Modelling the Effect of HIV on the TB Epidemic in South Africa

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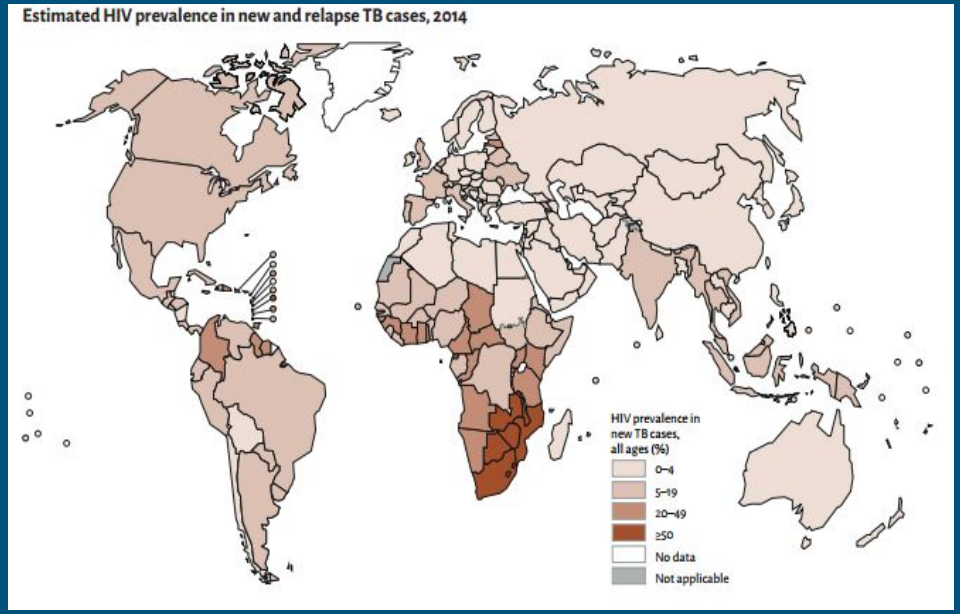
Background

- Globally TB causes 1.5 million deaths and 9.6 million infections annually
  - 12% of incident cases are HIV+
- South Africa has the 2nd highest incidence of TB (834/100,000 person-years)
  - 61% of incidence TB cases are in HIV+ individuals



Scientific Question

How can we model the population effects of TB treatment and/or chemoprophylaxis in a country with a significant HIV burden?

Statement of Aims

1. Recreate the Blower et al model that describes the population dynamics of TB in an HIV- population
2. Extend the model to include the population dynamics of TB in an HIV+ population as well as the interactions between the HIV- and HIV+ populations
3. Understand how varying levels of TB treatment and chemoprophylaxis can reduce TB burden of disease in both the HIV- and HIV+ populations
4. Determine how varying levels of reinfection rate among the HIV+ population will affect the success of population-level TB treatment and chemoprophylaxis

Blower et al Model

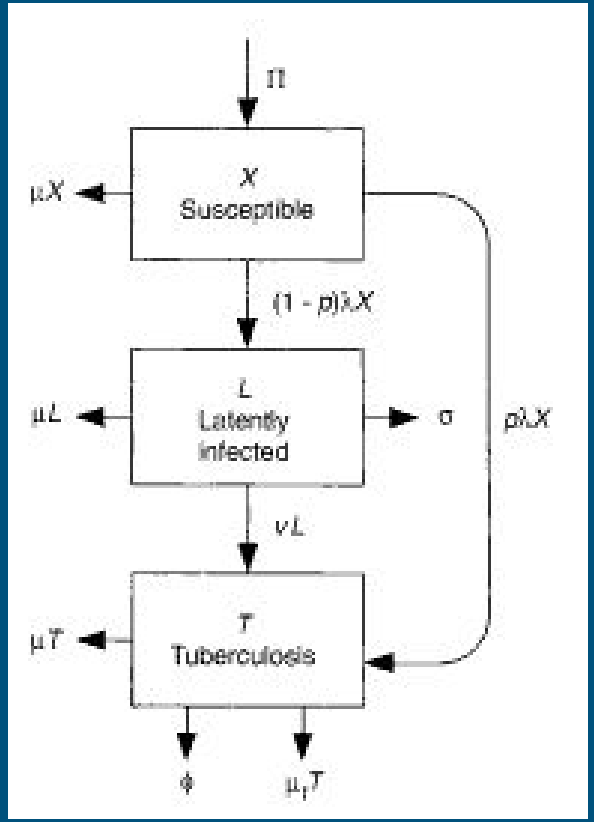
$$dX/dt = \Pi - \lambda X - \mu X,$$

$$dL/dt = (1 - p)\lambda X - (\nu + \mu + \sigma)L,$$

$$dC/dt = \sigma L - \mu C,$$

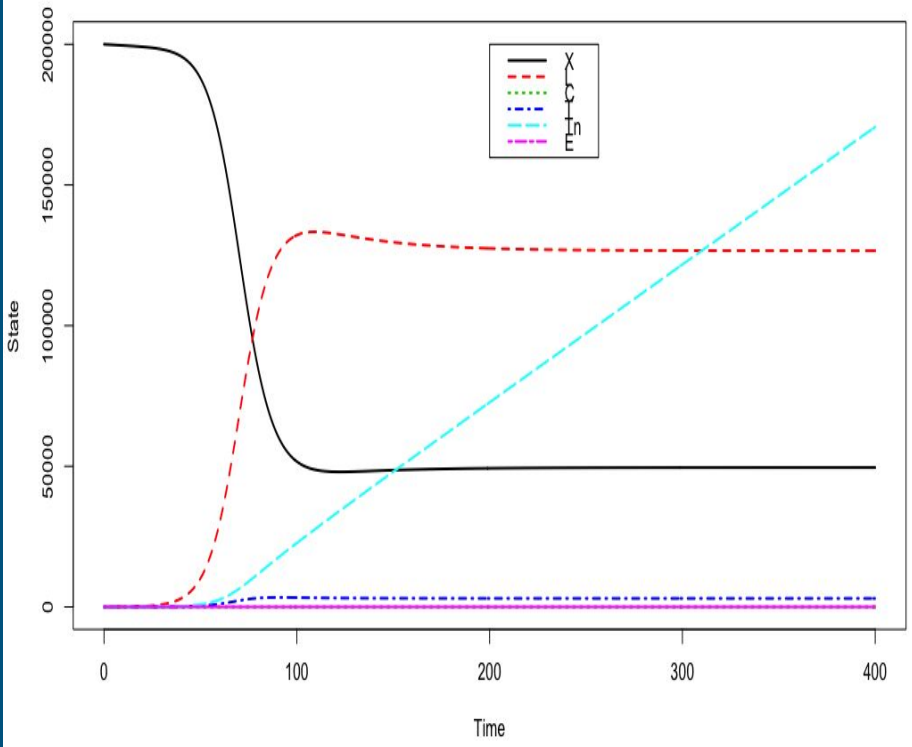
$$dT/dt = \nu L + p\lambda X - (\mu + \mu_T + \phi)T,$$

$$dE/dt = \phi T - \mu E.$$

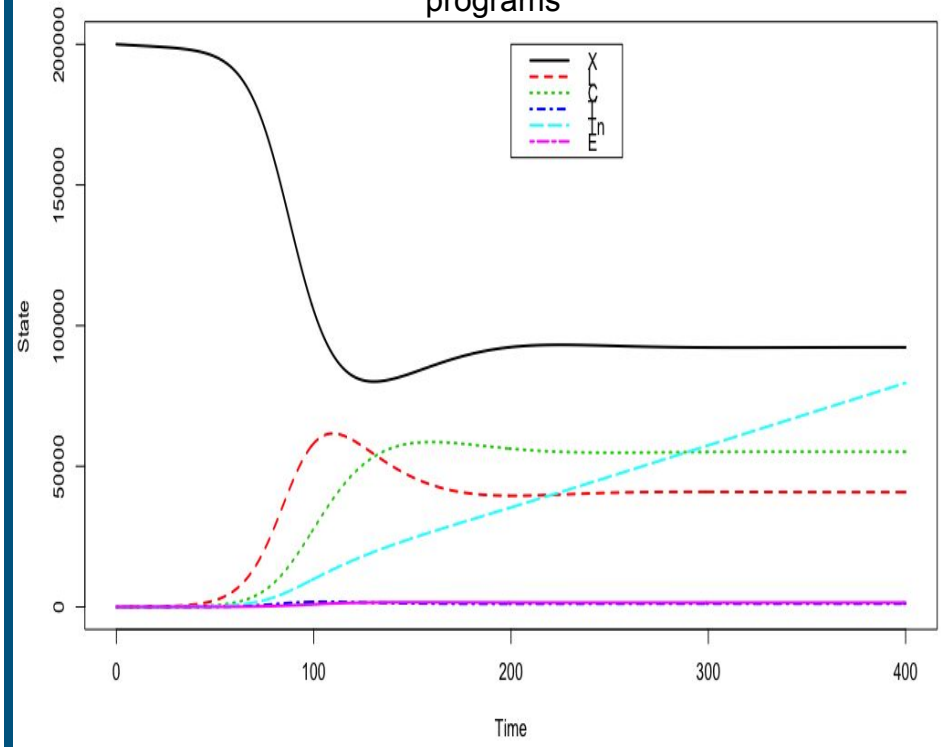


Original Original Compartment Model

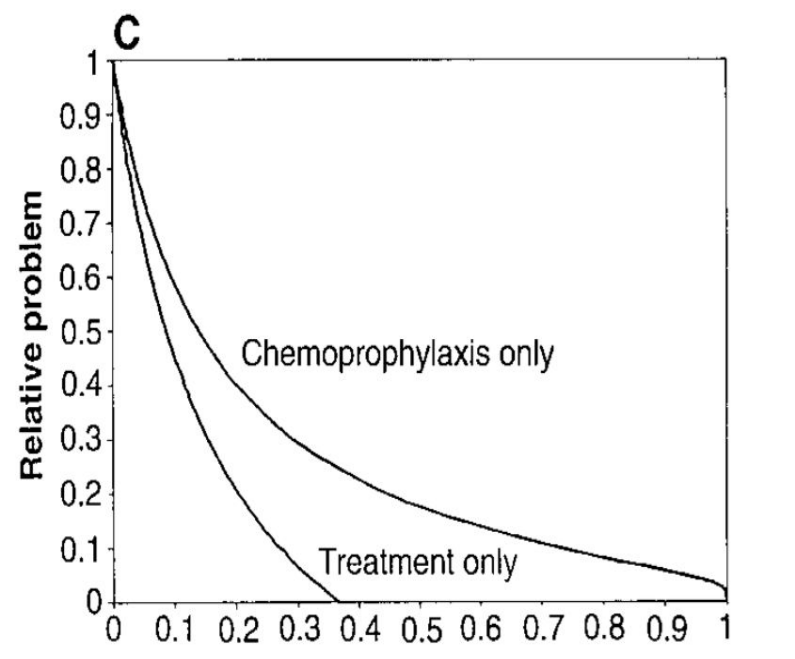
No treatment or chemoprophylaxis control programs

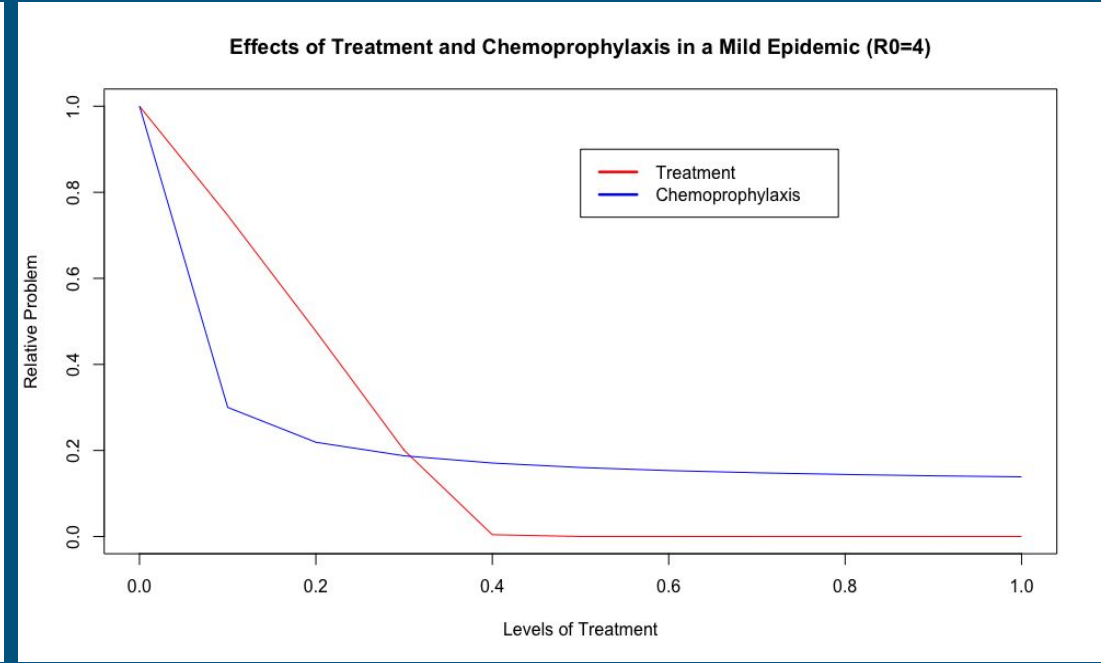


In presence of treatment and chemoprophylaxis control programs

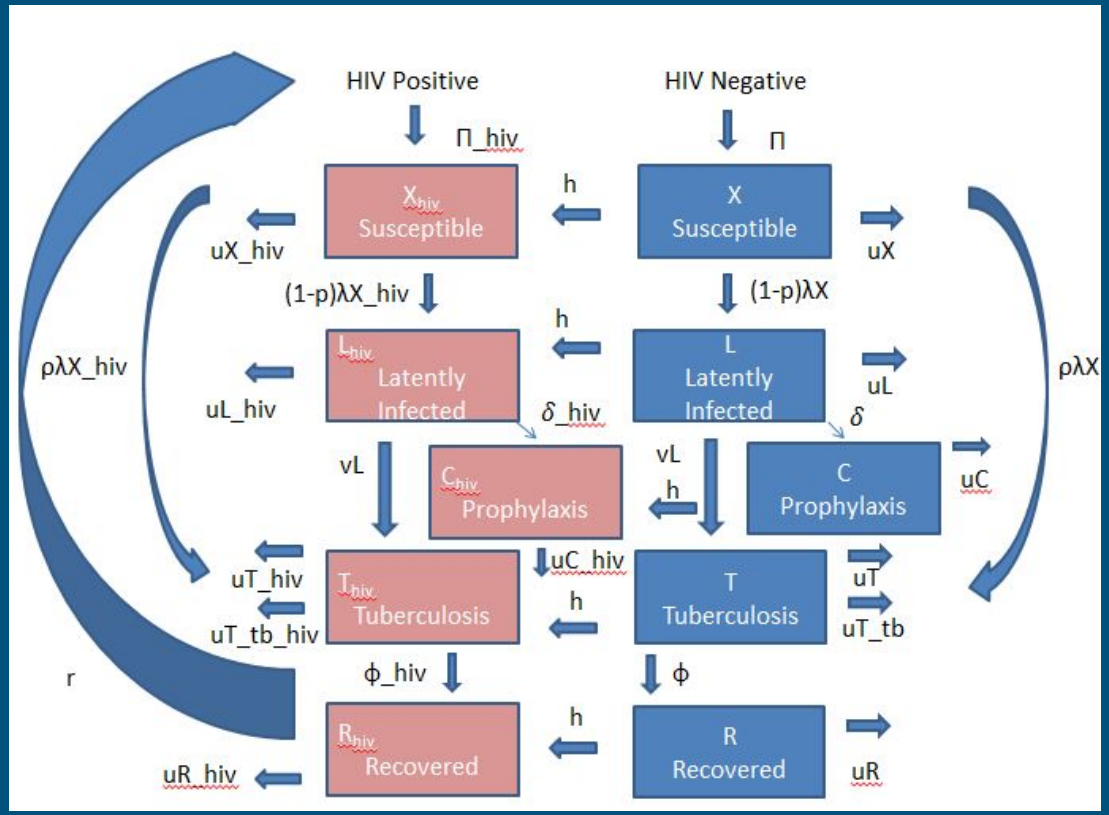


Recreating the Blower et al Model





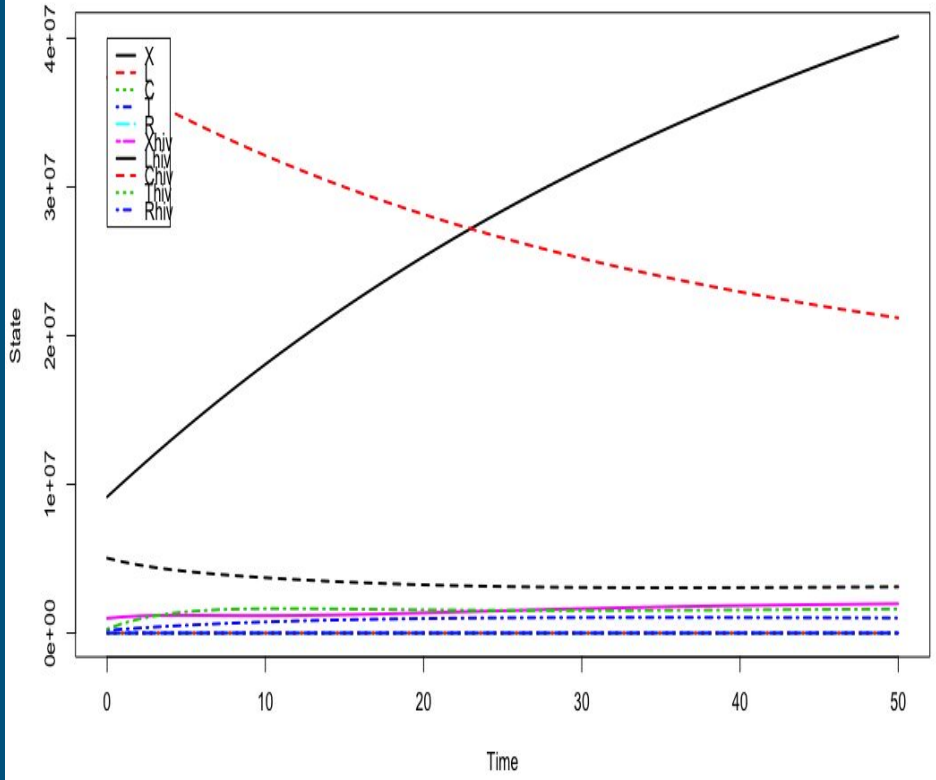
Model Extension



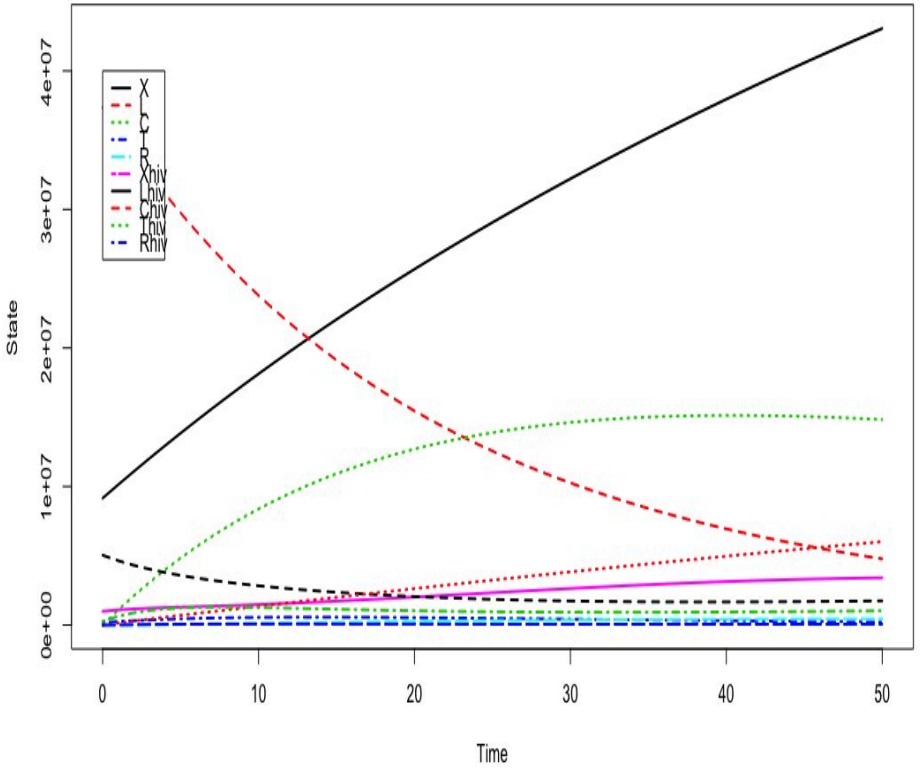
- Added HIV positive Compartments
- Added an HIV positive immigration rate, reinfection rate (r), HIV infection rate (h)
- Updated other parameters to reflect values in HIV positive populations
- Data is from South African vital statistics and data reported to the WHO for TB and HIV/AIDS rates

Extended Model Primary Results

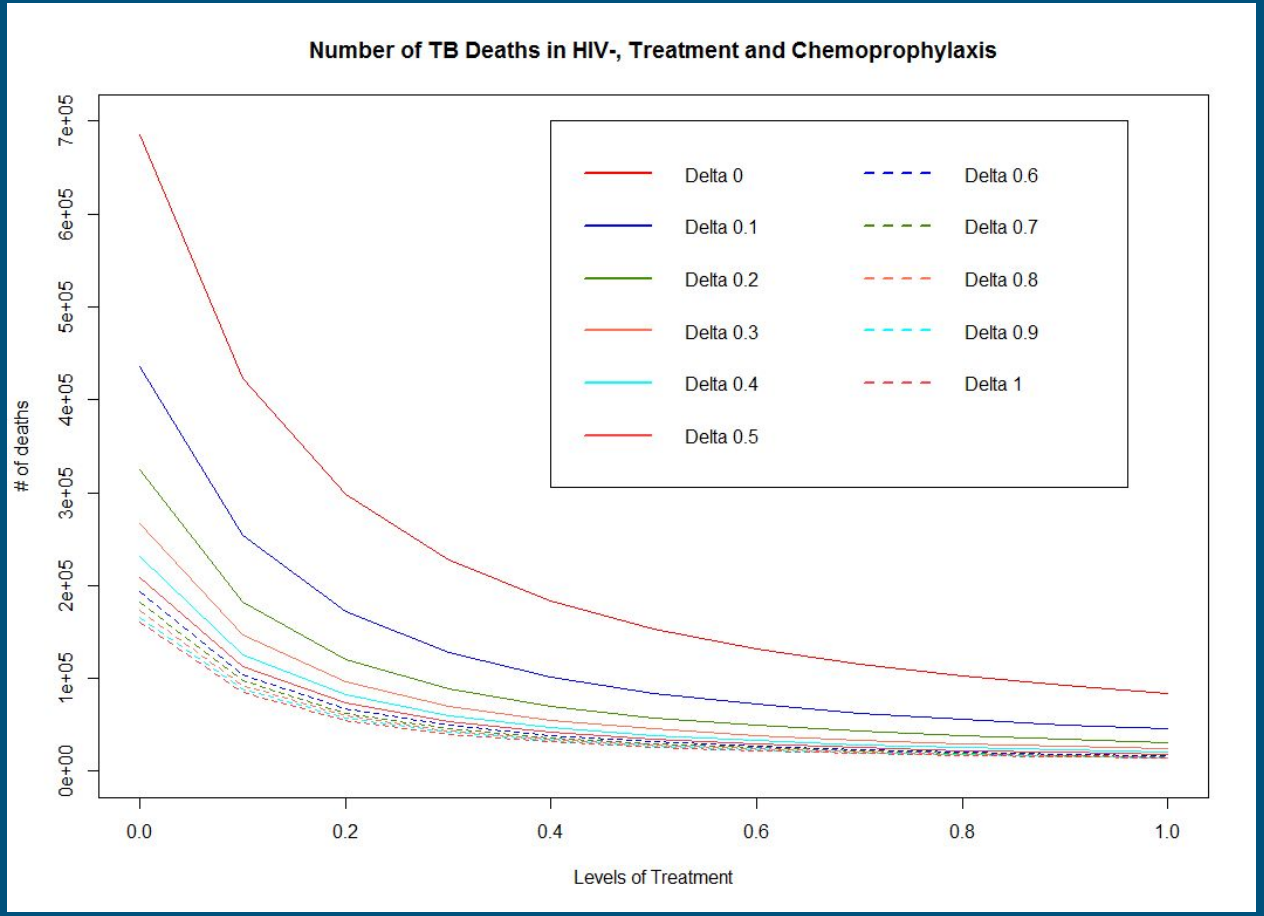
No treatment or chemoprophylaxis control programs



In presence of treatment and chemoprophylaxis control programs

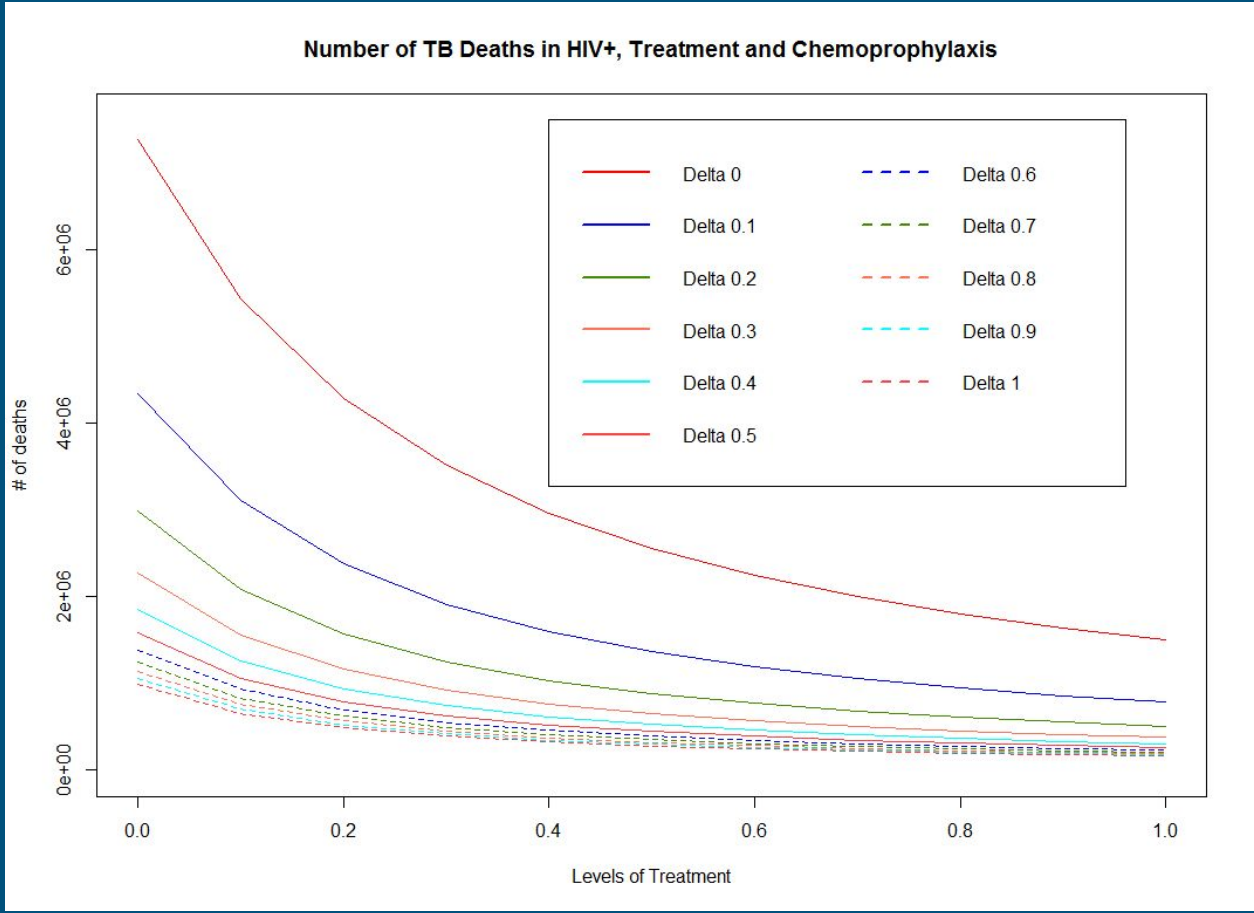


Combining Treatment and Prophylaxis



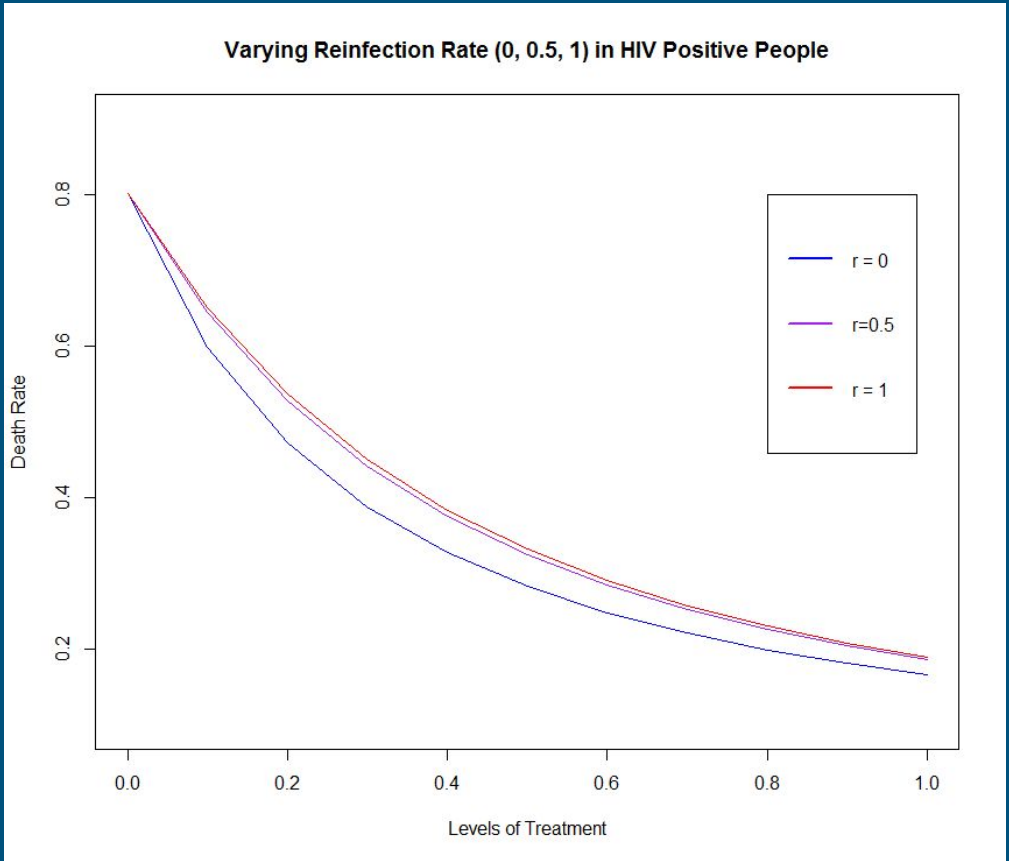
Number of deaths from TB in HIV negative people

Combining Treatment and Prophylaxis



Number of deaths from TB in HIV positive people

Accounting for Reinfection



- The change in the death rate by levels of treatment at different levels of TB reinfection rate in HIV positive people
- HIV negative people experienced no TB reinfection after being treated

Public Health Implications

- Achievement of the WHO’s 2050 TB elimination goal
- Deepens understanding between HIV and TB
  - Impact of HIV in TB dynamics and control strategies
- Joining of programs strengthen diagnosis and treatment systems at low cost
  - HIV/AIDS already strained healthcare systems in developing countries
- Insight into local, regional, and national role of HIV in TB dynamics
  - Elucidate benefits and opportunities to strengthen healthcare system

Limitations and Future Directions

- Model did not include:
  - Drug-resistant strains
  - Number of cases effectively treated
  - Migration rates
- Force of infection was difficult to estimate
- Assumed that once chemoprophylaxed, could not develop active TB

Questions?