An Economic Analysis of HIV Vaccine Research and Development

Simiao Chen

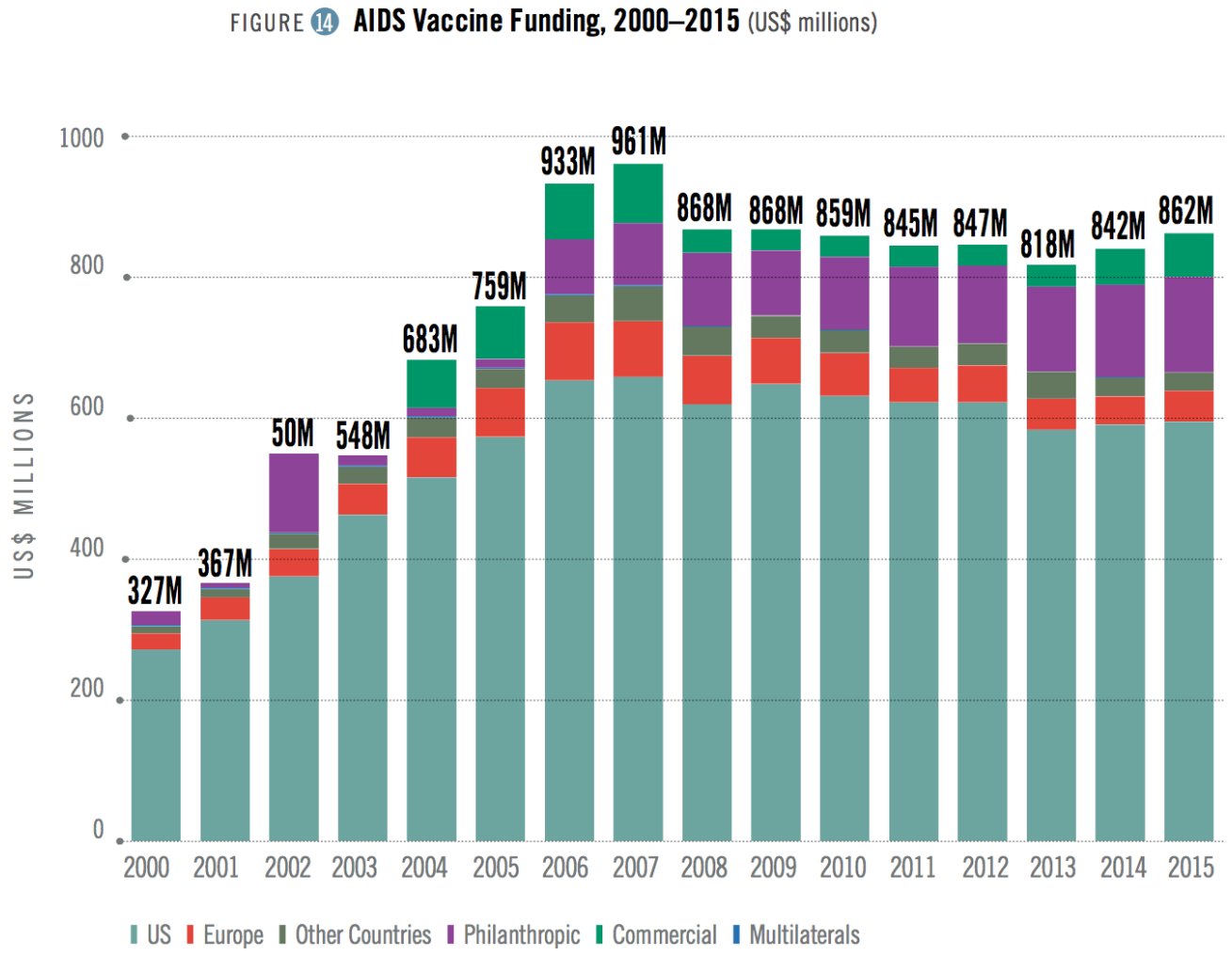
Outline

- Background
- Research Objectives
- Contribution
- Model Setup
- Results
- Conclusion

Background

- First HIV vaccine clinical trial was conducted in 1987
- First efficacious trial—RV144
  - Shows 31.2% efficacy
  - This is the first, and to date only, large clinical trial demonstrating efficacy for an HIV vaccine
- Multiple vaccine clinical trials on the way
  - HVTN 100 was conducted in 2015
  - HVTN 702 was conducted in 2016

Background



www.hivresourcetracking.org

- Development of vaccine is costly
  - RV144 trial costs $105 million
- Too much uncertainty
  - Vaccine attributes
  - Development time

Motivating Questions

- Should the world continue to invest in developing and establishing an HIV vaccination when several efficacious HIV prevention and treatment strategies already exist?
- Whether an annual global funding of $900 million on HIV vaccine R&D is worthwhile, or we should invest the same amount of money on alternative interventions such as male medical circumcision (MMC), antiretroviral therapy (ART), and treatment as prevention (TasP)?

Contribution

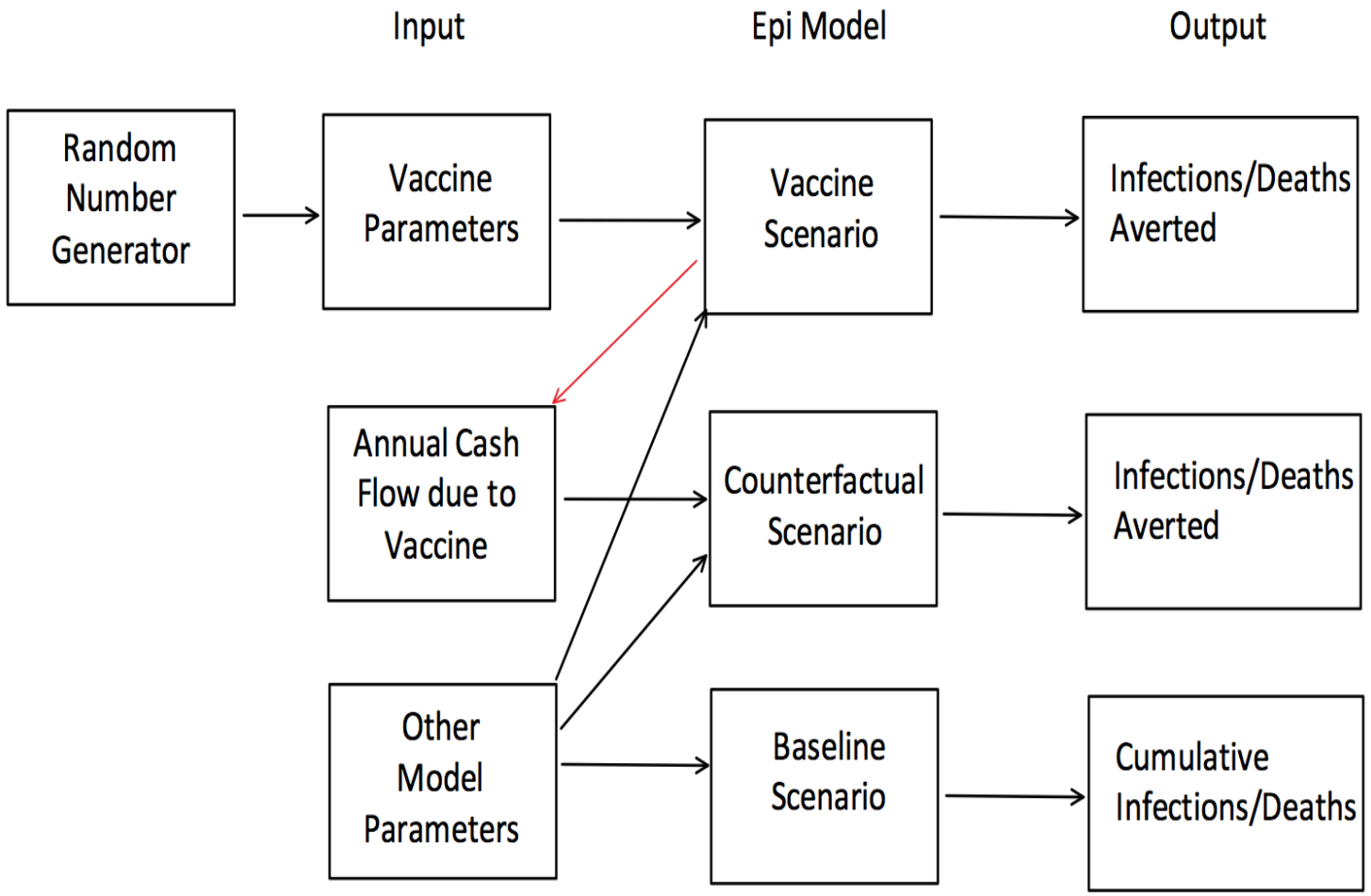
- First to address the question from the perspective of opportunity cost
  - Benefit would have been achieved if we invest the same amount of money on alternative interventions
- Unlike previously adopted frameworks, our approach also accounts for uncertainties that affect potential cost-effectiveness of an HIV vaccine
  - We not only consider uncertainty in vaccine attributes including efficacy, duration of protection, unit cost and speed of efficacy decay, but also uncertainty in the time horizon of developing an effective HIV vaccine
- This model is flexible and could also be used to explore whether it is economic viable to invest in those interventions involving uncertainty

Model Setting

- We model the HIV epidemic (with vaccine) using a discrete dynamic model from Chen et al (2017)
- Focus on South Africa
  - Vaccine development is a global effort, but it is not practical to consider all countries due to tractability reasons
  - South Africa has the largest HIV-positive population and one of the highest incidence rate
- Funding for vaccine development is allocated to South Africa proportional to its share of HIV-positive population in the world
  - Annual investment in vaccine is about $900 million. 19% of the world's HIV positive population is in South Africa
  - In counterfactual scenario, we assume 19%*900 million should be invested on alternative interventions for South Africa

Model Structure

- Random input: 1) T: the number of years it takes to develop and implement an effective HIV vaccine, which is a random input parameter for our model; 2) Four HIV attributes: *efficacy*, *duration of prevention*, *speed of efficacy decay* and *unit price*
- Baseline scenario: a status quo scenario, we assume ART (30.3%), MMC (46.5%) and TasP(0%) in 2012 to ART (80%), MMC (80%) and TasP(0%) in 2035 then stay constant from 2035 to 2075.
- Vaccine scenario: continuous investment on the HIV vaccine research until an effective HIV vaccine is obtained.
- Counterfactual scenario: all the resources invested in vaccine development previously are now diverted to alternative interventions (ART, MMC, and TasP) in the most cost-effective way
- Investments in HIV vaccine include both R&D cost (before time T) and implementation cost (after time T)



Probabilistic Analysis

- In our analysis, the expected vaccine introduction year is assumed to be 2027, which is consistent with the assumption of vaccine introduction between 2025 and 2030 in the investment framework enhanced (IFE) proposed by the Joint United Nations Programme on HIV/AIDS (UNAIDS) (Harmon et al. (2016)). Hecht et al. (2011) suggests it takes at least 5 years to develop an HIV vaccine.
- The uncertainty surrounding input parameters are addressed by generating the prior distributions through the model using Monte Carlo simulations, where values for the inputs are randomly drawn from corresponding distributions. The simulation is repeated 100,000 times, the output of which provides a distribution of outcomes for both scenarios.
- Parameters of the distribution are taken from estimates in International AIDS Vaccine Initiative (2007).

Parameter	Distribution	Mean (Range)	Standard Deviation
Efficacy	Beta	0.5 (0.3-0.7)	0.12
Duration	Beta	10 (5-15)	2.89
Unit Cost	Beta	10 (2-18)	3.46
Time For Vaccine Development	Gamma	12 (5-∞)	3

Table 1: Distribution of Input Parameters.

Results

- Flat → increase → decrease → increase again
- It takes at least five years to successfully develop a vaccine → once we successfully develop a vaccine, we need to spend money on massive implementation → after the first round of vaccination, the annual cost of implementation is very small since almost everyone has been vaccinated → a rapid growth of HIV-negative population need to be vaccinated

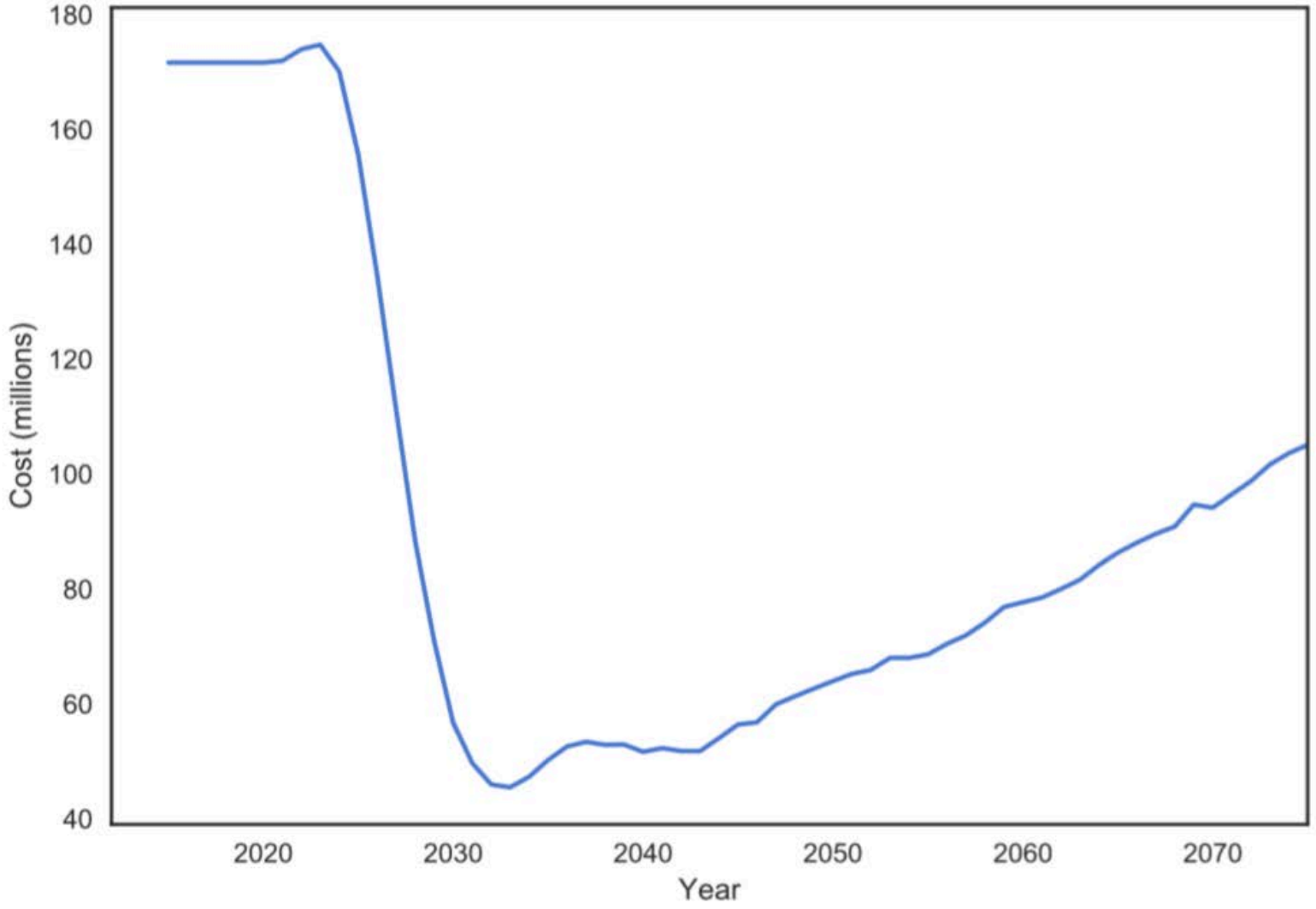


Figure 3: The average cost of HIV vaccine R&D and implementation.

Results: HIV prevalence

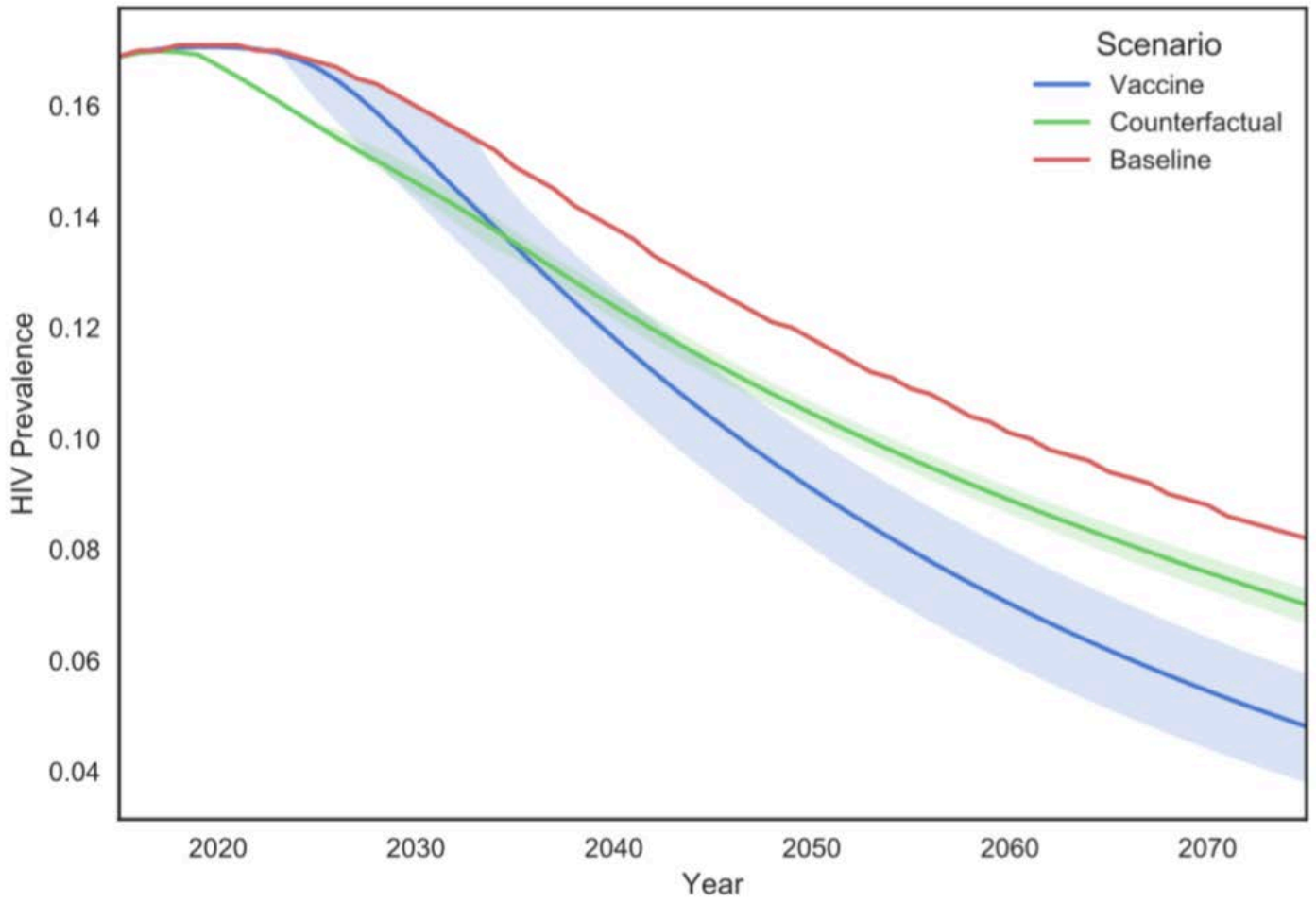


Figure 4: Projections of average HIV prevalence rate under each scenario. The shaded area is 95% confidence interval.

Results: HIV Incidence

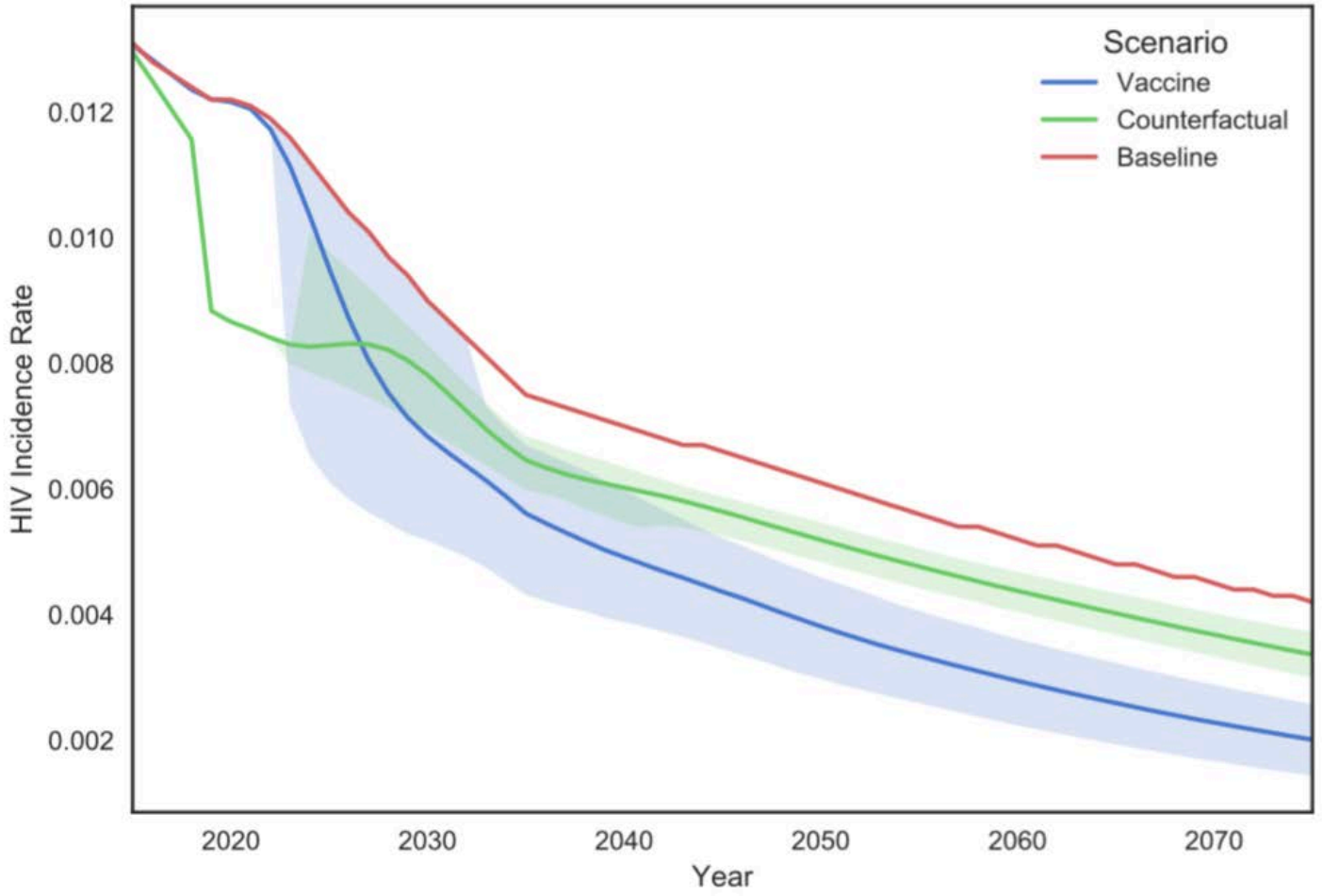


Figure 5: Projections of average HIV incidence rate under each scenario. The shaded area refers to the 95% confidence interval.

Results

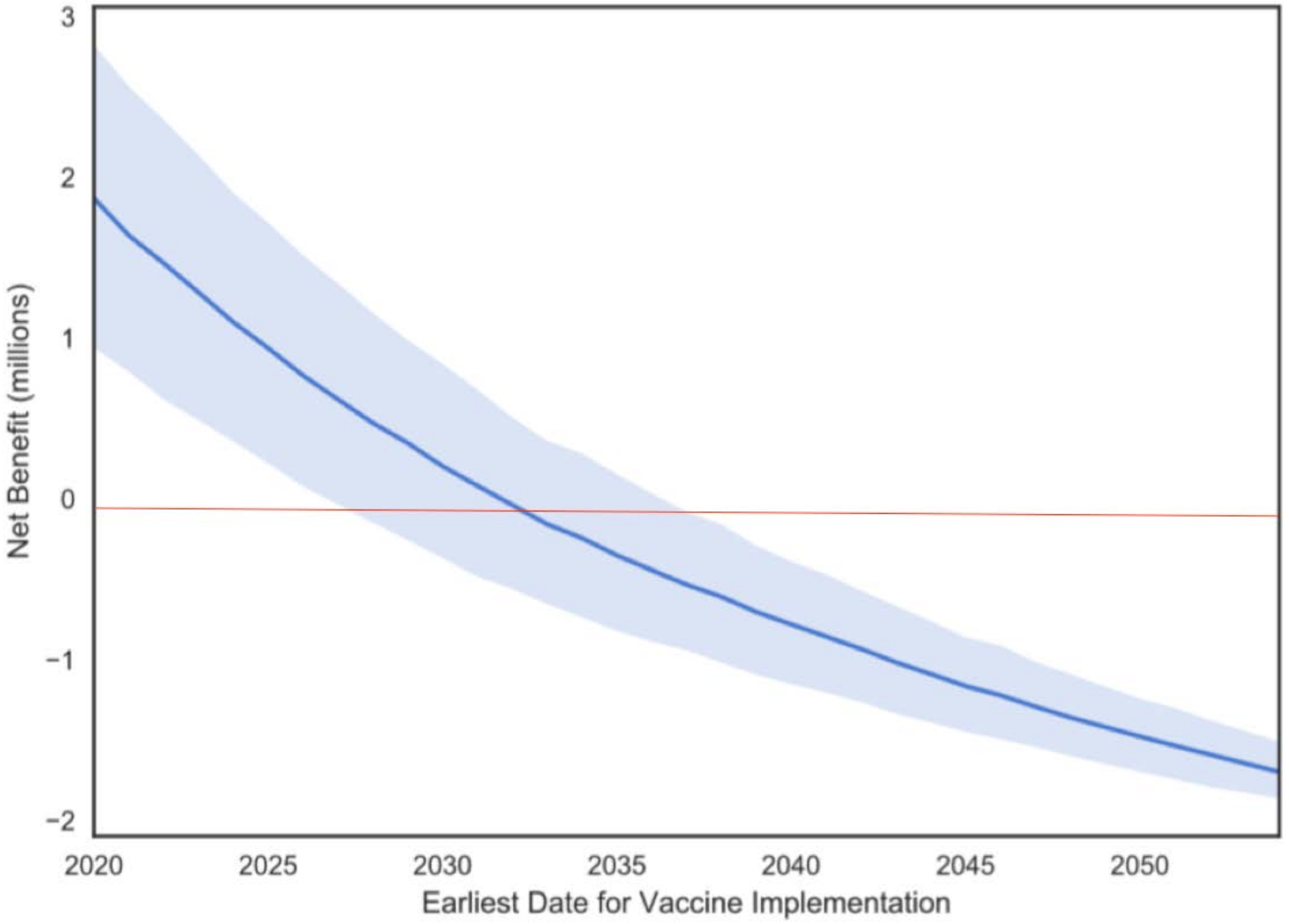


Figure 6: The Net Benefit of HIV Vaccine Development as a Function of the Earliest Date for Massive Implementation.

Conclusion

- Although it may seem attractive to invest in current interventions such as MMC, ART and TasP, investment in HIV vaccine is rewarding in the long run.
- It is worthwhile to invest in vaccine if we can get a vaccine before 2033.
- It is highly impossible to be worthwhile for vaccine investment if a vaccine is available after 2038. (Prob(Net benefit>0) < 2.5%)

Thank You!