Bayesian evidence synthesis to estimate subnational TB incidence: an application in Brazil

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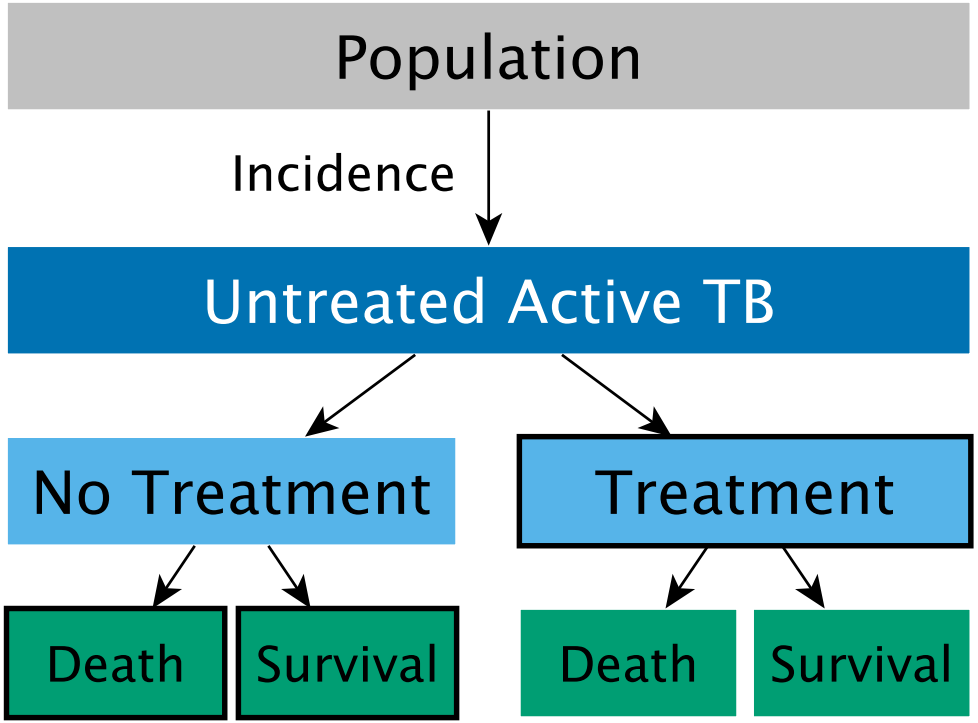
Motivation

- Understanding the geographic distribution of untreated active TB can help target efforts to strengthen TB control
- Aim: Using only routinely available data, develop and apply a new method for estimating incidence and the fraction of incident cases that receive treatment

Model: Framework



Data Inputs

- For each Brazilian state and the Federal District (n = 27) from 2007 – 2016:
  - Tuberculosis treatment notifications
  - Death records for TB-related and ill-defined causes
  - Demographic and health system survey data
    - Population, GDP, primary healthcare coverage

Data Inputs

- Derived inputs
  - Mortality system coverage estimates
  - Probability that a TB death is coded with a TB-related ICD-10 code
  - Probability of survival given no treatment

Model: Likelihood Functions

$$Case\ Notifications_{ij} \sim Poisson(\gamma_{ij} * \alpha_{ij} * \beta_{ij})$$

$$TB\ Mortality_{ij} \sim Poisson\Big(\gamma_{ij} * \alpha_{ij} * \Big[(\beta_{ij} * \delta_{ij}) + \Big((1 - \beta_{ij}) * \mu\Big)\Big] * \pi_i * \rho_{ij}\Big)$$

- γ_{ij} - population
- α_{ij} - incidence
- β_{ij} - fraction treated
- δ_{ij} - probability mortality | treatment initiation
- μ – probability mortality | no treatment initiation
- π_i - mortality system completeness
- ρ_{ij} - adjustment for systematic underreporting of TB as cause of death

Model: Transformed Parameters

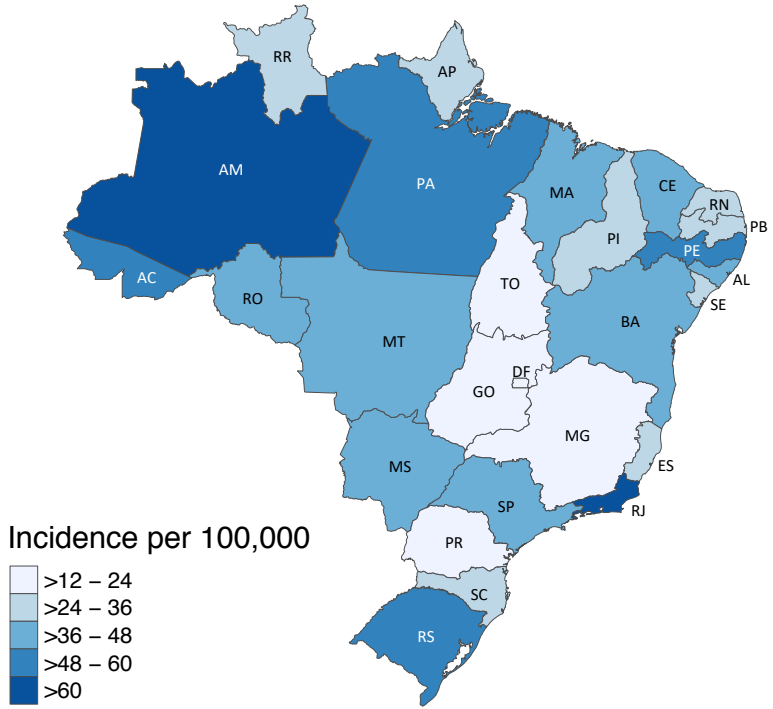
$$Incidence_i = \alpha_i = exp\left(\varphi_0 + \varphi_{1_{ij}} + \varphi X_{ij}\right)$$

$$Fraction\ Treated_i = \beta_i = logit^{-1}\left(\omega_0 + \omega_{1_{ij}} + \omega X_{ij}\right)$$

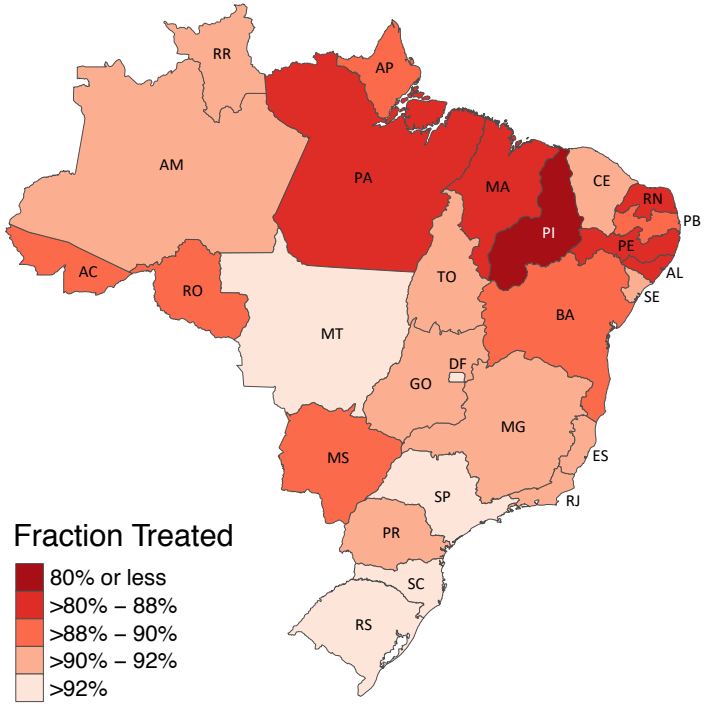
- φ_0 and ω_0 are constants
- $\varphi_{1_{ij}}$ and $\omega_{1_{ij}}$ are state-time random effects, allowed to follow a random walk
- X_{ij} is vector of state-level covariates (GDP per capita, primary healthcare coverage); φ and ω are vectors of regression coefficients

Outcomes: 2016 Estimates

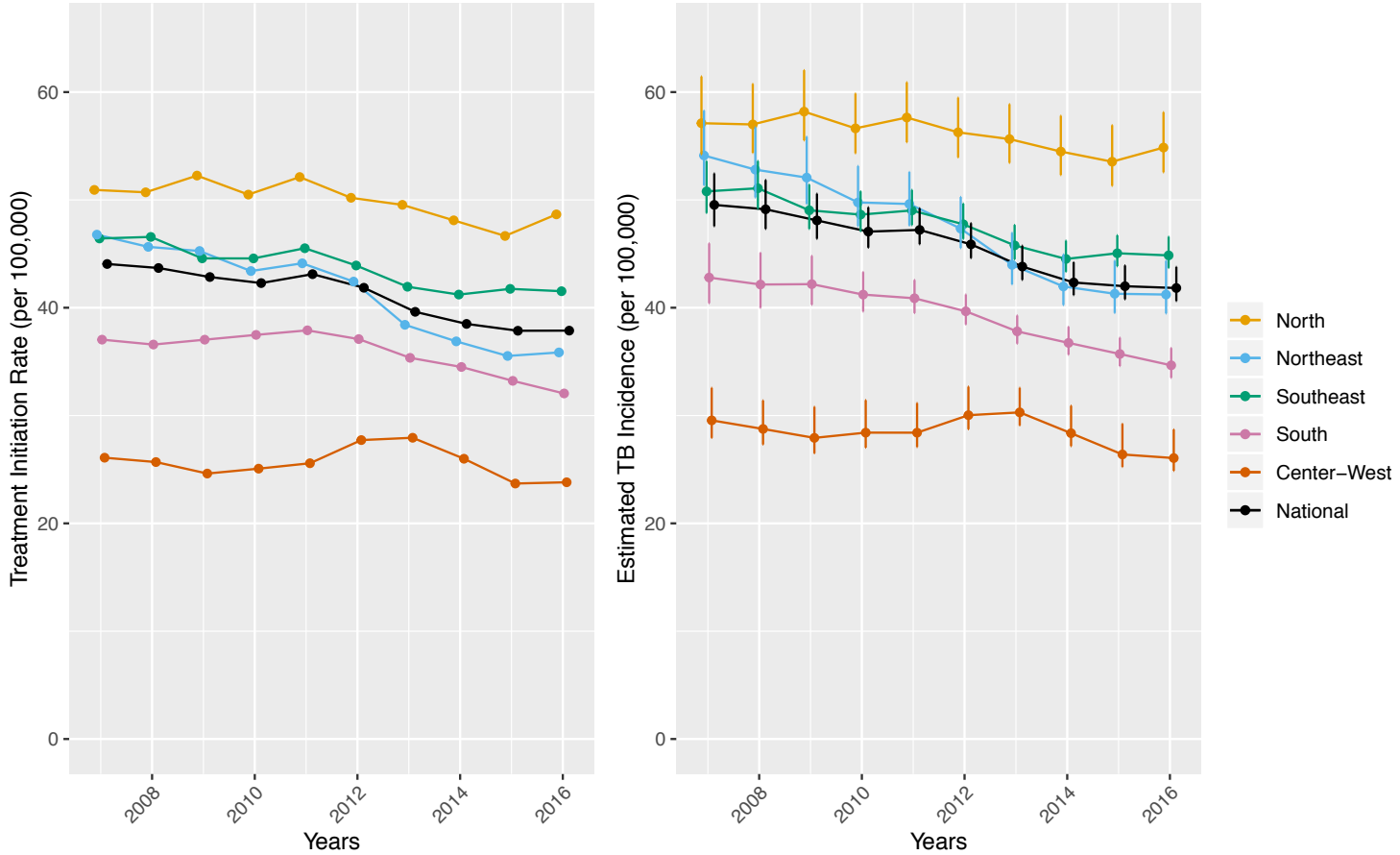
Incidence rate



Fraction treated



Outcomes: 10-year time trend



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Advantages

- Does not require primary data collection
- Distinguishes between areas with low burden and areas of low fraction treated.
- Model leverages known relationships between treatment and mortality
  - Internal consistency creates opportunities for model checking

Limitations

- Data limitations: treatment free survival, TB death under-reporting
- Multiple databases, no consistent patient ID among them: GAL-TB, SINAN-TB, SITE-TB
- Treatment reporting assumption is valid in Brazil, but may not hold in other settings

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