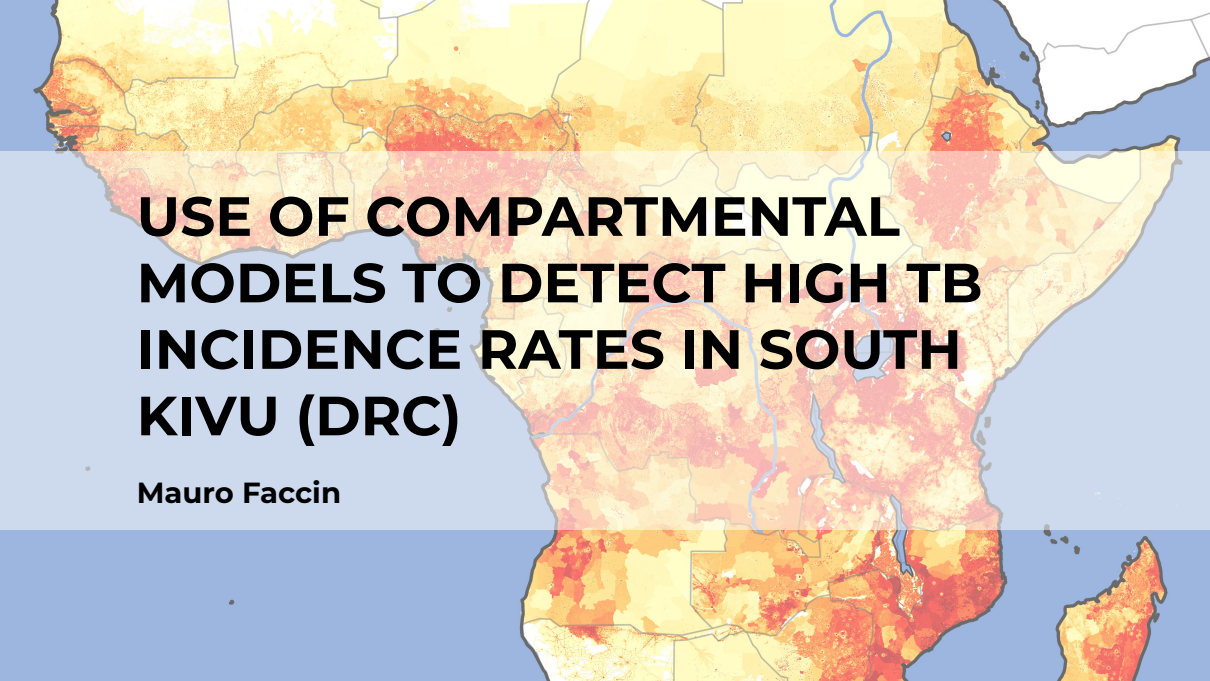


USE OF COMPARTMENTAL MODELS TO DETECT HIGH TB INCIDENCE RATES IN SOUTH KIVU (DRC)

Mauro Faccin

TUBERCULOSIS UNDER-DETECTION

- 4 million of undetected/untreated TB cases, yearly [WHO]
- Hard to reach communities with high levels of TB incidence:
  - rural areas
  - unequal access to health services
  - costly interventions in remote areas
- hidden pockets of population with high incidence of TB

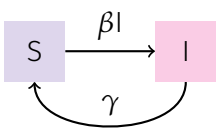
Efficient approach to ACF

Data driven estimation of TB incidence rates to focus health-care interventions such as Active-Case Findings (ACF)

Active-Case Finding: systematic screening of the population for active TB cases.

THE MODEL

Use of compartmental models (SIS) to disaggregate the reported cases.



Assumption

Endemic disease with slowly evolving **well mixed population**

$$\begin{cases} \frac{dS}{dt} &= \gamma I - \beta \frac{IS}{S+I} \\ \frac{dI}{dt} &= \beta \frac{IS}{S+I} - \gamma I \,. \end{cases}$$

$\rightarrow$ fit the parameters to:

- the number of cases reported by the **local health system** subunits;
- the population density in as estimated in a 100m^2 lattice [Worldpop]

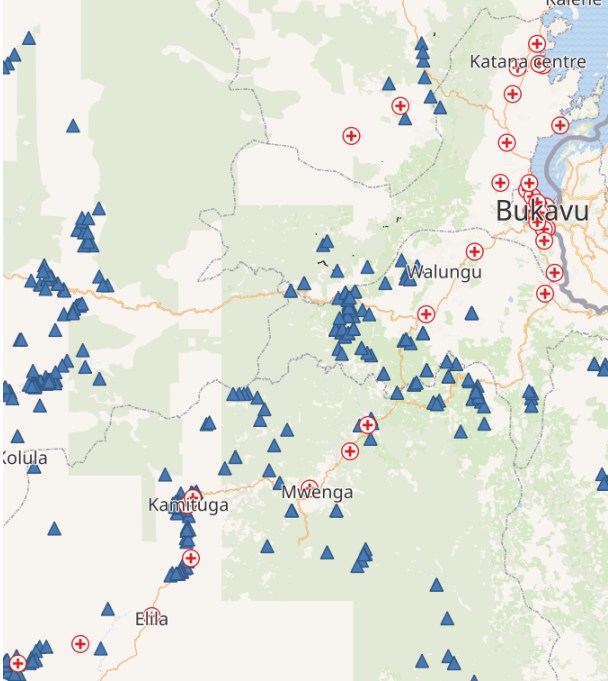
MODEL REFINEMENT

We include additional data to refine the model:

- Mine locations (we expect higher incidence rates close to mining activities);
- Health facilities (we expect a high number of undetected cases far from health-care facilities),

from a number of openly available sources:

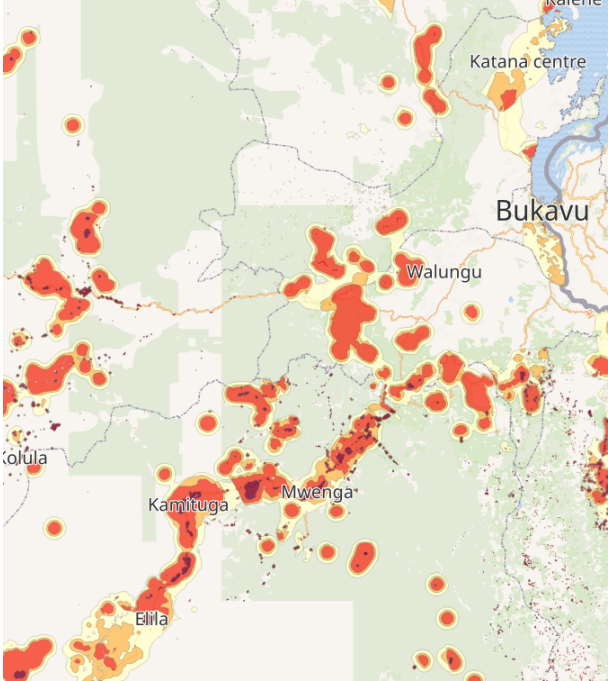
- OpenStreetMap
- IPIS Research Project



INCIDENCE RATE ESTIMATION

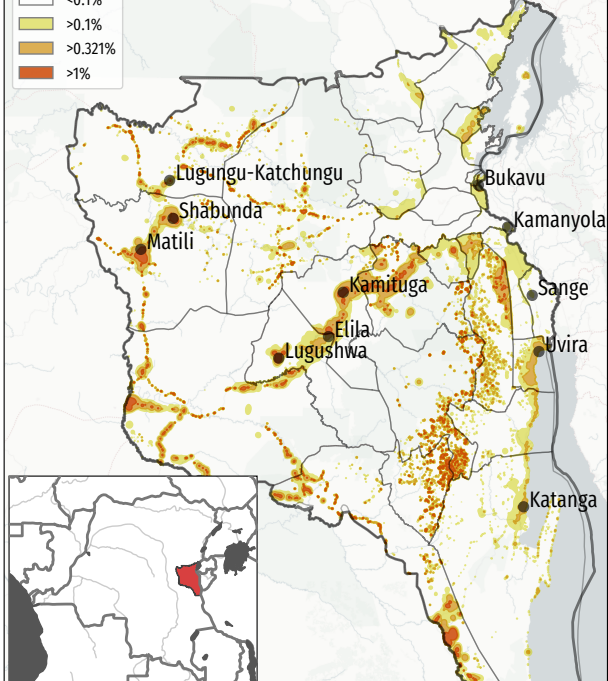
The estimated incidence rates highlight to the location of population pockets with high risk of TB.
This can guide ACF interventions in an efficient way.

color	incidence rate
	>0.1%
	>0.32%
	>0.5%
	>1%



MULTICENTRIC CLINICAL TRIAL

We performed a multicentric clinical trial addressing 11 location with heterogeneous estimated incidence rate.

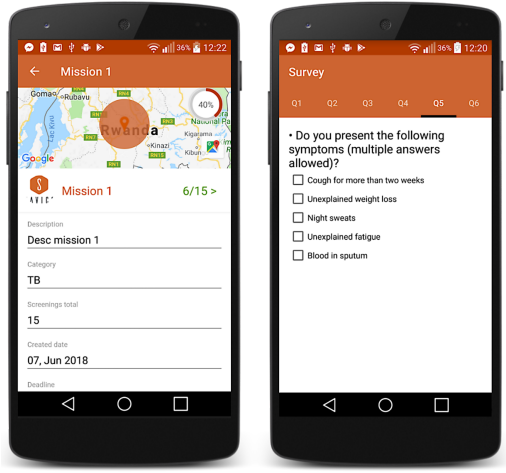


DIGITAL SUPPORTED QUESTIONNAIRE

Triage survey based on symptom, exposure and environment weighted questions.

Use of **MediScout©** (Savics, Belgium) for screenings activities:

- Mobile apps to plan and carry on the survey



DIGITAL SUPPORTED QUESTIONNAIRE

Triage survey based on symptom, exposure and environment weighted questions.

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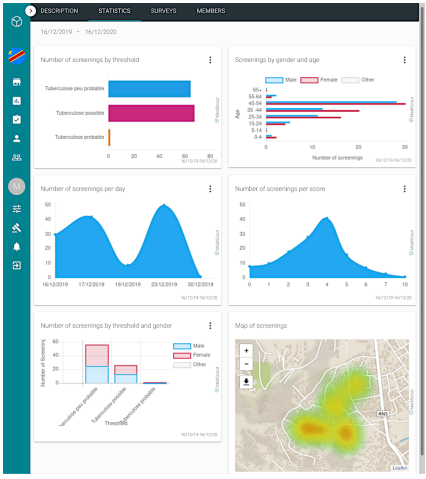
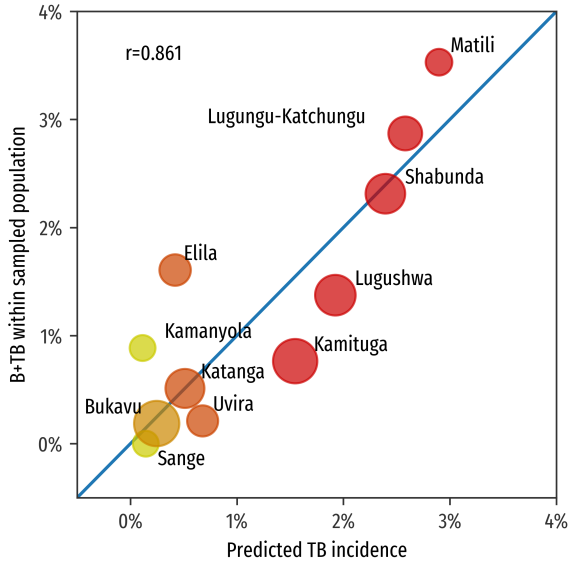
- Mobile apps to plan and carry on the survey
- Web app to collect data and perform analysis



RESULTS

screenings	13.841
lab tests	1153
positive cases	112

> 80% of positive cases originated from location at estimated at high risk (incidence rate higher than 1%).



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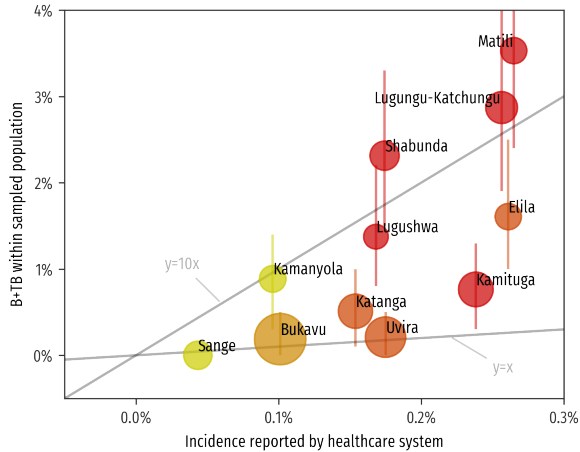
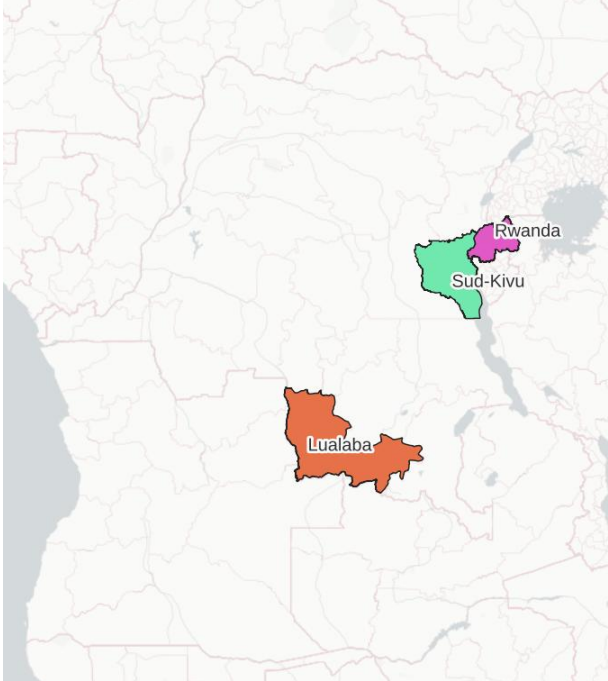


OTHER PILOT PROJECTS

We performed additional tests with similar results:

- **Fungurume** (Lualaba, DRC): a mining area;
- **Kigali** (Rwanda): an urban area

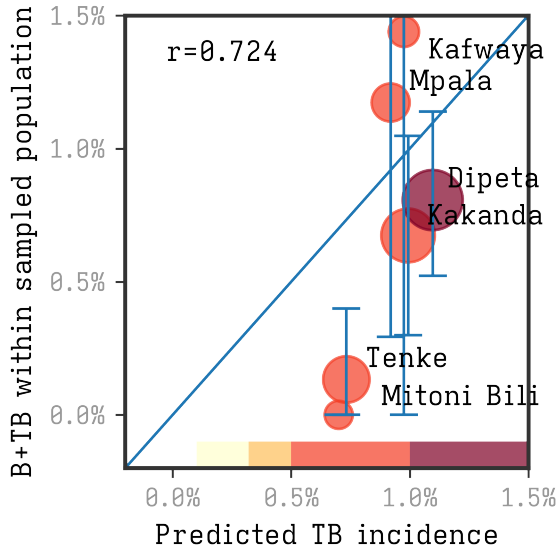


FUNGURUME – MINING AREA

In Fungurume we could not address heterogeneous communities.

Screenings	4776
Locations	6
Tests (Xpert MTB)	458
positive cases	33

Some outliers are probably due to the low statistics.



KIGALI – SATELLITE IMAGERY

In urban areas the same assumptions on well mixed population of compartmental models cannot be applied.

Use of computer vision algorithms to detect highly populated neighborhoods.

Algorithms

- detection of high density of object contours;
- detection of green areas 🌲.

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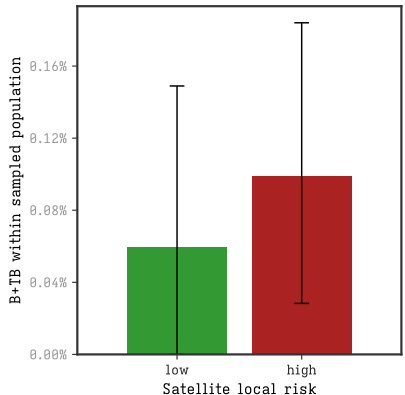
- detection of green areas 🌲.

MEASURED INCIDENCE RATES

Measured incidence rates in high-risk areas is almost twice that at lower-risk areas.

Screenings	10422
Tests (Xpert MTB)	202
positive cases	9



EFFICIENT TB DETECTION

In all cases, in high risk areas, we increased ACF efficiency.

South Kivu

Communities	NNS	NNT
Low risk	396	18.2
High risk	60	8.5

Fungurume

Communities	NNS	NNT
Low risk	167	19.4
High risk	123	8.7

Kigali

Areas	NNS	NNT
Low risk	1678	33.5
High risk	1009	19.3

NNS: Number of screenings needed to find 1 positive case
NNT: Number of lab tests needed to find 1 positive case

THANKS AND COMMENTS

Thanks to all collaborators:

- Emmanuel Andrè (UZLeuven, UKLeuven, Belgium)
- Fairouz Boutachkourt (UCLouvain, Belgium)
- Savics (Belgium)
- Rwanda Biomedical Center
- Ambassadeurs de la lutte contre la Tuberculose (Bukavu, DRC)
- Fungurume Mining (Lualaba, DRC)

More information at:

M.Faccin et al., Scientific Reports, 12(3912) p.2045-2322 (2022) and

`https://maurofaccin.github.io/cartotb`

I will happily answer to any question or comment.

Mauro Faccin:

`https://maurofaccin.github.io`

`mauro.fccn@gmail.com`