

COVID-19 Mathematical Models

May 7, 2020

Agenda

- **Welcome/Introductions - AVAC**
- **Introduction to COVID-19 models - John Stover**
- **Teaser: “Build your skills to understand and use mathematical models” course – Nadia Carvalho**
- **Discussion: COVID-19 models & HIV – Katharine Kripke & John Stover**
- **Q&A**

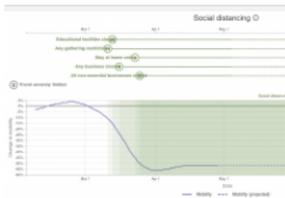
Introduction to COVID-19 Mathematical Models

John Stover

top Washington Post

Draft report predicts covid-19 cases will reach 200,000 a day by June 1

White House officials have been relying on other models to make decisions on reopening, including the IHME model and a “cubic model” ...



MAY 4, 2020

New IHME Forecast Projects Nearly 135,000 COVID-19 Deaths in US

News Release

New COVID-19 forecasts for the US project nearly 135,000 deaths through the beginning of August, according to the Institute for Health Metrics and Evaluation (IHME) at the University of Washington.



Aljazeera.com

Report: US model projects eight-fold increase in COVID-19 cases

Report: US model projects eight-fold increase in COVID-19 cases. Document projects that coronavirus could kill 3,000 Americans a day by the



FiveThirtyEight

Where The Latest COVID-19 Models Think We're Headed — And Why They Disagree

Models predicting the potential spread of the COVID-19 pandemic have become a fixture of American life. Yet each model tells a different story ...

COVID-19 models take the center stage

Purpose of models

- **Forecast what might happen**

How many people are likely to become infected?

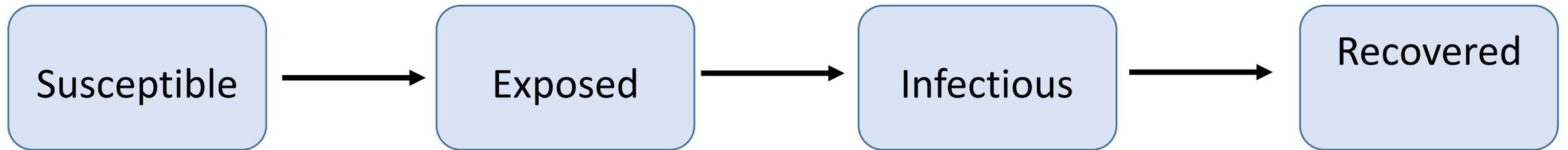
- **Project what could happen under certain conditions**

When is the peak of new infections expected?

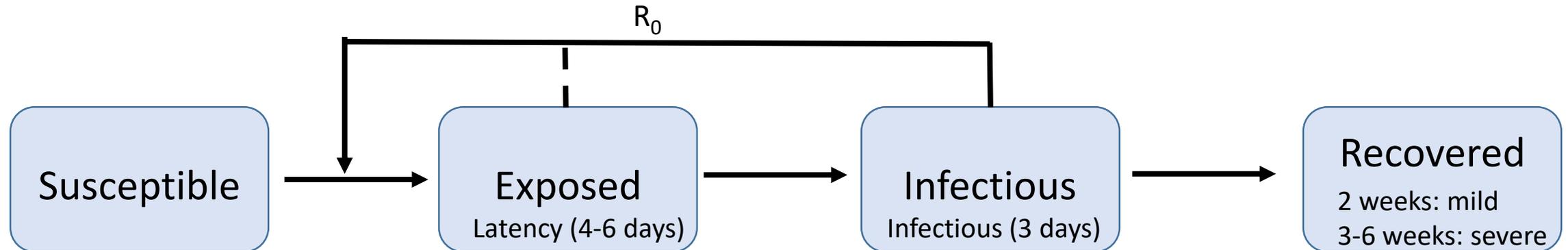
- **Explain how something happened**

When did the virus begin circulating in the US?

S-E-I-R Models of Infectious Diseases



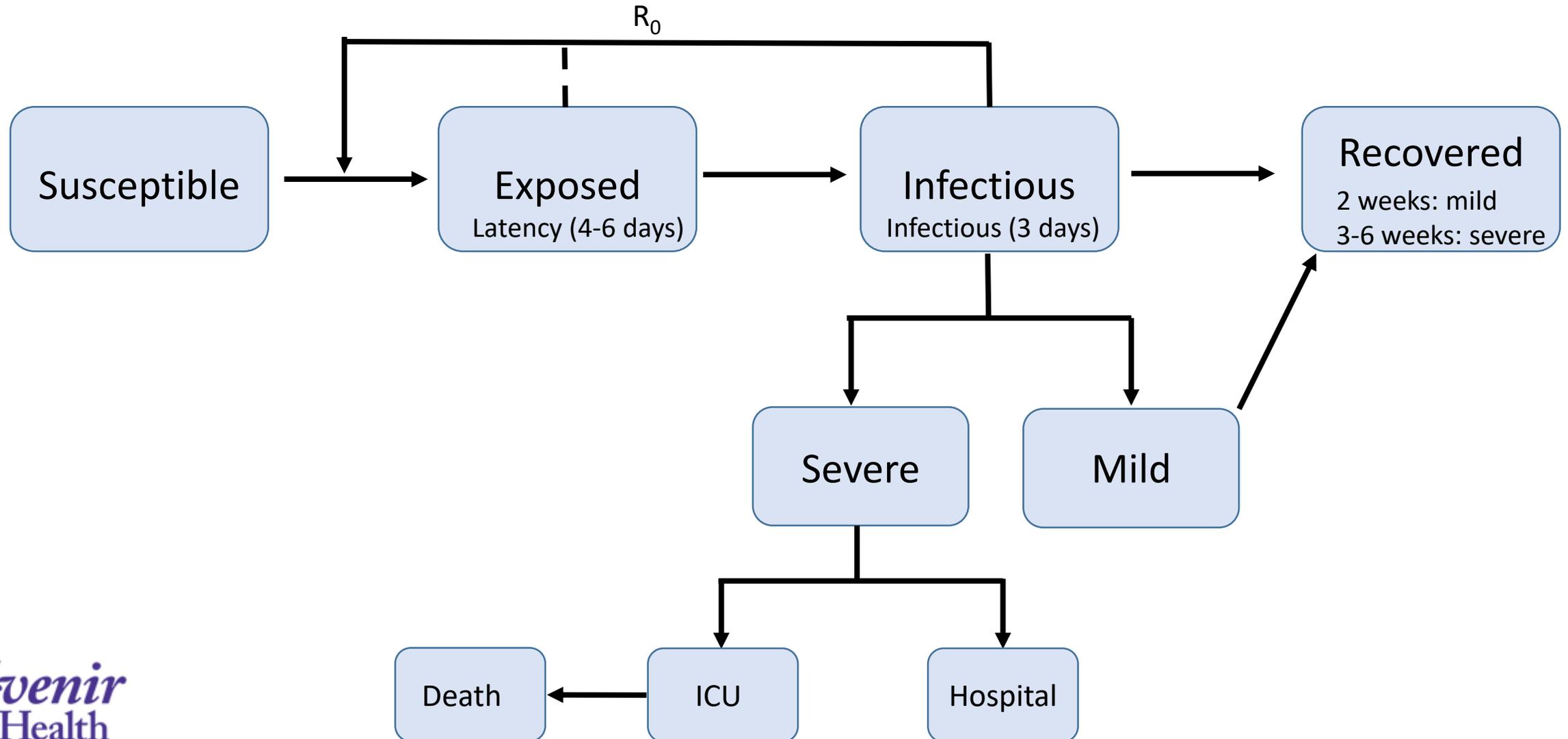
S-E-I-R Models of Infectious Diseases



R_0

- Initial values may be assumed, based on data from Wuhan, or fitted to data on reported cases or deaths
- May vary by severity of infection
- Will be different by geographic location
- Will depend on contact rates.
- Contact rates can vary by age, type of work, transportation patterns, day of week

S-E-I-R Models of Infectious Diseases



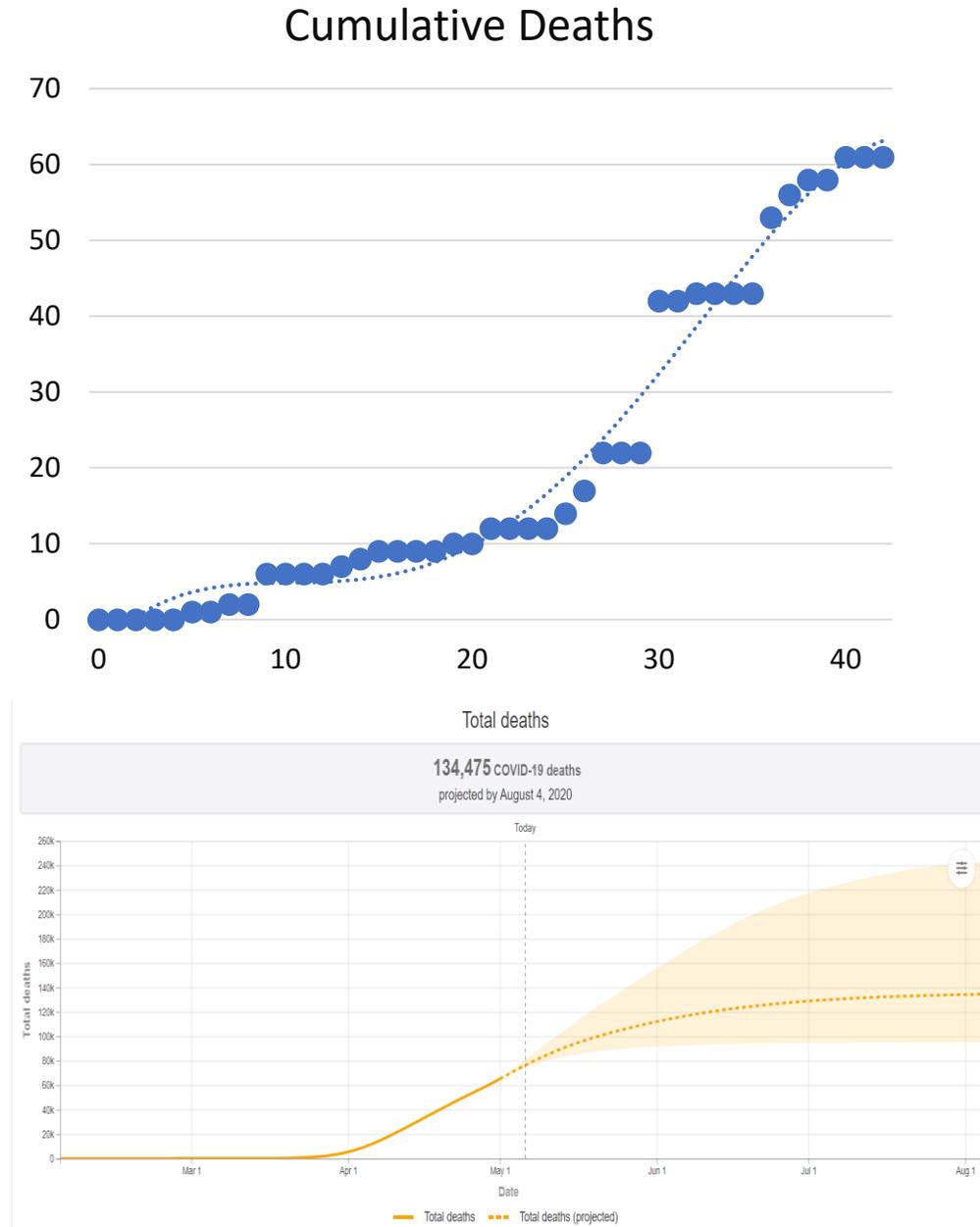


SEIR Models

Model	Characteristics
United States	
Imperial College: UK/US	Agent-based model with age disaggregation
Columbia University	County estimates
Northeastern University	US
University of Texas	Major metropolitan areas
MIT/Hartford HealthCare	State level
International	
Imperial College	Detailed age disaggregation and contact matrix
Maher Model, Univ of Basel, CIVD-19 Scenarios	Aggregate model, easy-to-use web interface
London School of Hygiene and Tropical Medicine (CMMID)	Web application, social distancing
Country-specific models	South Africa, Kenya, Malawi, India

Statistical Models

- Develop equations to relate indicators of interest directly to output indicators
 - Deaths \leftarrow duration of epidemic, location, social distancing
 - Hospitalizations \leftarrow cumulative deaths
- IHME COVID-19
 - Regular updates, nice website, state level forecasts
 - Early version based on data from Wuhan, Italy, Spain, King County (USA)



Model Projections

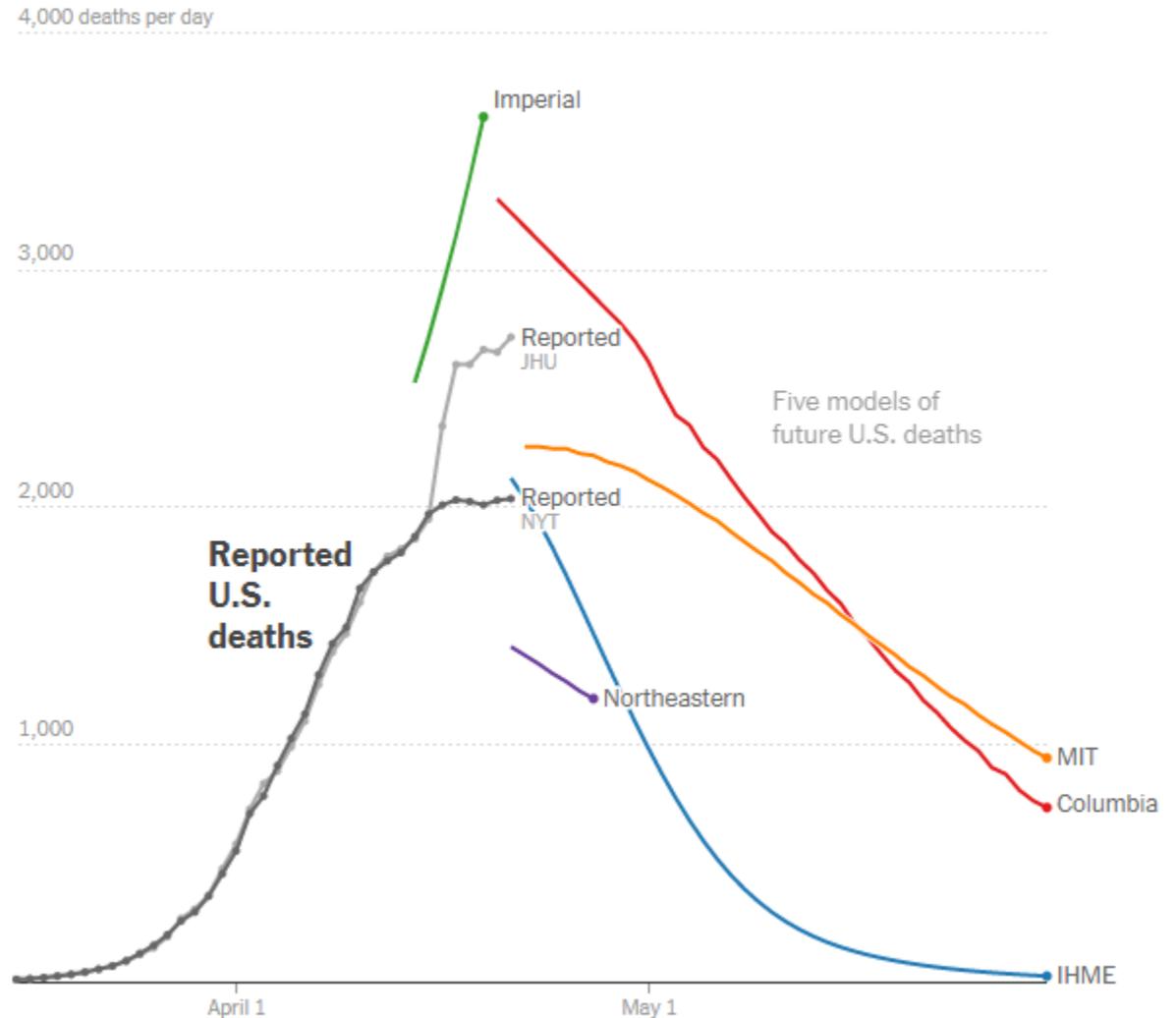
Different models will produce different forecasts based on:

- Model structure
- Data sources
- Modeling teams
- Model focus
- Projection assumptions

New York Times

<https://www.nytimes.com/interactive/2020/04/22/upshot/coronavirus-models.html>

U.S. coronavirus deaths in five different forecasts



Reported deaths are rolling 7-day averages. Lines differ on whether to include roughly 5,000 probable deaths in New York City.

Latest model projections for Northeastern, I.H.M.E. and M.I.T. are April 21; Columbia is April 19; Imperial is April 13.

Build your skills to understand and use mathematical models

Nadia Carvalho

Build your Skills to Understand and Use Mathematical Models!

Do you want to learn more about mathematical models? Do you want to gain valuable skills to help you understand the findings from mathematical modeling, and to use these in your advocacy efforts or your journalistic work? Did you miss one of the earlier mathematical modeling webinars but still want the information. Then this is the course for you!

- 14 participants enrolled thus far
- Start mid-May
- 6 lessons
- Self-paced, pre-recorded videos, assignments to practice your skills, lots of resources!



Mathematical modeling is a powerful tool for health policy evaluation, decision-making, health planning, policy dialogue, and advocacy.

- The insights gained from mathematical models can influence real world decisions.
- Advocates can engage with modeling to communicate modeling results to their community, examine the data and assumptions used to inform modeling results, and support or reject policy decisions based on models.

- ▶ **L** Introduction
- ▶ **L** Lesson 1. What are Mathematical Models?
- ▶ **L** Lesson 2. Key Terminology used in Mathematical Modeling
- ▶ **L** Lesson 2a. AVAC's Mitchell Warren talks about models
- ▶ **L** Lesson 3. Case Studies
- ▶ **L** Lesson 4. Making Models Matter!
- ▶ **L** Lesson 5. Asking the Right Questions
- ▶ **L** Lesson 6. Practice Your Skills
- ▶ **L** Course Completion



Term	Definition	Example
Cost-effectiveness analysis	A formal methodology for evaluating the value for money of an intervention. Outcomes are usually reported in both costs (\$ or other currency) and impact (HIV infections averted, HIV cases detected, quality-adjusted life years gained, etc.).	<p>Fig 6. Cost per QALY gained (2027-2070) according to vaccine efficacy under two cost scenarios in LICs (discounted at 3% per year) when a vaccine is added to Full Scale-up of IFE.</p> <p>With a vaccine that costs \$20, the vaccine was projected to be cost-effective at when vaccine efficacy is as low as 30%, and the vaccine was projected to be highly cost-effective with an efficacy of 70% (red bar). When the vaccine costs \$65, it is only cost-effective when efficacy is greater than 60%.</p> <p><i>Source: Harmon TM, Fisher KA, McGlynn MG, Stover J, Warren MJ, et al. (2016) Exploring the Potential Health Impact and Cost-Effectiveness of AIDS Vaccine within a Comprehensive HIV/AIDS Response in Low- and Middle-Income Countries. PLOS ONE 11(1): e0146387. https://doi.org/10.1371/journal.pone.0146387</i></p>

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- Interview with AVAC's Mitchell Warren: HIV Models & Advocacy
- Interview with Dr. Reuben Granich: Modeling that influenced treatment as prevention
- Interview with Dr. Emmanuel Njeuhmeli on VMMC modeling

KEY QUESTIONS

Why was the mathematical modeling done?

- a. What question is being answered?
 - b. Who needs this study and why?
1. In what context was the model applied?
 2. What data were used? What assumptions were made?
 3. What were the results from the modeling?
 - a. How generalizable are these results?
 4. What is the key message for my audience?



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