Impact of Vaccines and Behavior on Covid-19 Mortality

Discussant: Coady Wing

Brookings Papers on Economic Activity

28 March 2024

Two main comments

Compartmental models

- Essential for planning/forecasting.
- But how can we judge credibility?

Vaccines

- Vaccines with and without spillovers
- Externalities

Compartmental Models

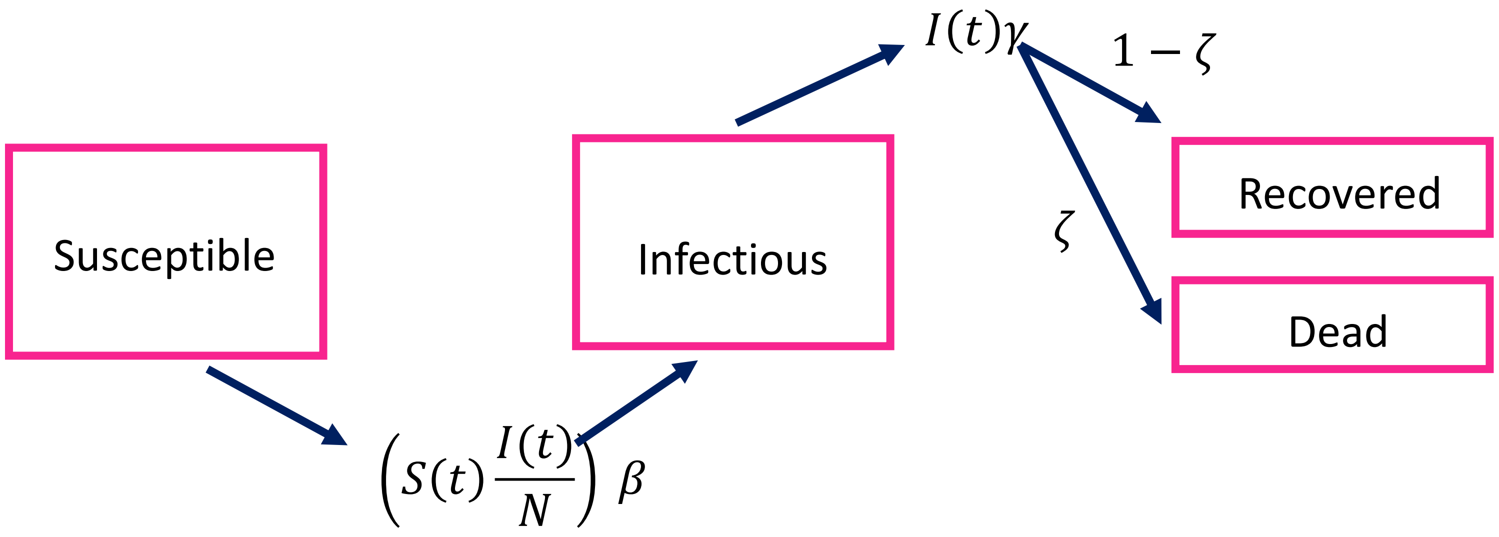
Compartmental models

Logical framework for thinking about an infectious disease outbreak.

Important tool for assessing possible policy responses.

Perhaps also useful for evaluating policy ex post.

Simple SIR model



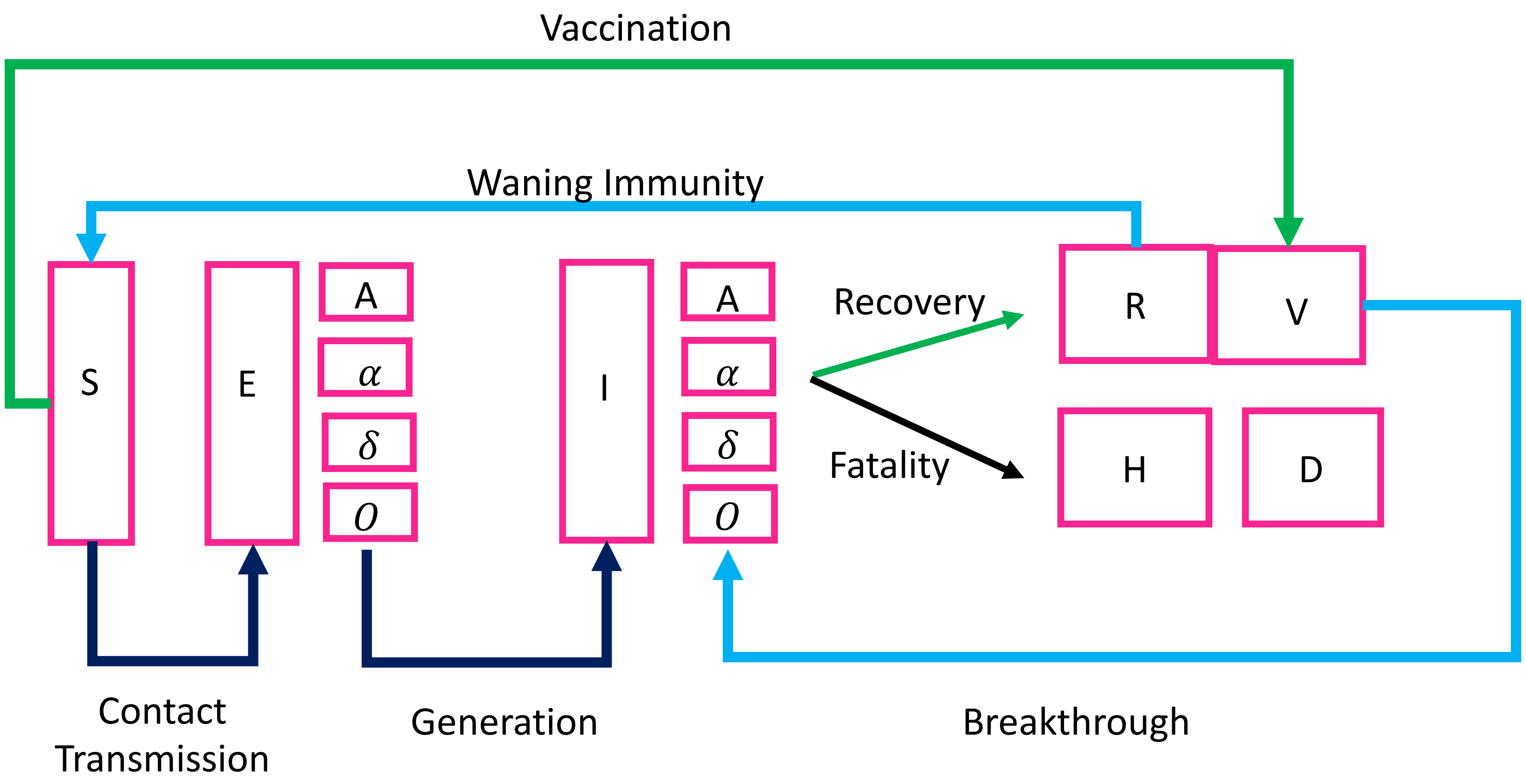
Logical and clarifying

Simple structure does not capture dynamics of epidemics.

Assumes random mixing of S and I.

No behavioral changes, policies, vaccines.

Expanded Model: SEIHR



The expanded model is intended to be more realistic and accurate.

Add compartments to match dynamics, allow viral strains, allow vaccines.

Add parameters

Baseline transmission varies across 4 variants, each introduced at specific times.

Seasonally varying transmission

Variant/time varying mortality

Breakthrough capacity introduced at specific time (omicron)

Waning immunity

Behavior – Transmission rates respond to daily deaths, semi-elasticity. But fatigue sets in at a specified date reducing the behavioral elasticity.

Key feature: behavior modifies transmission

$$\beta_i(t) = \bar{\beta}_i \times \exp\left[-\kappa(t)\frac{dD(t)}{dt} + \psi(t)\right]$$

- $\beta_i(t)$: Transmission Rate for variant i in period t
- $\bar{\beta}_i$: Inherent transmissibility of variant i
- $\kappa(t)$: Semi-elasticity of transmission with respect to new deaths
- $\psi(t)$: Seasonality

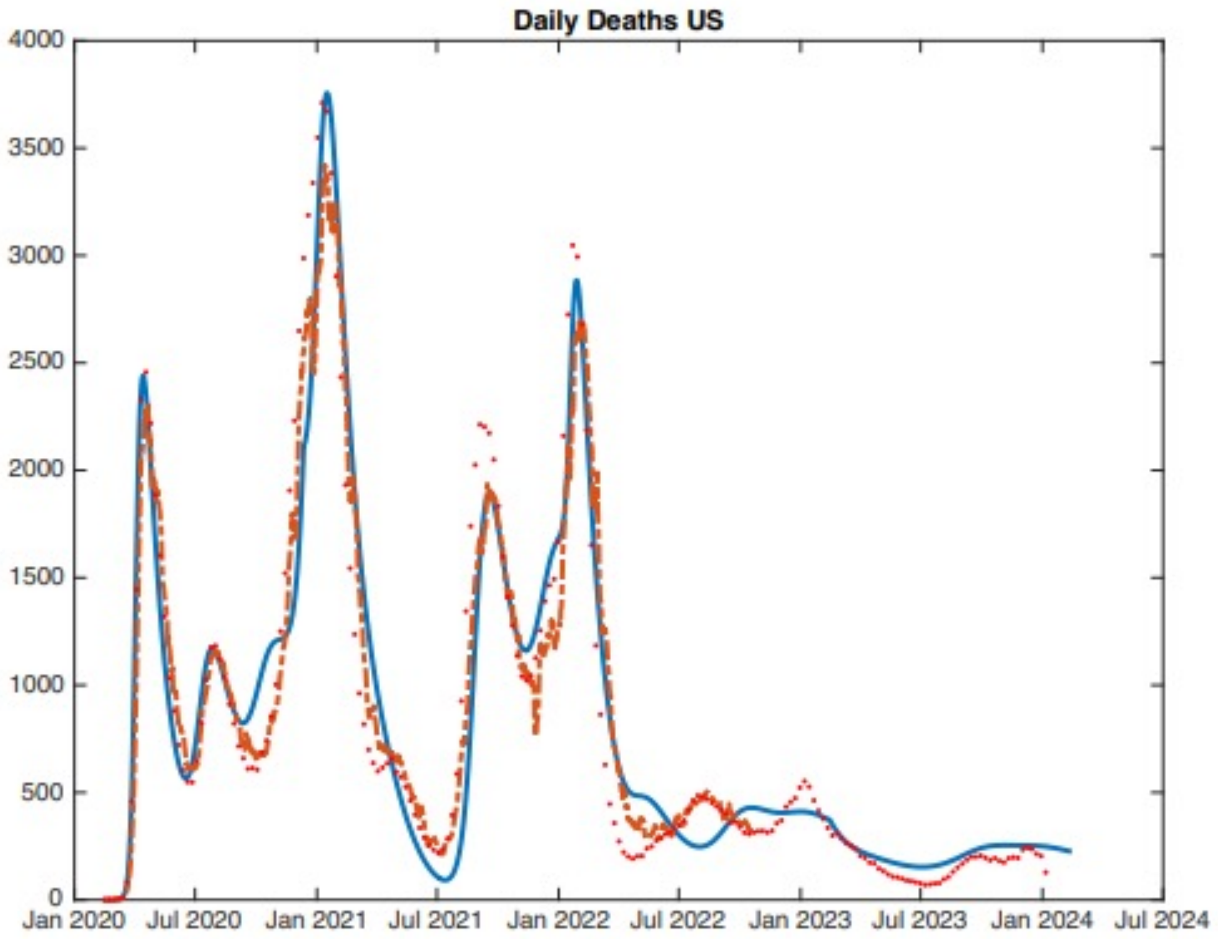
Predicted mortality from the model lines up well with actual mortality time series

Model has many parameters & compartments

- Some chosen to match epi literature
- Some chosen to improve model fit.

How to judge performance out of sample?

- Predictions about quantities identified in quasi-experimental studies?
- Geographic hold out samples?



Vaccines and Spillovers

Vaccines effects

Direct Effects

Vaccination reduces own risk of infection and mortality

Benefits are larger for people with higher mortality risk

Private benefits

Indirect Effects

Vaccinating one person may reduce infection and mortality risk among other people.

Indirect effects may be positive externalities, which may create a role for government

Where do indirect effects come from?

Sterilizing Immunity:

Vaccination prevents a pathogen from establishing an infection in the body.

Vaccinated people do not transmit

Examples: Polio and Measles

Non-Sterilizing Immunity:

Vaccination does not fully prevent infection and transmission.

Reduce risk of severe illness and mortality

Examples: Covid-19 and Influenza

Simple SIR with sterilizing immunity

Vaccine removes people from susceptible compartment.

$$New\ Infections = (1 - v)\left[\left(S(t)\frac{I(t)}{N}\right)\beta\right]$$

Increasing the vaccination rate reduces infection risk among unvaccinated.

SEIHR Model considers a vaccine that is not quite sterilizing: allow some waning and a 75% success rate.

Simple SIR with non-sterilizing immunity

Add compartment for infections among vaccinated:

$$I_v(t) = V(t)\frac{I_u}{N}\alpha_v$$

Infections among unvaccinated: $\big((1-v)S(t)\big)\left[\frac{I_u(t)}{N}\beta_u + \frac{I_v(t)}{N}\beta_v\right]$

Vaccination does not "protect the unvaccinated" if $\beta_u = \beta_v$.

Full spillover protection if $\beta_v = 0$ or $\alpha_v = 0$.

Recent work on spillovers

The Effect of Vaccine Mandates on Disease Spread: Evidence from College COVID-19 Mandates

Riley K. Acton, Wenjia Cao, Emily E. Cook, Scott A. Imberman & Michael F. Lovenheim

WORKING PAPER 30303 **DOI** 10.3386/w30303 **ISSUE DATE** July 2022

Direct and indirect effects of vaccines: Evidence from COVID-19

Seth M. Freedman, Daniel W. Sacks, Kosali I. Simon & Coady Wing

WORKING PAPER 30550 **DOI** 10.3386/w30550 **ISSUE DATE** October 2022 **REVISION DATE** August 2023

Evidence from college vaccine mandates

Acton et al study counties with at least one 4 year residential college.

Event study comparison: vaccine mandate vs no vaccine mandate.

Main result: college vaccine mandate reduces county level Covid cases by about 10% and Covid deaths by about 12%

Evidence from 11 vs 12 year old vaccine eligibility in Indiana

Freedman et al Exploit the delay in vaccine eligibility for 11 vs 12 year olds to study spillover effects in two key settings:

1. Schools – Compare ineligible 6th graders in middle vs elementary schools: do middle school 6th graders benefit from having vaccinated peers?

2. Households – Compare households living with one “newly eligible” child vs one “not eligible” child.

Results

1. Direct effects are clear and large: 80% effectiveness, or -1.3 ppts.

2. Indirect effects are context-specific

   School Setting: No detectable spillover created, despite shift from 5→25 ppts vaccinated schoolmates

   Household Setting: Substantial spillover, extra vaccinated person reduces infection among other household members by about 2/3 the size of direct effect of vaccine.

3. Mechanisms

   Indirect effects seem to depend on level of mixing.

   Households mix more than school children.

Implications

If vaccine effects depend on context and mixing, compartmental models that weaken the “random mixing” assumptions may be important.

Future research:

- when and where are mandates apt to be helpful?
- when are spillovers internalized?
- how do “mixing” patterns depend on policy levers?