A Portfolio Approach for HIV Control in South Africa

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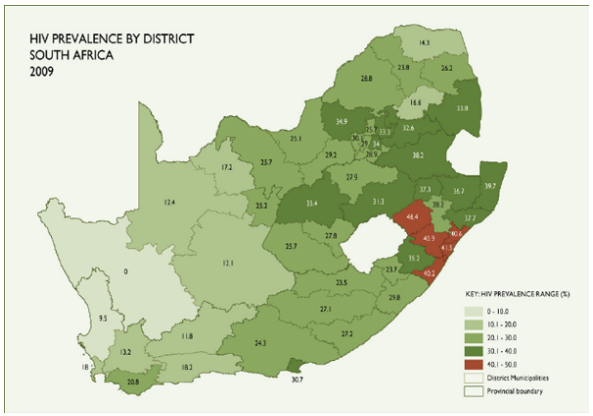
HIV in South Africa

- Largest HIV epidemic in the world
  - 5.3 million HIV+ adults (18%)
  - 300,000 HIV+ children
  - 310,000 AIDS-related deaths in 2009
- Disproportionately afflicts young people
  - GDP reduced by 17% over next 10 years due to HIV
- Increasing antiretroviral therapy (ART)
  - 1 million (2010) to 1.4 million (2011) people on ART
- HIV Counseling and Testing (HCT) campaign
  - >10 million people tested in 2011



Recent HIV clinical trials

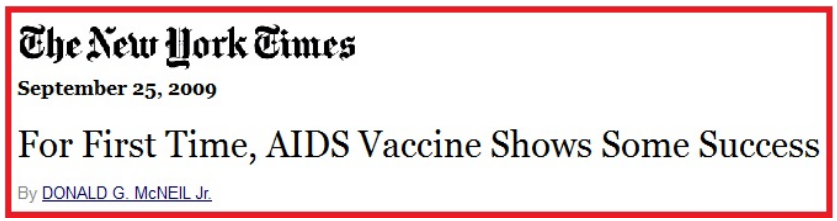
	Control		Intervention		Efficacy	
	n	HIV+	n	HIV+	(95% CI)	p-value
Male circumcision	5497	141	5411	64	0.50 (0.28-0.66)	0.0002
South Africa, Kenya, Uganda (2005-07)						
Vaccine	8198	74	8197	51	0.31 (0.01-0.52)	0.04
Thailand (2009)						
Microbicide	444	60	445	38	0.39 (0.06-0.60)	0.017
KwaZulu-Natal, South Africa (2010)						
Early treatment	882	27	893	1	0.96 (0.73-0.99)	$<$0.0001
Africa, Brazil, India, Thailand, US (2011)						


THE WALL STREET JOURNAL.
WSJ.com

LEADER (U.S.) | JULY 5, 2005

Study Says Circumcision Reduces AIDS Risk by 70%

Findings From South Africa May Offer Powerful Way To Cut HIV Transmission


The New York Times

September 25, 2009

For First Time, AIDS Vaccine Shows Some Success

By DONALD G. McNEIL Jr.


npr

Scientists Say A Gel Can Slow HIV Spread

July 23, 2010

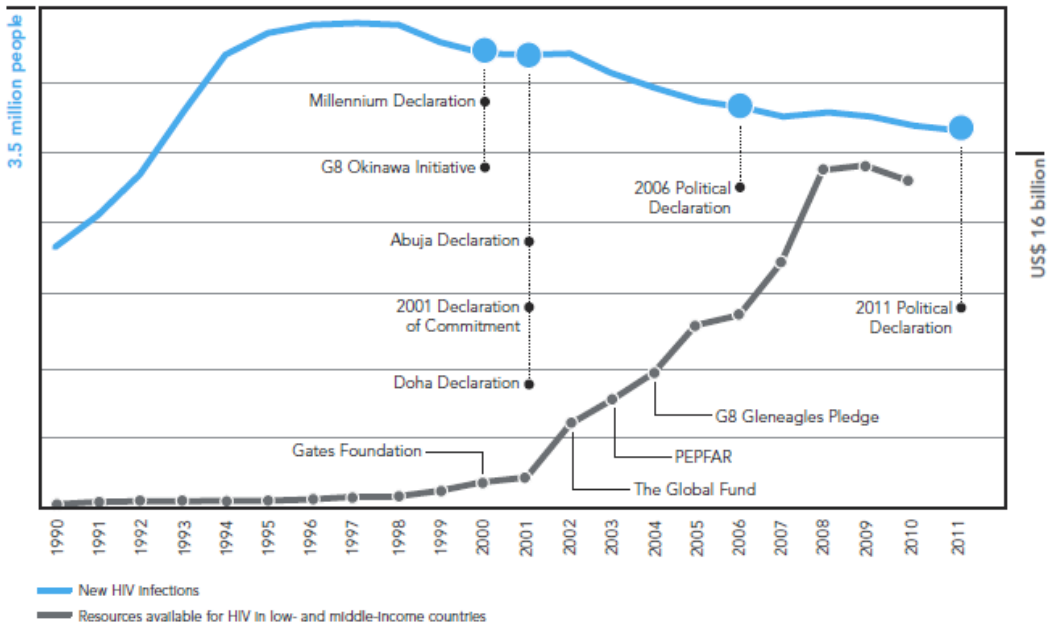

The New York Times

Early H.I.V. Therapy Sharply Curbs Transmission

By DONALD G. McNEIL Jr.
Published: May 12, 2011

2011 Political Declaration

Joint United Nations Programme on HIV/AIDS (UNAIDS)



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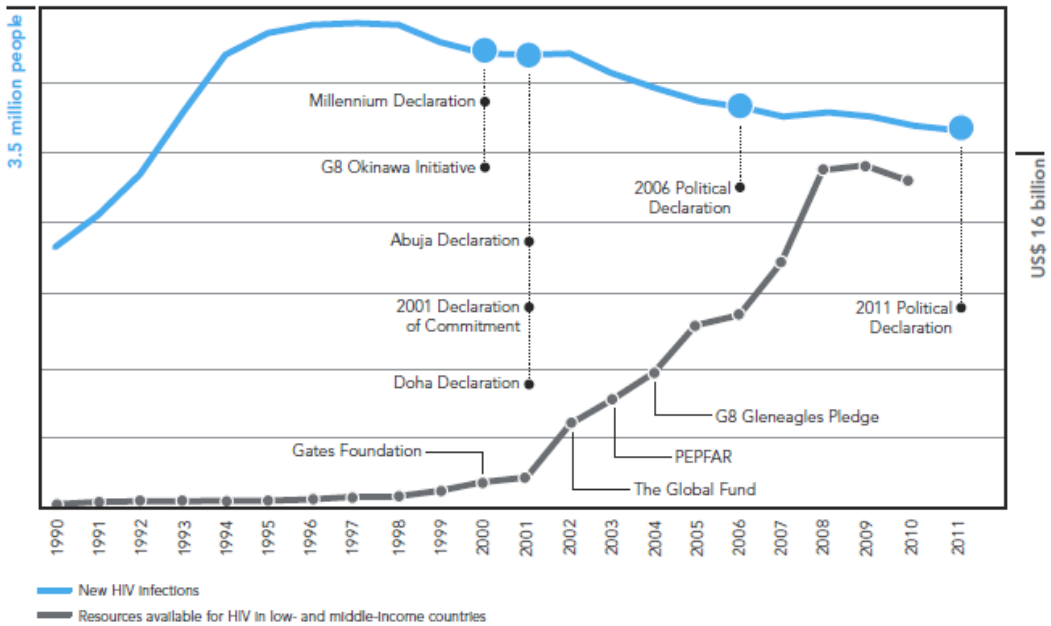

"The framework represents a radical departure from current approaches, and has 4 aims

1. Maximizing the benefits of the HIV response,
2. Using country-specific epidemiology to ensure rational resource allocation,
3. Encouraging countries to implement the most effective programmes based on local context,
4. Increasing efficiency in HIV prevention, treatment, care and support."

Research questions

- **What is the effect of implementing a portfolio of partially effective HIV interventions in South Africa?**

- HIV screening
- Antiretroviral treatment (2010 WHO guidelines)
- Male circumcision
- Microbicide
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- **Is there an optimal portfolio, given limited resources?**

Study overview

1. Develop a **dynamic HIV epidemic model** to evaluate the cost-effectiveness of alternative portfolios in South Africa.
   (a) Heterosexual transmission, disease progression, morbidity, mortality
   (b) Parameterization - epidemiologic, demographic, behavioral, clinical data
   (c) Outcomes - HIV prevalence, incidence, costs, QALYs, cost-effectiveness
   (d) Time horizon - 10 years
   (e) Implementation - Matlab 2011, Runge-Kutta 4th-order solution technique

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3. Incorporate a **Monte Carlo simulation** for probabilistic sensitivity analysis on program efficacies.

Portfolios considered

- Select individual interventions
- Select combinations
- All 3,500 combinations

ART	Screening	Circumcision	Vaccine	Microbicide
50%	every 3y	0	0%	0%
60%	every 2y	0.10	25%	25%
70%	every 1y	0.20	50%	50%
75%	every 6m	0.30	75%	75%
80%		0.40	100%	100%
90%				
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Deterministic results

Intervention strategy	HIV cases averted (%)		
	Men	Women	Total
Antiretroviral therapy (CD4 350 cells/mm^3)	17.5	16.0	16.7
Screening	21.7	26.9	24.5
Screening & ART	41.3	45.7	43.7
Male circumcision	18.5	6.5	12.1
Microbicide	10.5	30.4	21.1
Vaccine	25.8	26.7	26.3
Circumcision, Microbicide & Vaccine	43.9	51.4	47.9
Combination (all 5 programs)	64.5	72.4	68.7

- Screening and ART have increasing returns $\Rightarrow$ *complements*.
- Circumcision, microbicide, vaccine have decreasing returns $\Rightarrow$ *substitutes*.
- Reduced secondary transmission is an important consideration.

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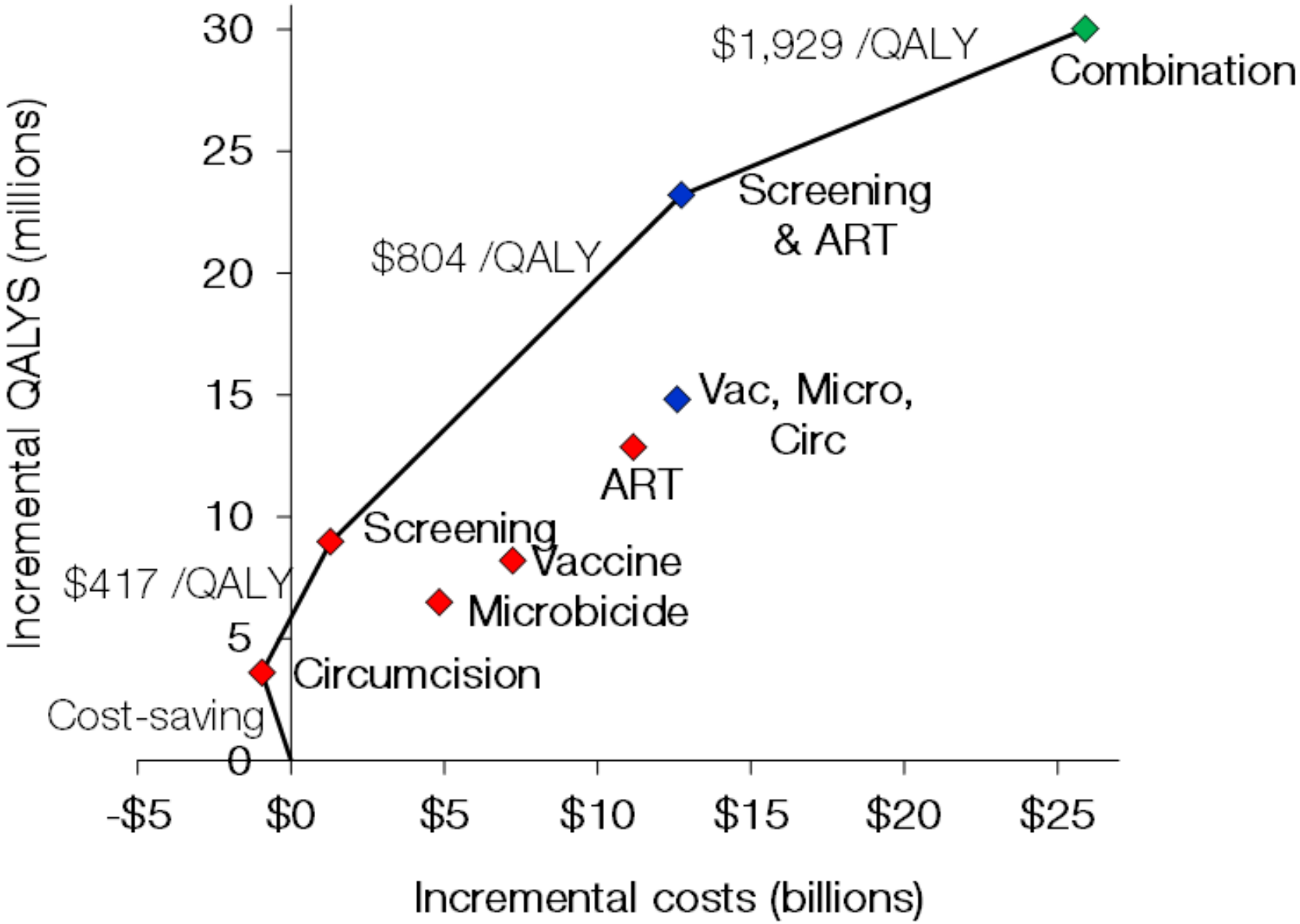
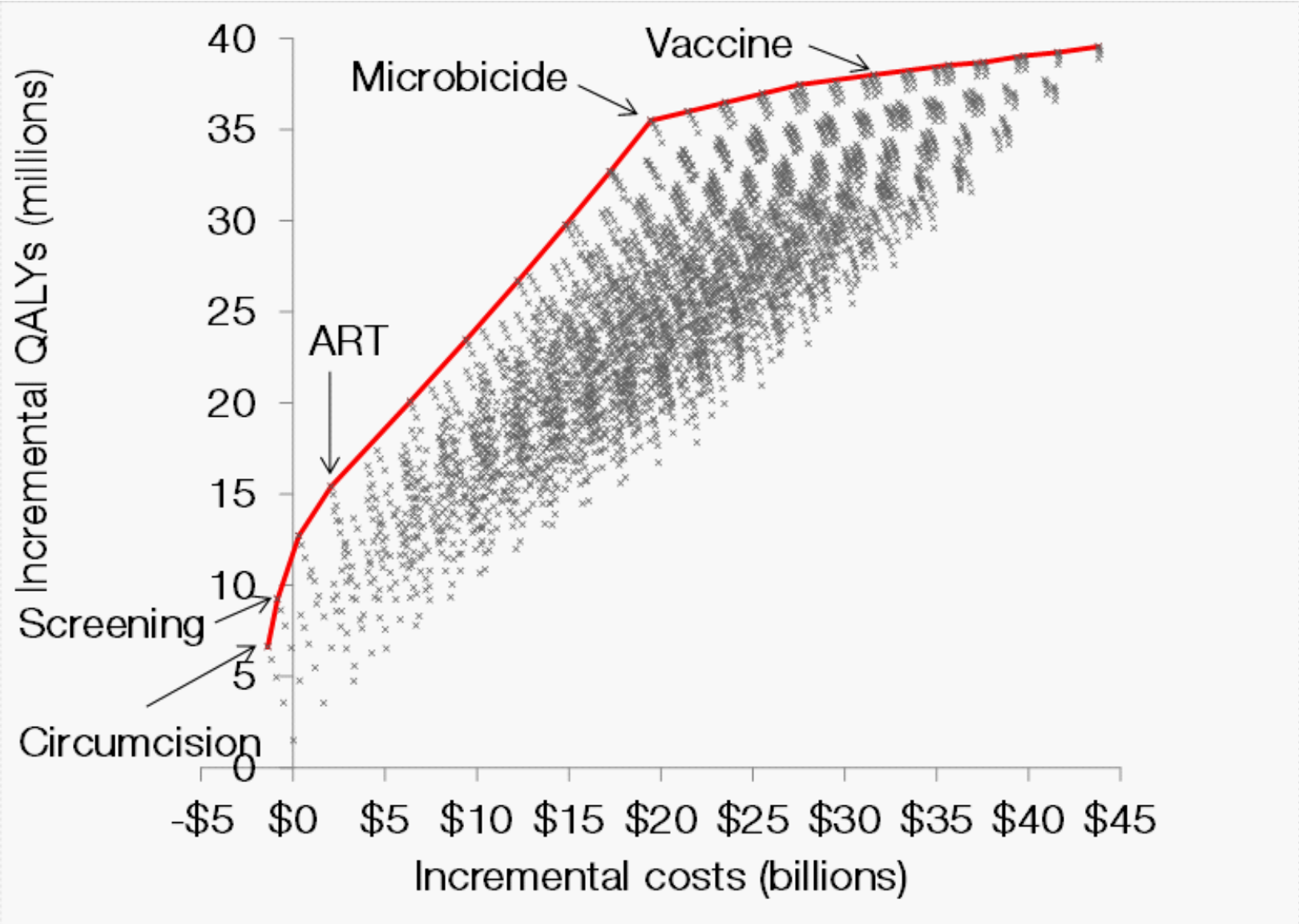
Cost-effectiveness analysis

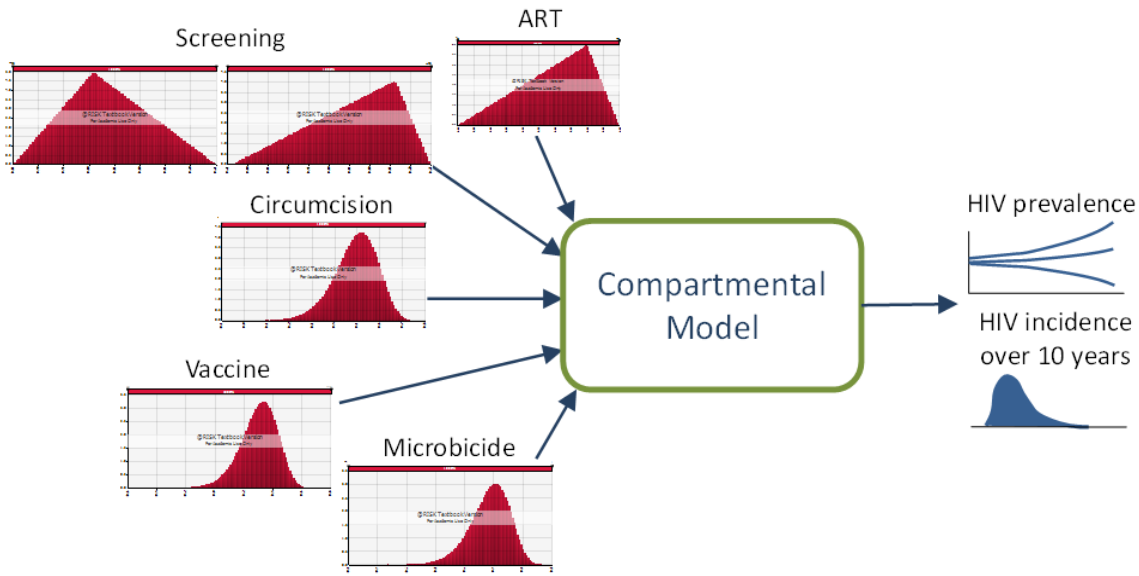


Efficient vs optimal portfolio

Maximize QALYs



Monte Carlo simulation (intervention effectiveness)



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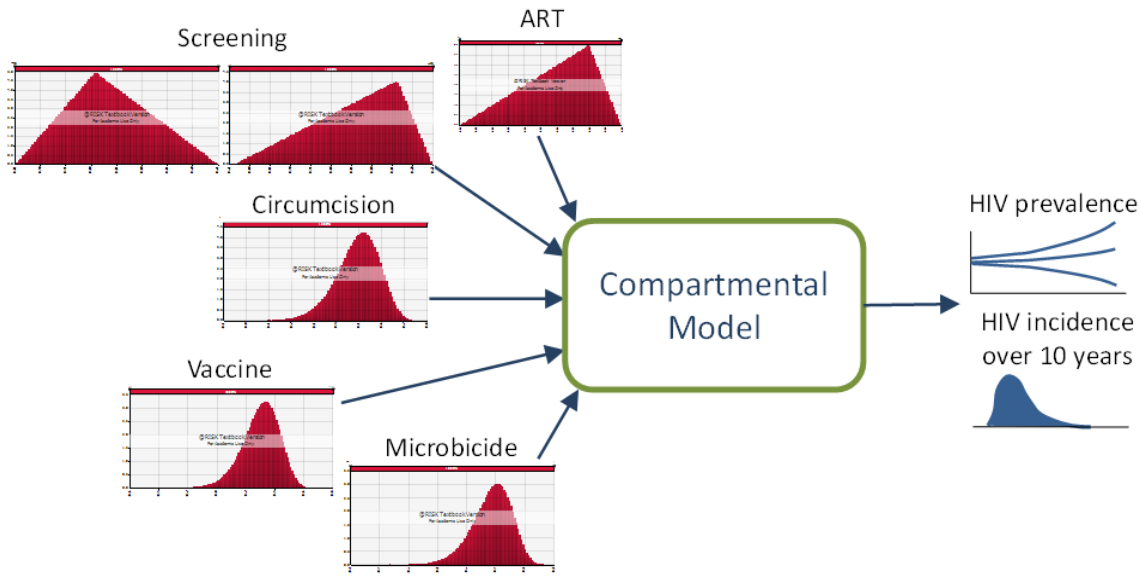
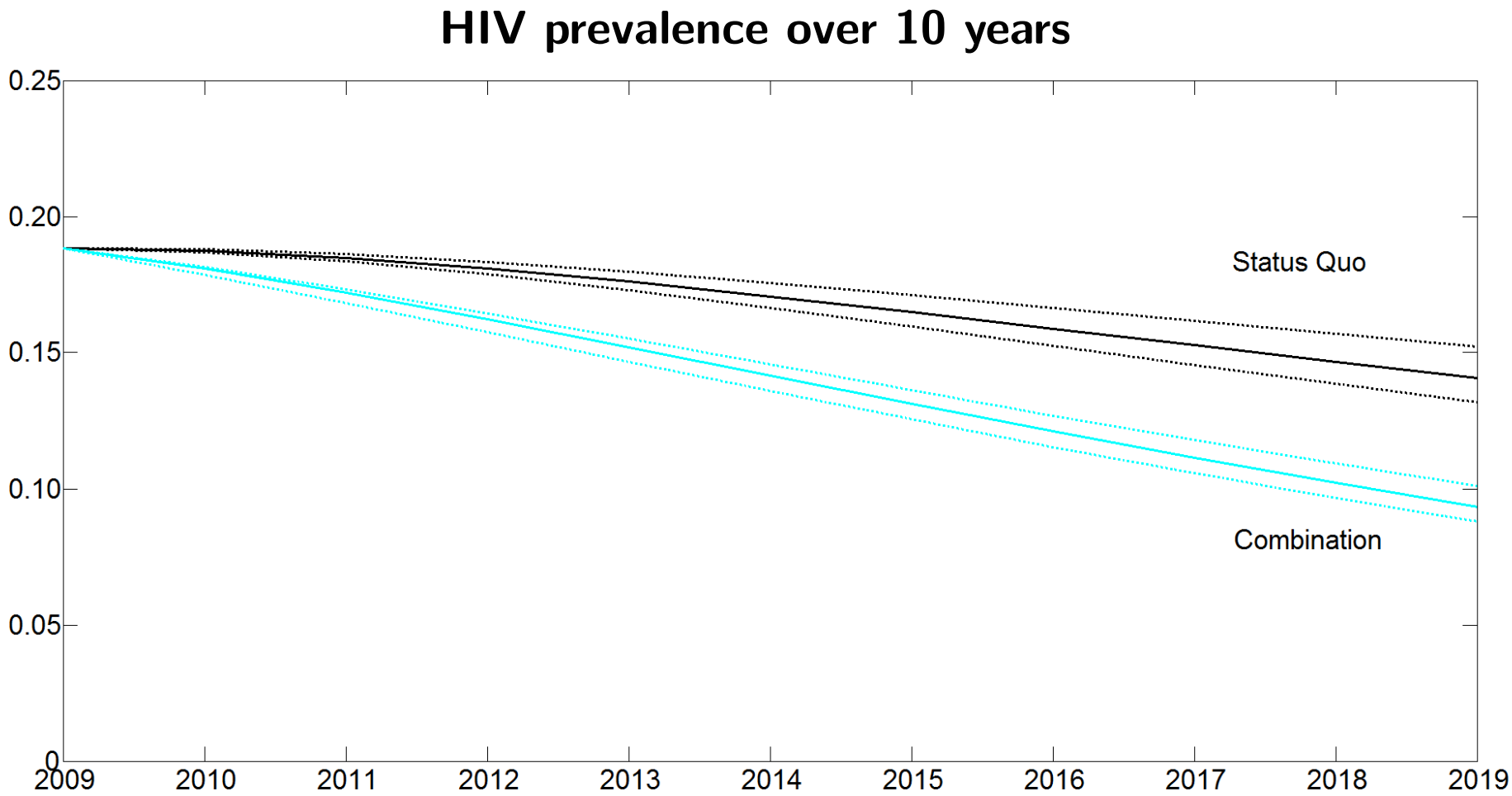


Intervention effectiveness	Probability Distribution
Male circumcision	$1-\exp\left[Normal(-0.6932, 0.1914)\right]$
Vaccine	$1-\exp\left[Normal(-0.3737, 0.1818)\right]$
Microbicide	$1-\exp\left[Normal(-0.4855, 0.2180)\right]$
Screening (condom use if screened)	
Uninfected	$Triangular(0.35, 0.50, 0.75)$
HIV-infected	$Triangular(0.26, 0.66, 0.75)$
Antiretroviral therapy	$Triangular(0.50, 0.90, 1.00)$

Simulation results



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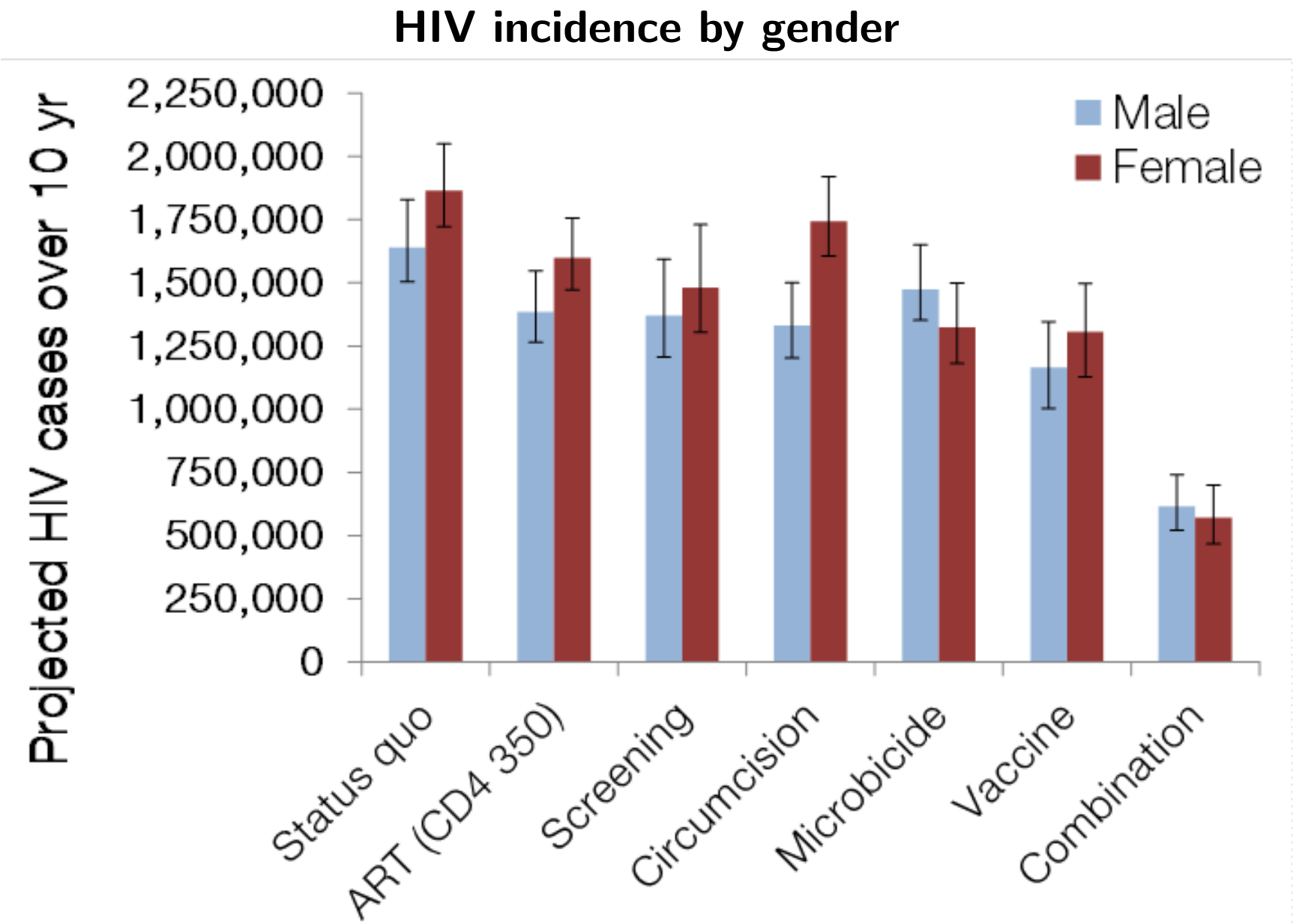
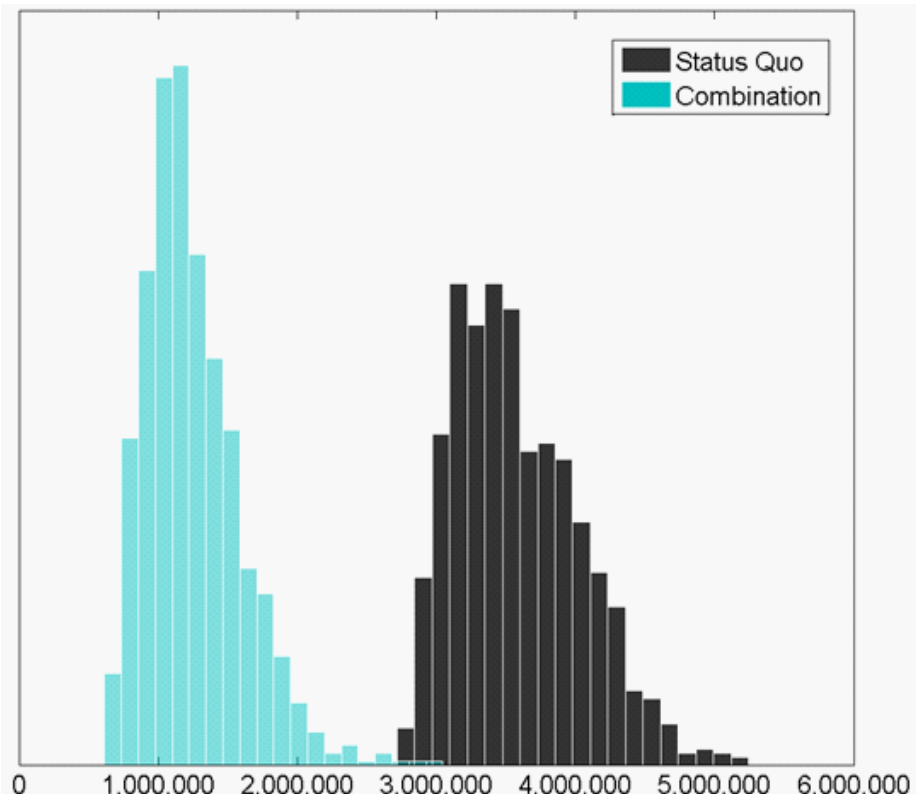
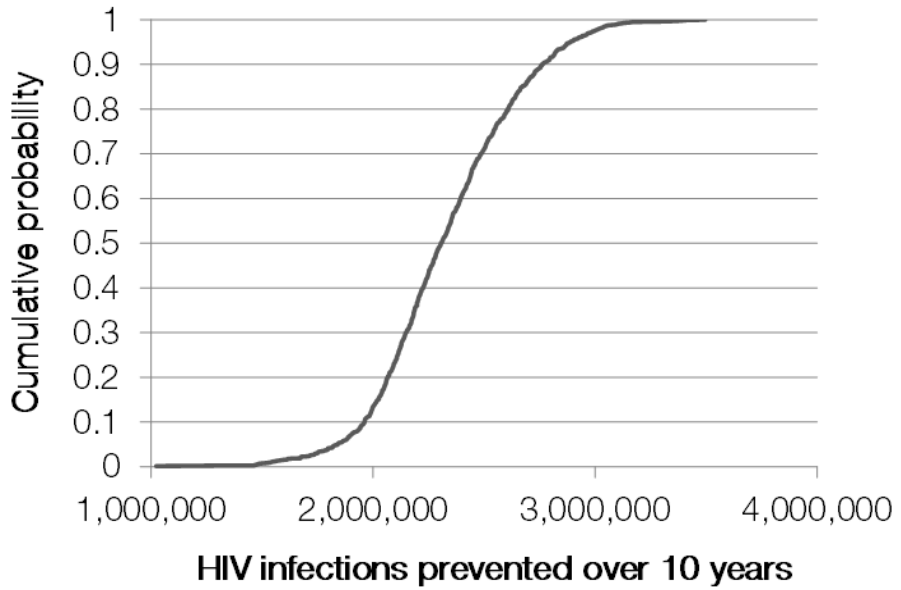


Simulation results

HIV incidence over 10 years



HIV infections prevented



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4. Even with substantial uncertainty in efficacy, a combination portfolio prevents more than 2 million HIV cases over 10 years with high probability.
5. Given limited resources, the optimal portfolio of interventions can be determined.

Thank you!

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