The implications of using different time horizons when evaluating investment to prevent infectious disease

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Background

- The assumed time horizon in cost-effectiveness analyses can substantially influence the value assessment of medical interventions
- Adopting a lifetime analytic horizon is conventional; however, such long projection periods are not routine for transmission-dynamic modelling, as the uncertainty around future epidemiological dynamics can become unacceptably large, and computational costs can be high.

Objective: We used a case study of novel tuberculosis (TB) vaccine introduction to demonstrate the implications of alternative analytic time horizons when assessing the cost-effectiveness of infectious disease prevention

Methods

- We developed a system of epidemiological and economic models calibrated to demographic, epidemiological, and health service data for India (Clark RA, et al. 2023)
- We assessed a novel TB vaccine for adolescents and adults with 50% efficacy and 10-year duration of protection introduced in 2030, compared to a status-quo baseline scenario
- We examined analytic time horizons of 20, 50, and 200 years to quantify how this choice affected discounted disability-adjusted life years (DALYs) averted, incremental costs (health system perspective), and incremental cost-effectiveness ratios
- For each time horizon scenario, we assumed the vaccination program was implemented across the full time horizon
- Additionally, we used statistical extrapolation methods to project health and cost outcomes over 200 years, based on estimates from 20- and 50-year simulation results, to determine whether this approach could approximate the results of full model runs
- We used generalized additive models to extrapolate annual values of each outcome y_i on a log-linear scale
- We assessed cost-effectiveness against a threshold of the per-capita gross domestic product (GDP) of India in 2023 ($2,485)
- We drew 1,000 random values for each uncertain parameter to generate 1,000 estimates for each outcome of interest

Conclusions

In high-burden, low-resource settings, such as India, the choice of analytic horizon can be influential for economic evaluation of infectious disease prevention programs, even when future outcomes are discounted. Despite the additional epidemiological uncertainties and computation costs, designing evaluations to include long-term intervention consequences can be important. Using statistical extrapolation methods to provide model results over longer time horizons may not be a sufficiently robust approach to reduce the computational burden of long simulation periods when they are unable to project changing trends in outcomes over time

Results

- For intervention vs. status-quo, cumulative DALYs averted increased when extending the analytic time horizon from 20 years to 50 years and 200 years (Table 1)
- However, incremental costs did not increase in proportion as additional cost savings due to averted disease accumulated as the analytic time horizon lengthened
- These cost savings yielded improvements in cost per DALY averted, with TB vaccination found to be cost-effective compared to 10% of per-capita GDP at a 20-year analytic time horizon, compared to 5% of per-capita GDP at a 50-year horizon, and compared to 3% of per-capita GDP at a 200-year horizon

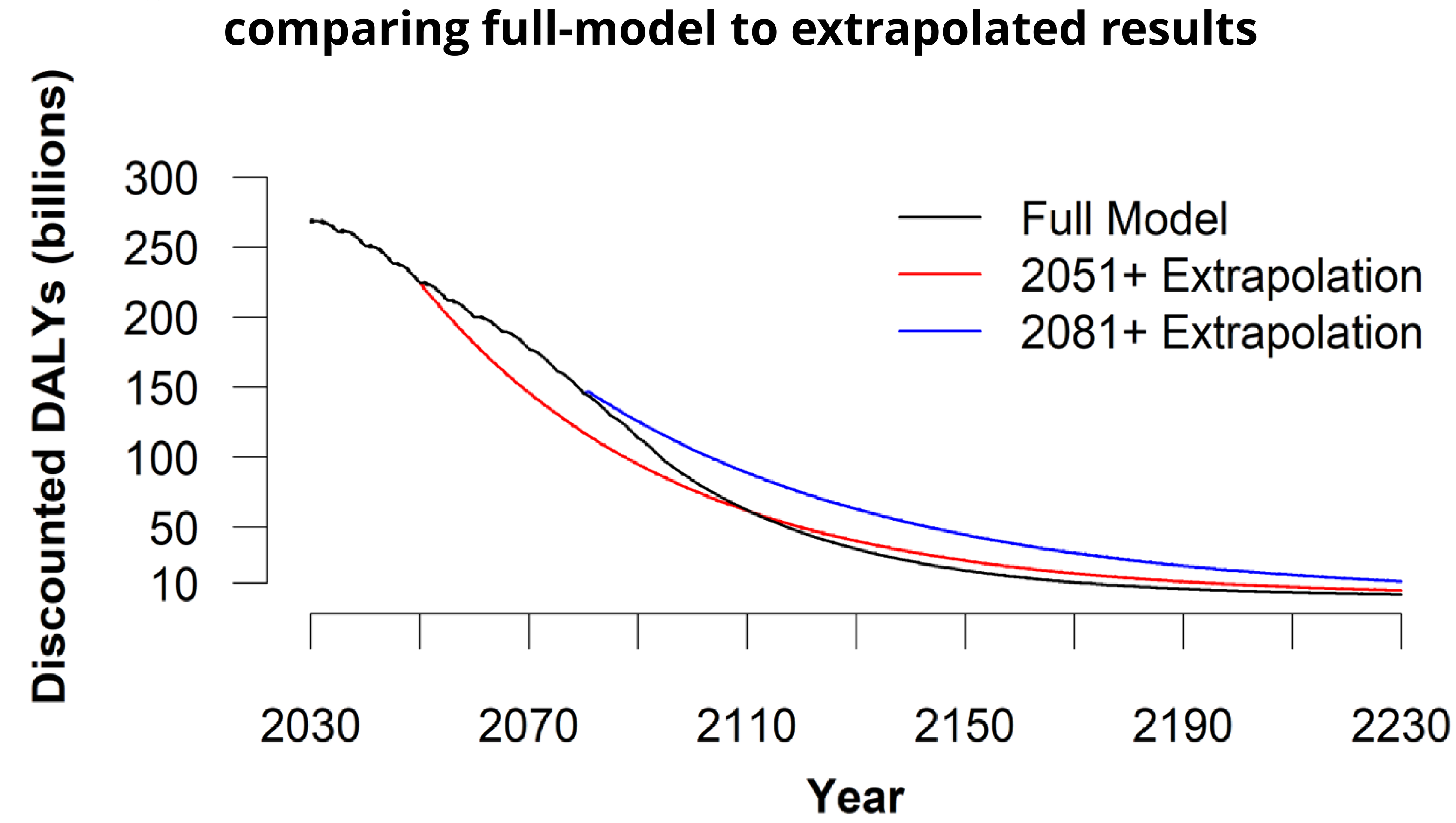
Table 1. Discounted health system costs (USD), DALYs averted, and cost-effectiveness of novel tuberculosis vaccines

Analytic time horizon	Incremental cost (billions)	DALYs averted (millions)	Cost per DALY averted
2030–2050	11.8 (9.0–16.6)	69.8 (62.5–79.6)	170 (125–243)
2030–2080	12.2 (8.8–18.2)	141 (126–161)	87.1 (60.6–131)
2030–2230	11.7 (7.9–18.4)	193 (172–221)	61.0 (39.3–96.4)
2030–2050–extrapolated to 2230	10.3 (6.4–16.6)	220 (190–271)	47.3 (26.0–79.3)
2030–2080–extrapolated to 2230	11.0 (7.1–17.5)	183 (161–213)	60.4 (37.2–100)

Costs from the health system perspective include vaccination costs and tuberculosis testing and treatment costs. Values in parentheses represent equal-tailed 95% credible intervals.

- Statistical extrapolation based on estimates from 20- and 50-year simulation results yielded incremental cost and benefit outcomes that were up to 14% and 6% different on average, respectively, than full-model runs (highlighted section, Table 1)
- However, extrapolation based on longer simulation results (50-year vs. 20-year) more closely approximated the full-model incremental cost-effectiveness ratio (within 1% vs. within 23%)
- Statistical extrapolations did not capture trends in the full-model outcomes that occurred beyond the simulated time horizon (Figure 1)
- Statistical extrapolations may miss important variations with implications for the evaluation of investment to prevent infectious disease

Figure 1. Discounted DALYs for the vaccination scenario comparing full-model to extrapolated results



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