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

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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
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

\[ \text{Case Notifications}_{ij} \sim \text{Poisson} (\gamma_{ij} \ast \alpha_{ij} \ast \beta_{ij}) \]
\[ \text{TB Mortality}_{ij} \sim \text{Poisson} (\gamma_{ij} \ast \alpha_{ij} \ast \left[ (\beta_{ij} \ast \delta_{ij}) + ((1 - \beta_{ij}) \ast \mu) \right] \ast \pi_{i} \ast \rho_{ij}) \]

- \( \gamma_{ij} \) - population
- \( \alpha_{ij} \) - incidence
- \( \beta_{ij} \) - fraction treated
- \( \delta_{ij} \) - probability mortality | treatment initiation
- \( \mu \) – probability mortality | no treatment initiation
- \( \pi_{i} \) - mortality system completeness
- \( \rho_{ij} \) - adjustment for systematic underreporting of TB as cause of death
Model: Transformed Parameters

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

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

- \( \varphi_0 \) and \( \omega_0 \) are constants
- \( \varphi_{1ij} \) and \( \omega_{1ij} \) 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); \( \varphi \) and \( \omega \) are vectors of regression coefficients
Outcomes: 2016 Estimates

Incidence rate

Fraction treated

Incidence per 100,000

>12 – 24

>24 – 36

>36 – 48

>48 – 60

>60

Fraction Treated

80% or less

>80% – 88%

>88% – 90%

>90% – 92%

>92%
Outcomes: 10-year time trend
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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