The impact of HIV and TB interventions on South African adult TB trends, 1990-2019: a mathematical modelling analysis

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BACKGROUND

- The South African tuberculosis (TB) epidemic is largely driven by HIV.
- TB control interventions implemented in South Africa include:
  - Directly observed therapy (DOTS)
  - Antiretroviral therapy (ART)
  - Isoniazid preventative therapy (IPT)
  - Increased TB screening
  - Xpert MTB/RIF to replace smear microscopy.
- There are limited formal analyses that have evaluated the past impact of HIV and TB control interventions on the South African TB epidemic.

OBJECTIVE

To estimate the impact of HIV and TB control interventions on the South African TB epidemic in adults (15+ years) between 1990 and 2019.

METHODS

- Developed an age-sex stratified dynamic TB transmission model and combined it with an existing HIV model.
- Modelled effects of HIV on TB depended on CD4 count and ART status.
- Performed Bayesian calibration to South African data:
  - TB deaths from the vital register (1997-2016)
  - National TB prevalence survey (2018)
  - Microbiological TB tests performed (2004-11)
  - TB treatment initiations and outcomes from the electronic TB register (2004-16).
- Simulated counterfactual ('*no HIV*' or '*without interventions*') scenarios versus baseline ('*with HIV*' and '*with interventions*') scenario to estimate TB burden attributable to HIV, and TB incidence reductions due to respective interventions.

RESULTS

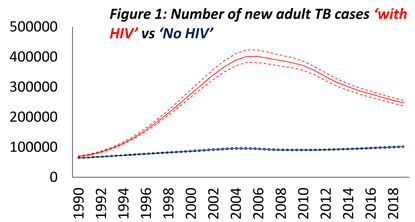
TB incidence between 1990 and 2019:

- 8.0 million (95% CI 7.7 – 8.3) million people developed TB; of these, 67.4% (95% CI 66.9 – 68.0%) were due to HIV.

TB incidence in 2019:

- Assuming there was 'No HIV', there would have been 101 500 (95% CI 98 800 – 104 200) new TB cases; however, 'With HIV' there were 247 000 (95% CI 237 000 – 256 000).

Figure 1: Number of new adult TB cases 'with HIV' vs 'No HIV'



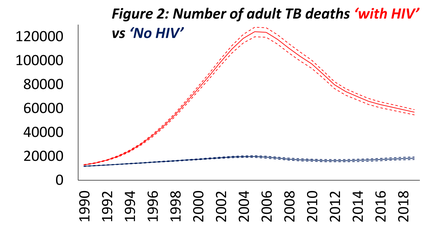
TB deaths between 1990 and 2019:

- 2.1 million (95% CI 2.0 – 2.2) million people died due to TB; of these, 76.4% (95% CI 75.5 – 77.3%) were due to HIV.

TB deaths in 2019:

- Assuming there was 'no HIV', there would have been 18 400 (95% CI: 17 300 – 19 400) TB deaths; however, 'With HIV' there were 56 900 (95% CI: 54 600 – 58 900).

Figure 2: Number of adult TB deaths 'with HIV' vs 'No HIV'

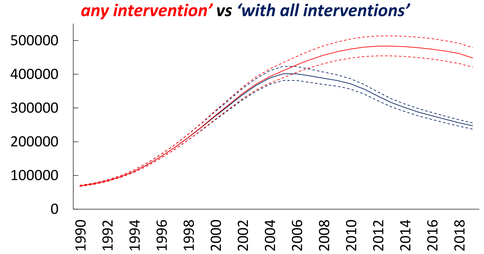


Red lines: Baseline scenario 'with HIV'. Blue lines: Counterfactual scenario assuming there was 'no HIV'. Dash lines = 95% Confidence intervals (CI).

Impact of interventions on TB incidence

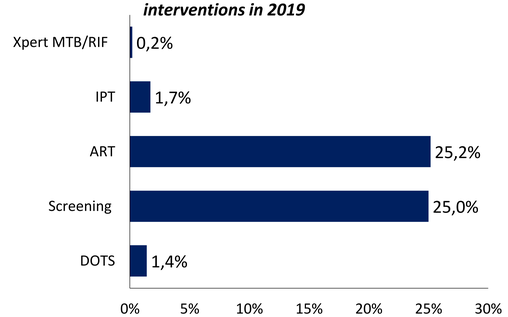
- Over the 10-year period 2009-2019, TB incidence declined by 35.3% (95% CI 34.5 – 36.8%).
- 'Without any TB intervention' in 2019, there would have been ~82% more new TB cases compared to with all interventions in place (449 000 (95% CI 421 000 - 479 000) vs 247 000 (95% CI 237 000 – 256 000)) (Figure 3).
- Provision of ART and intensified TB screening led to substantial reductions in TB incidence; DOTS, IPT and Xpert MTB/RIF led to modest reductions (Figure 4).

Figure 3: Number of new adult TB cases 'without any intervention' vs 'with all interventions'



Red lines: Counterfactual scenario 'without any intervention' Blue lines: Baseline scenario 'with all interventions Dash lines = 95% Confidence intervals (CI).

Figure 4: Reduction in adult TB incidence due to interventions in 2019



CONCLUSION

- Our analysis has given a retrospective account of the effect HIV has had on heightening the South African adult TB epidemic.
- We have also shown the important impact of TB control interventions on reducing the TB burden.
- ART and TB screening explain most of the declines in TB incidence. Therefore, continued efforts to strengthen ART provision and TB screening are required to sustain the decline in TB incidence.
- DOTS, IPT and Xpert/MTB/RIF had smaller impacts on TB incidence. As such, more innovation in identifying potential and active TB cases (E.g., Biomarkers, digital x-rays, targeted universal testing, urine Lipoarabinomannan) is required.
- There is also a need to improve preventative therapy uptake and target it to other high-risk individuals (E.g., previously treated TB, infected individuals at high risk of progression to TB disease).

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