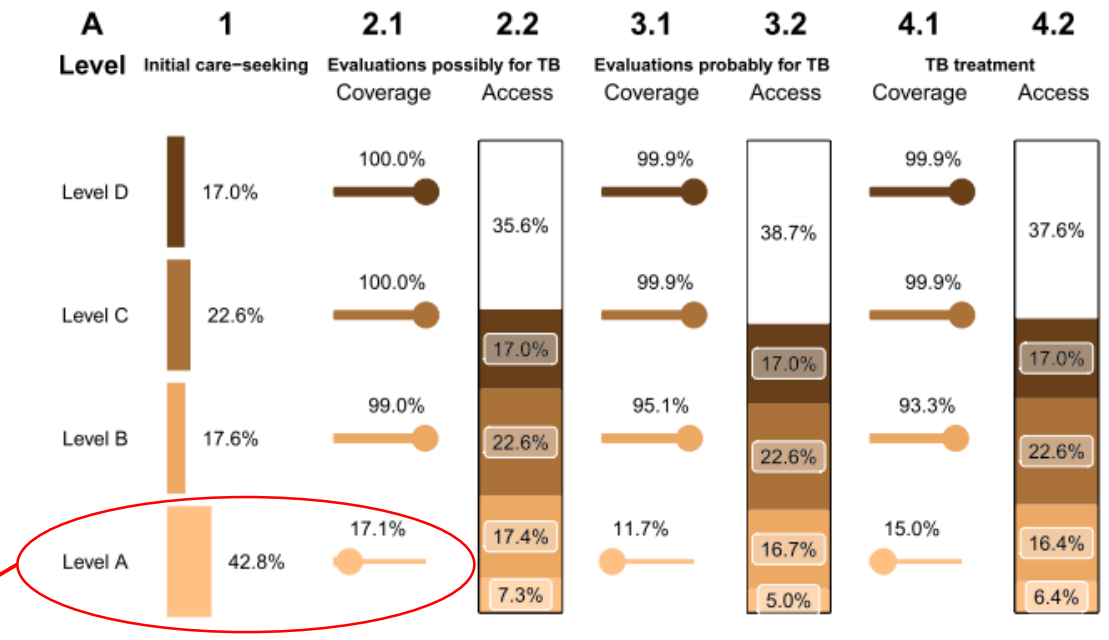
Hospital level

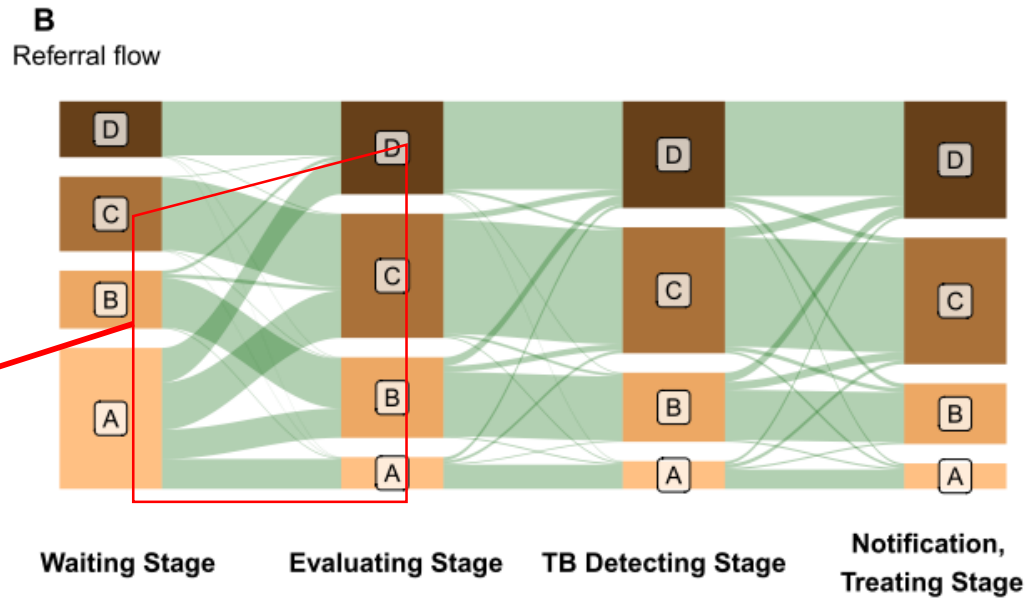
D: medical centre

C: district level

B: regional level

A: GP, clinics





Pathways started with Level A, but some of those hospitals cannot provide TB diagnostics

Then, some Level A patients went to higher levels and started TB evaluation and treatment

From evidence to modelling

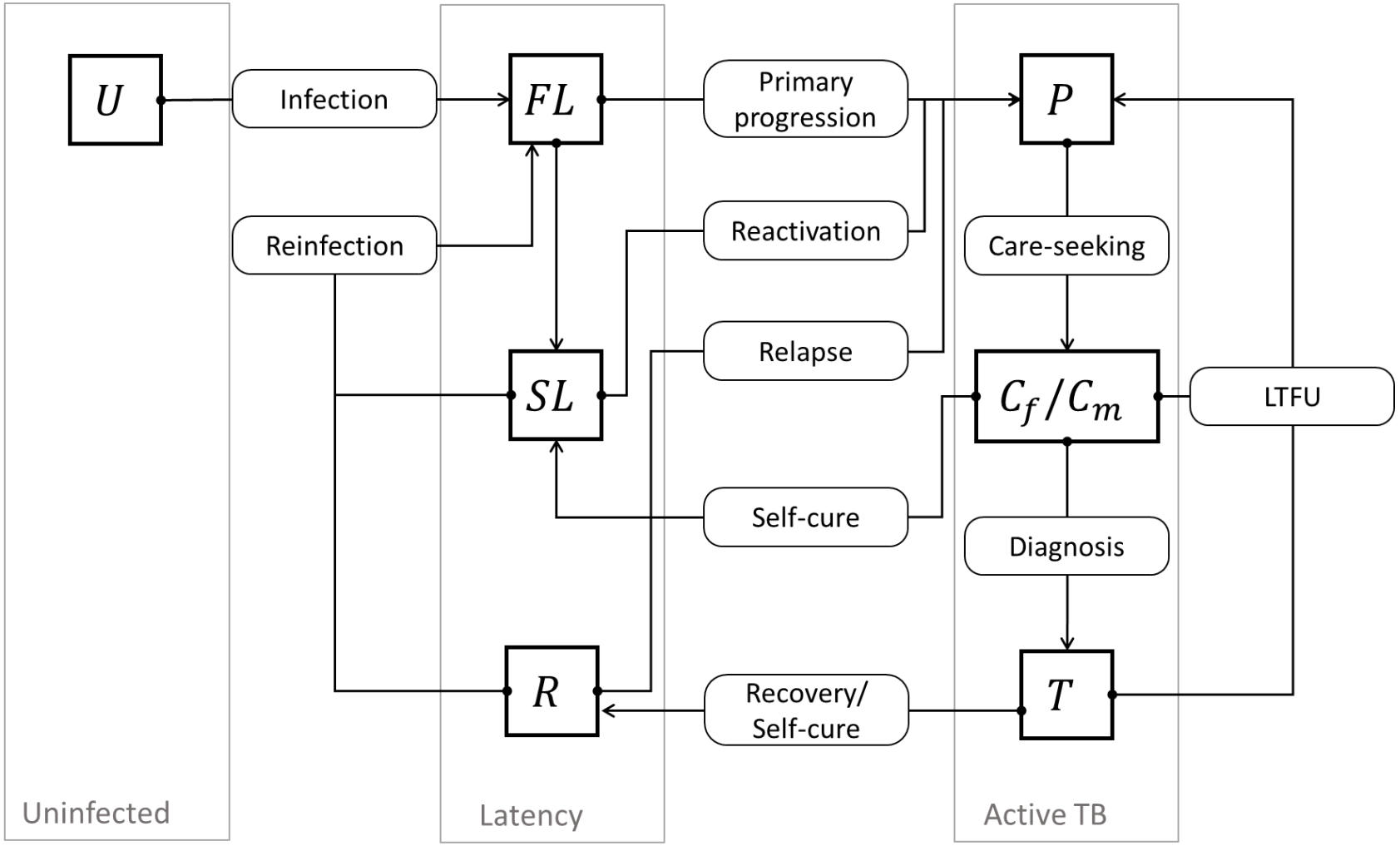
Data

- TB epidemiology
- Individual care-seeking pathways

Model

- Transmission dynamics
- Care-seeking flows

Model structure: compartmental model



Latency:

- Progression
- Reactivation
- Relapse
- Reinfection

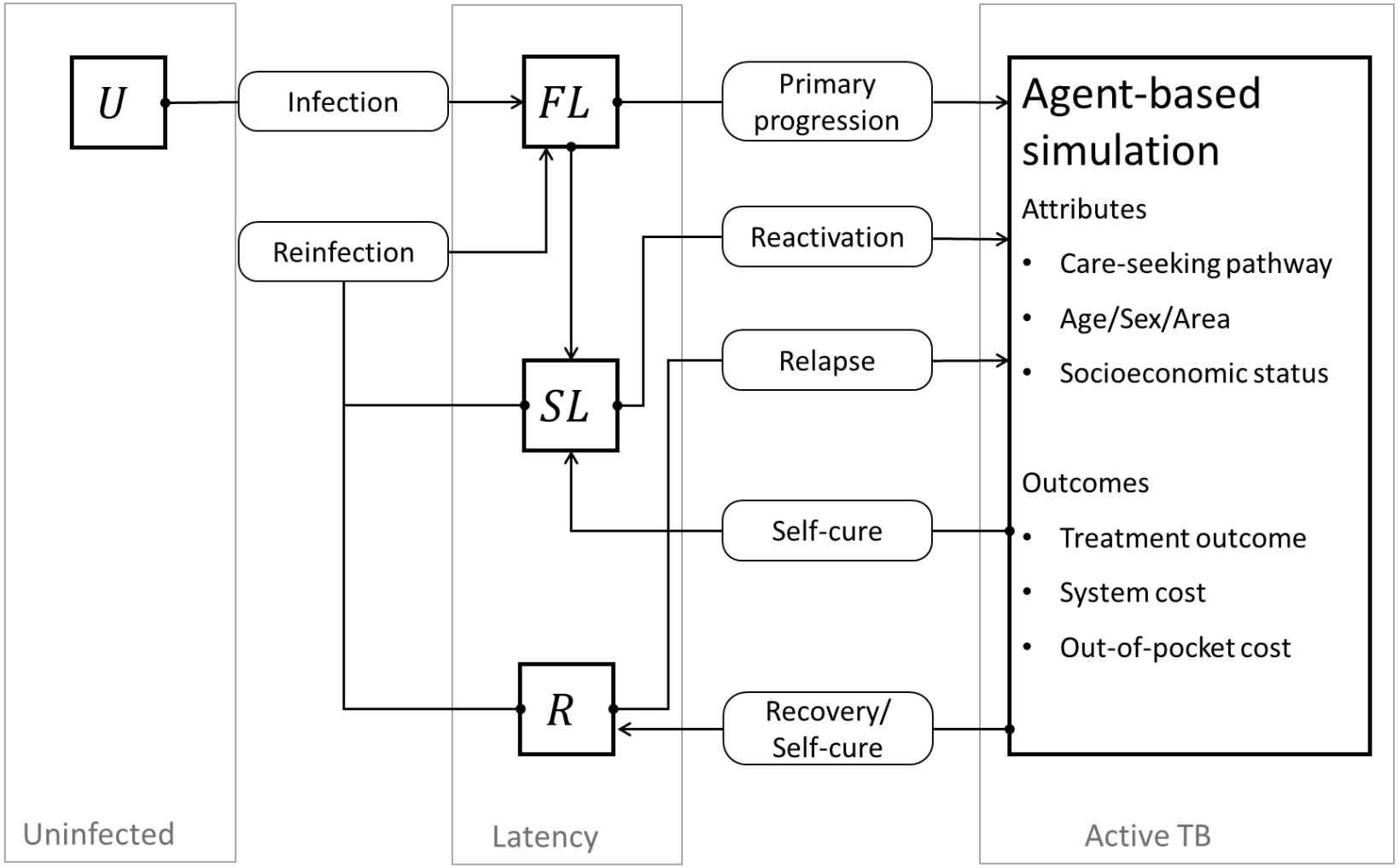
Active TB:

- Pre-hospital
- Care-seeking
- Under treatment

Demography:

- Country level
- Birth / death
- Ageing
- Migration

Model structure: hybrid model



Equation-based: Transmission

- + low simulation time
- + small parameter size
- + reductionism

Agent-based: Care-seeking

- + easy to feed data
- + non-linear behaviour
- + loose assumptions
- + stochasticity
- + heterogeneity

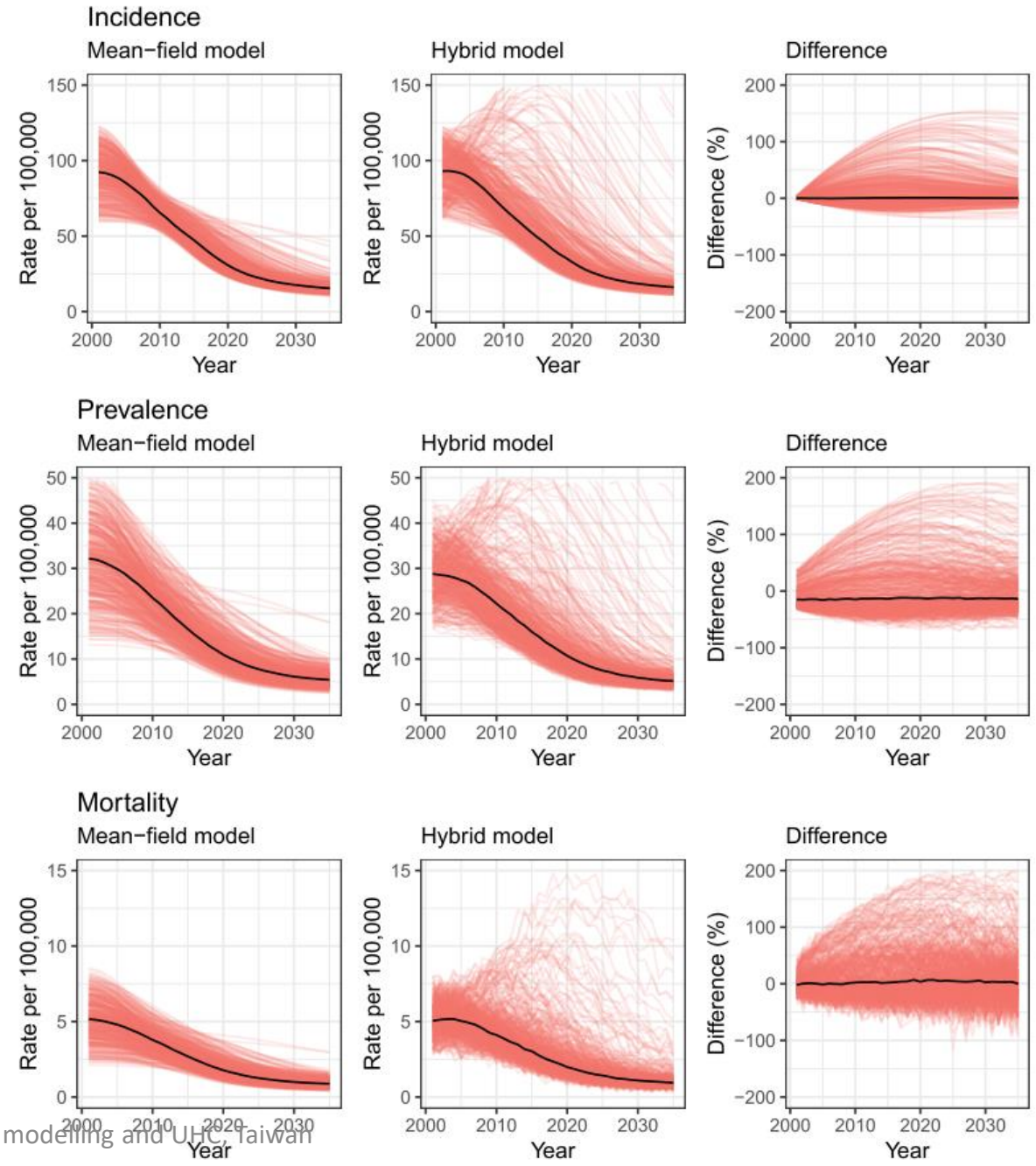
Model calibration

Data: incidence and notification by sex

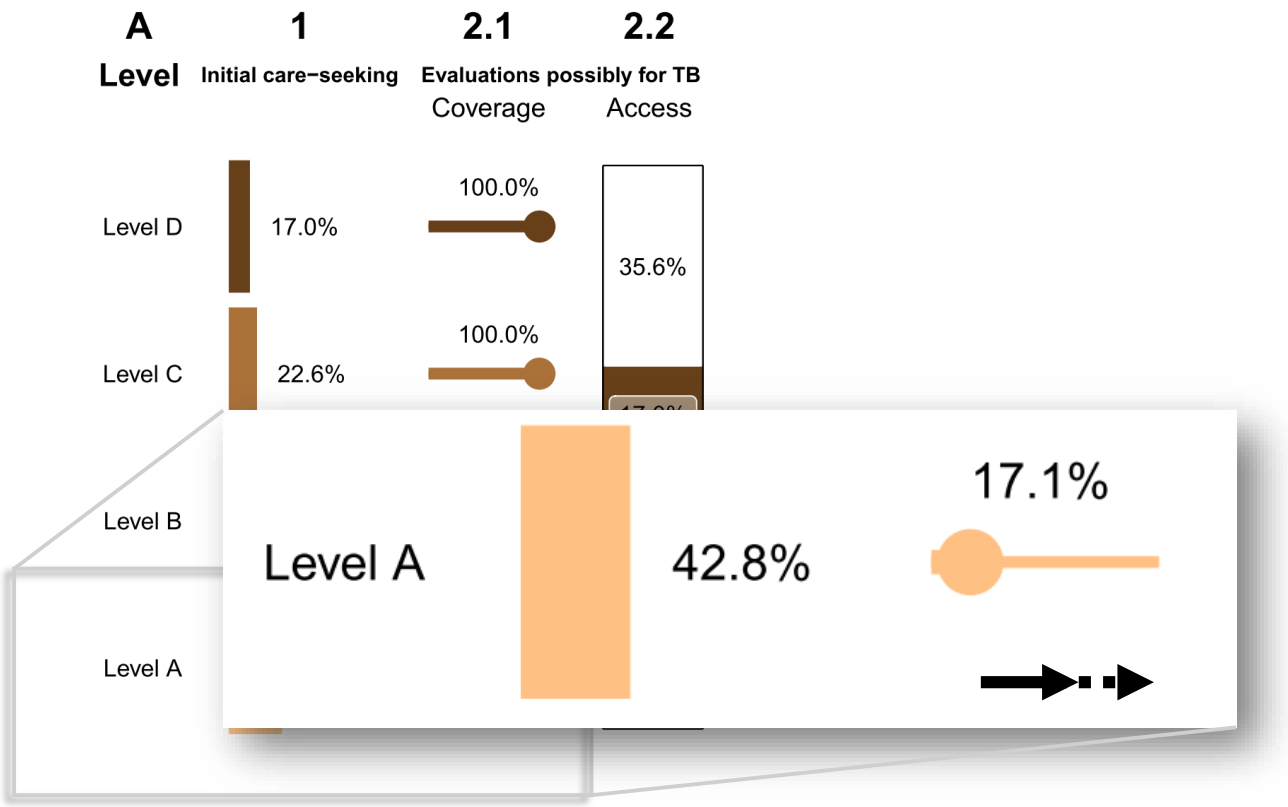
Methods: ABC-SMC

Procedure:

1. Fit the mean-field model to data
2. Export posterior parameters to the hybrid model



Example: intervention on TB service coverage



For hospitals without TB diagnostic services, give them the capacity

The priorities were based on

1. Hospital density (number of hospitals per km2)
2. Random shuffling

Epidemiological impacts

Year	Incidence per 100,000 mean (95% PI)	Prevalence per 100,000 mean (95% PI)	Mortality per 100,000 mean (95% PI)	Case detection gap per cent mean (95% PI)
Baseline				
2020	42.2 (22.5, 135.8)	14 (6.2, 48.6)	2.2 (0.9, 7.6)	10.8 (5.1, 16.8)
2025	30.1 (16.5, 103.9)	9.9 (4.6, 37.6)	1.6 (0.6, 5.6)	12 (6.2, 17.6)
2030	22.8 (13.6, 72.1)	7.5 (3.9, 24.7)	1.2 (0.5, 4)	13.1 (6.7, 19.1)
2035	18.8 (11.8, 47.7)	6.1 (3.3, 15.6)	0.9 (0.4, 2.4)	14.1 (8.5, 20.3)
From hospitals in poor area (30%)				
2020	42.4 (22.6, 138)	13.4 (6.1, 47.4)	1.4 (0.5, 5)	7.7 (2.4, 14)
2025	29.7 (16.5, 101.1)	9.3 (4.3, 35.1)	0.9 (0.3, 3.8)	10.7 (4.6, 16.4)
2030	22.3 (13.5, 68.5)	6.9 (3.5, 22.4)	0.7 (0.2, 2.6)	12 (5.8, 18)
2035	18.3 (11.8, 45.2)	5.6 (3.2, 14.1)	0.6 (0.2, 1.4)	13 (6.3, 20.1)
Random shuffling (30%)				
2020	42.4 (22.6, 137.2)	14.3 (6.6, 49.9)	1.5 (0.6, 5.4)	11.9 (8.2, 16.9)
2025	30.5 (16.5, 106.1)	10.4 (4.8, 39.8)	1.1 (0.4, 4.3)	12.5 (8.7, 16.6)
2030	23.2 (13.6, 74.2)	7.8 (4, 26.4)	0.8 (0.4, 2.9)	14 (9.8, 17.7)
2035	19.1 (11.9, 50)	6.4 (3.6, 16.5)	0.7 (0.3, 1.8)	14.9 (11.1, 18.5)

PI: prediction interval

Year	Reduction (%) Incidence	Mortality
From hospitals in poor area (30%) - Baseline		
2020	-0.3% (-2.1%, 1.5%)	36.6% (3.6%, 63.9%)
2025	1% (-0.4%, 3.5%)	38.9% (5.7%, 68.4%)
2030	1.6% (0.1%, 5%)	38.6% (-8.6%, 73.6%)
2035	1.7% (0.2%, 5.6%)	37.6% (-12%, 73.6%)
Random shuffling (30%) - Baseline		
2020	-0.2% (-1.6%, 1.1%)	32.8% (10.7%, 52.9%)
2025	-0.9% (-2.9%, 0.2%)	29.8% (1.9%, 53.4%)
2030	-1.1% (-3.6%, 0%)	28.5% (-8.5%, 52.6%)
2035	-1.1% (-3.8%, -0.1%)	28.4% (-7.8%, 55.9%)

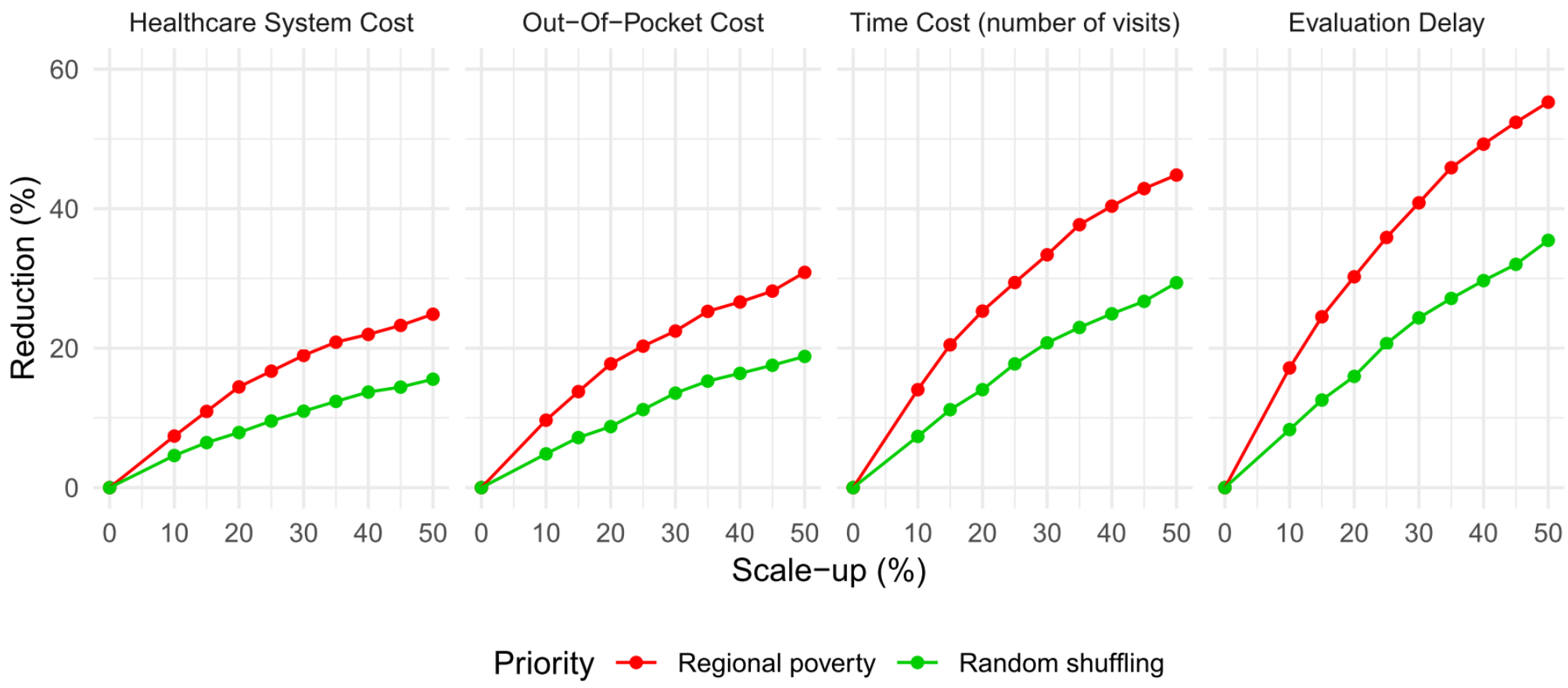
PI: prediction interval,
reduction: $(intervened - baseline)/baseline \times 100\%$

Dropout profiling

Dropout	3rd month mean (95% PI)	6th month mean (95% PI)	9th month mean (95% PI)	12th month mean (95% PI)
Baseline				
Self-cure	3% (2.1%, 4.2%)	5.1% (4.3%, 6.2%)	6.1% (5.3%, 7%)	6.6% (5.8%, 7.4%)
Death	1.1% (0.7%, 1.7%)	1.9% (1.4%, 2.5%)	2.3% (1.8%, 2.8%)	2.4% (2%, 2.9%)
From hospitals in poor area (30%)				
Self-cure	2.7% (1.9%, 3.8%)	4.6% (3.8%, 5.6%)	5.5% (4.7%, 6.3%)	5.9% (5.1%, 6.7%)
Death	1% (0.6%, 1.5%)	1.7% (1.3%, 2.2%)	2% (1.6%, 2.5%)	2.2% (1.8%, 2.6%)
Random shuffling (30%)				
Self-cure	3% (2.1%, 4.2%)	5.2% (4.3%, 6.3%)	6.3% (5.4%, 7.3%)	6.8% (6%, 7.7%)
Death	1.1% (0.7%, 1.6%)	1.9% (1.5%, 2.5%)	2.3% (1.9%, 2.8%)	2.5% (2.1%, 3%)

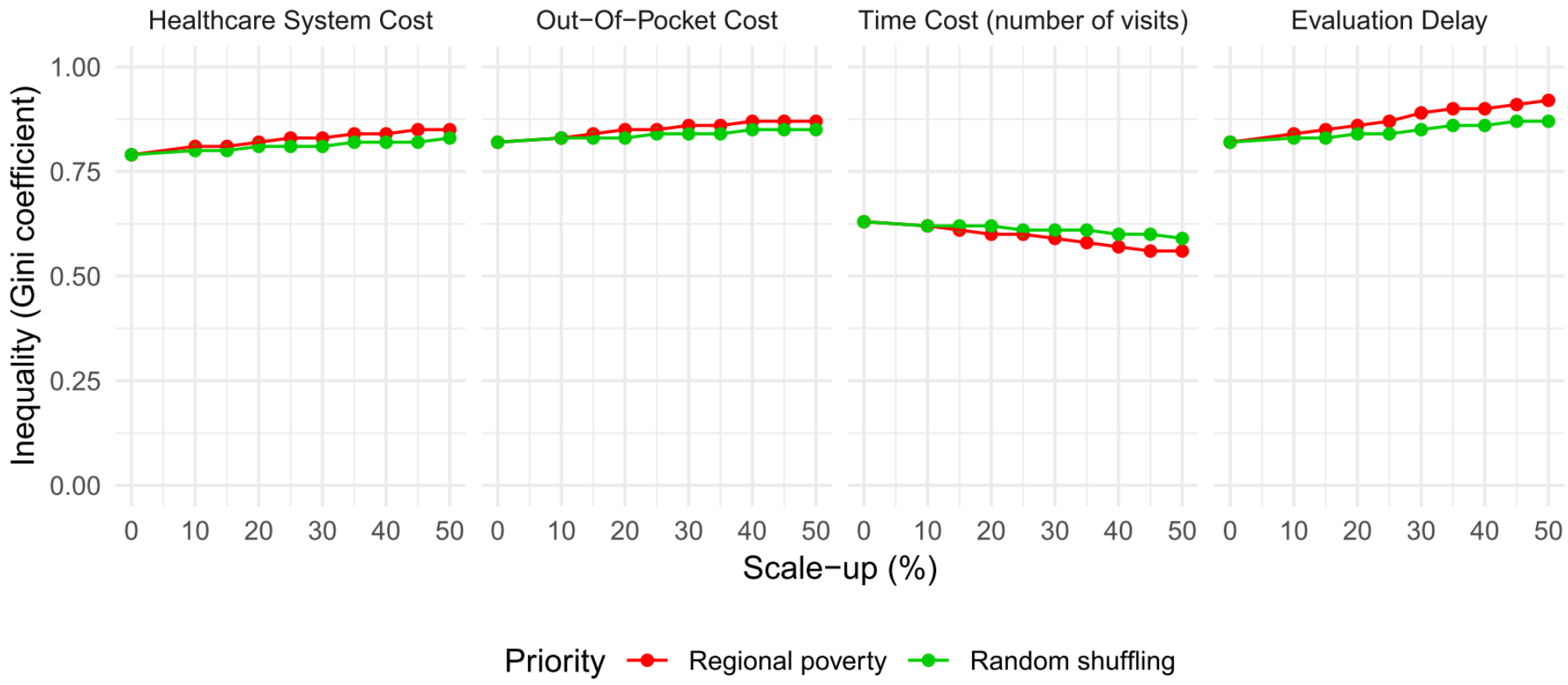
PI: prediction interval

Economic impacts



Impacts on equality

by Gini coefficient, 0: perfect equality; 1: extreme inequality



Next step:

1. More about costing

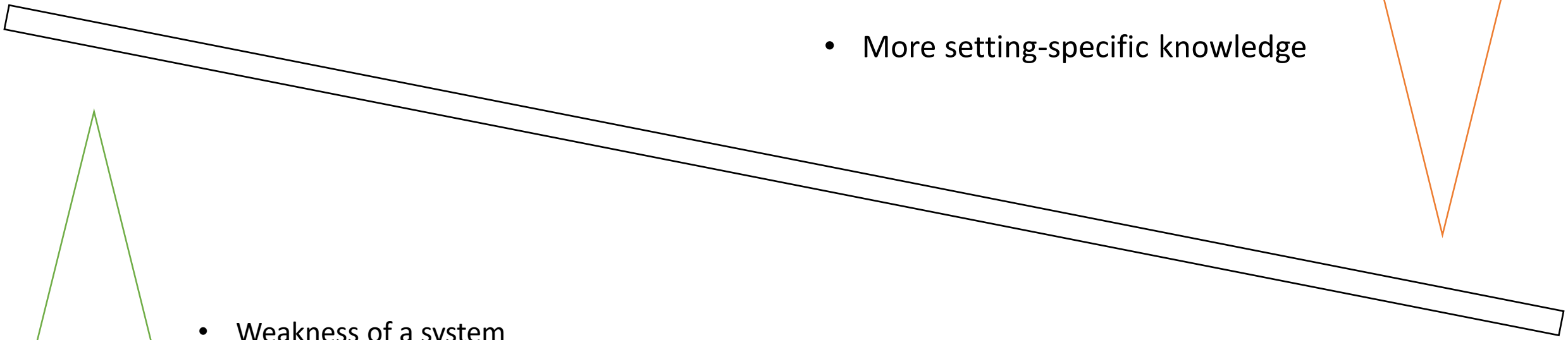
   Cost from patients directly due to TB care is close to zero but

   - Healthcare cost before a patient with TB became a TB patient
   - Traveling, carers, income loss

2. More potential interventions

Healthcare coverage

- More people under formal care
- More data
- More setting-specific knowledge



- Weakness of a system
- Roadmap to even higher coverage

Tuberculosis modelling