Epidemiological modeling in the context of COVID-19

Dr. Caroline Buckee
Associate Professor of Epidemiology,
Associate Director of the Centre for Communicable Disease Dynamics,
Harvard TH Chan School of Public Health
cbuckee@hsph.harvard.edu, @Caroline_OF_B

DATA SCIENCE ZOOMPOSIUM APRIL 2nd

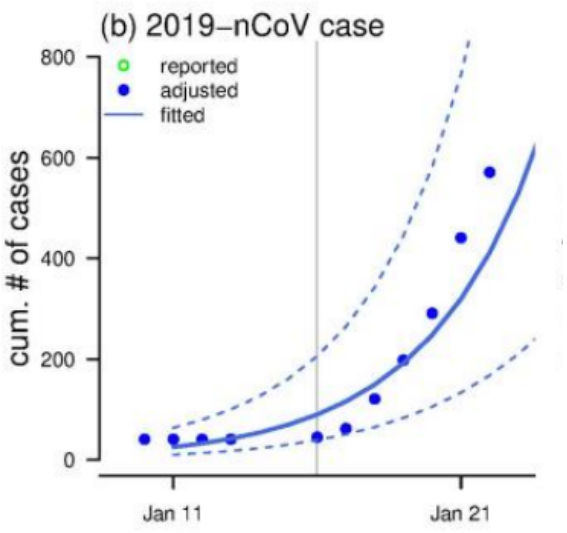
Early stage of the epidemic

- Estimation of R0 (simple growth rate estimate or mechanistic model)
- Establish basic parameters: incubation period, latent period, duration of infection, CFR

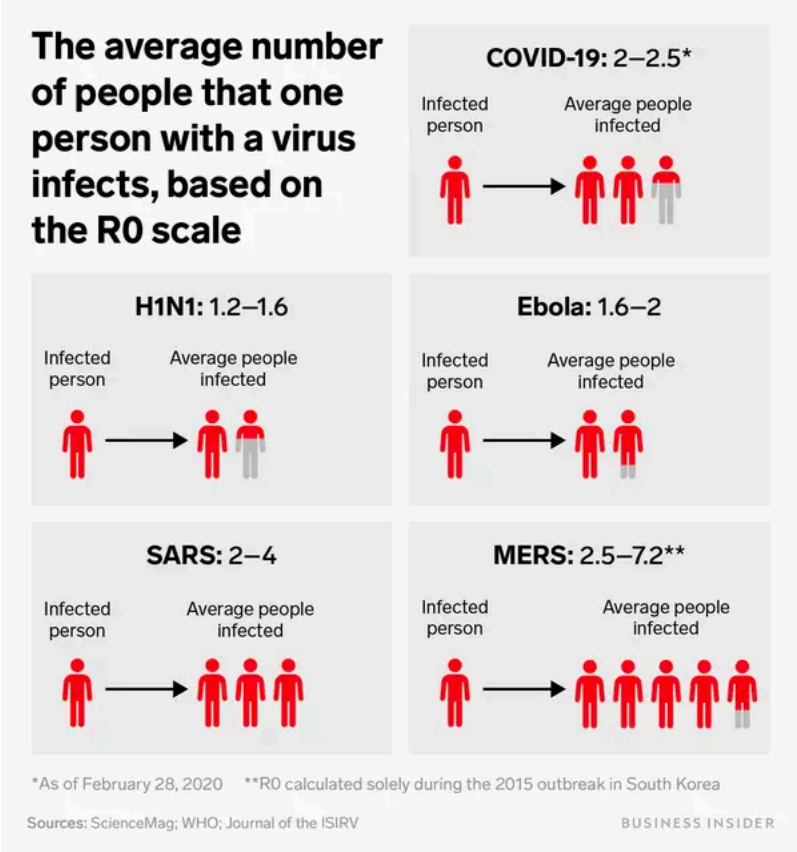
And then…

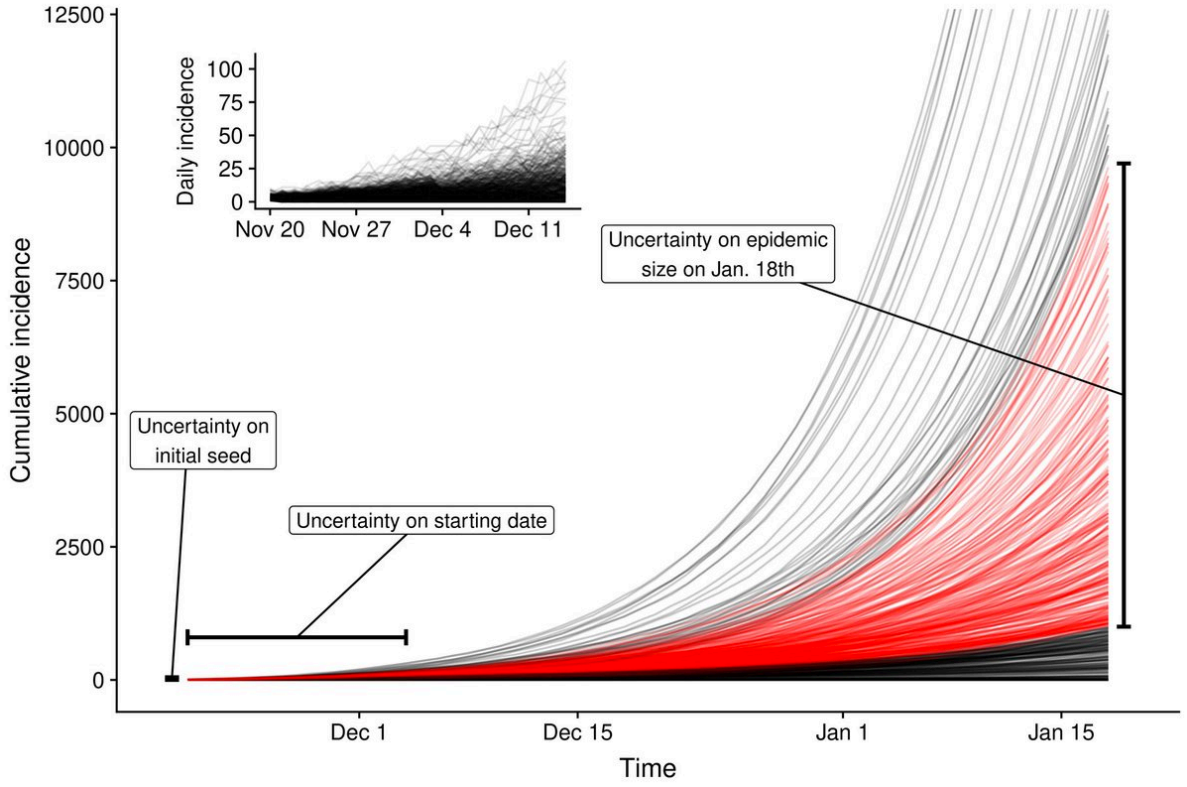
- Evaluate interventions, scenario planning
- Forecasting for particular places and issues (hospital bed capacity)
- Thinking through the endgame

Goal: Establish R0



Zhao et al (2020) biorxiv





ISPN University of Bern

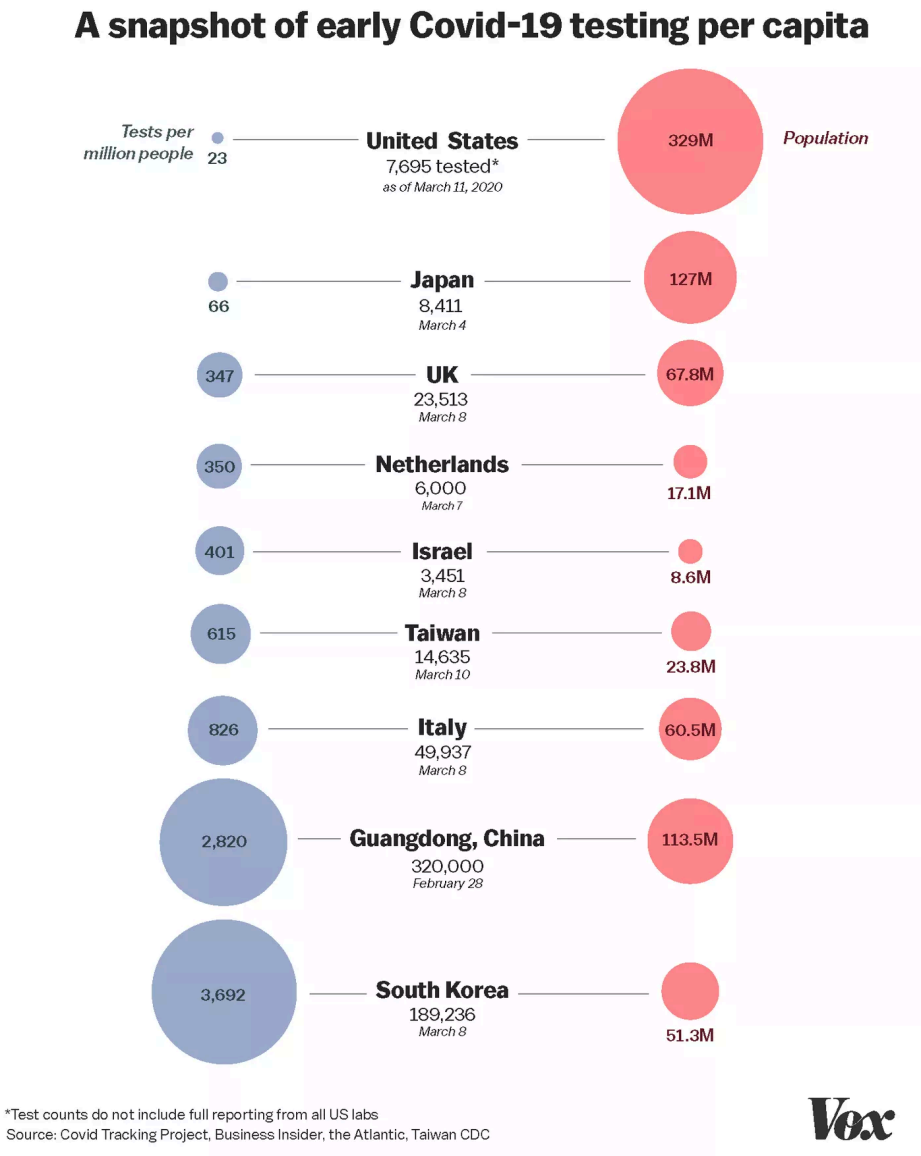
TESTING:

- Are there enough testing kits?
- What are the testing criteria?
- What is the clinical spectrum?

Implications for modeling:

*Difficult to assess the number of infected people in your model (where are we on the epidemic curve?)

*Model structure uncertainty: what fraction of infections are asymptomatic and how do they contribute to transmission?

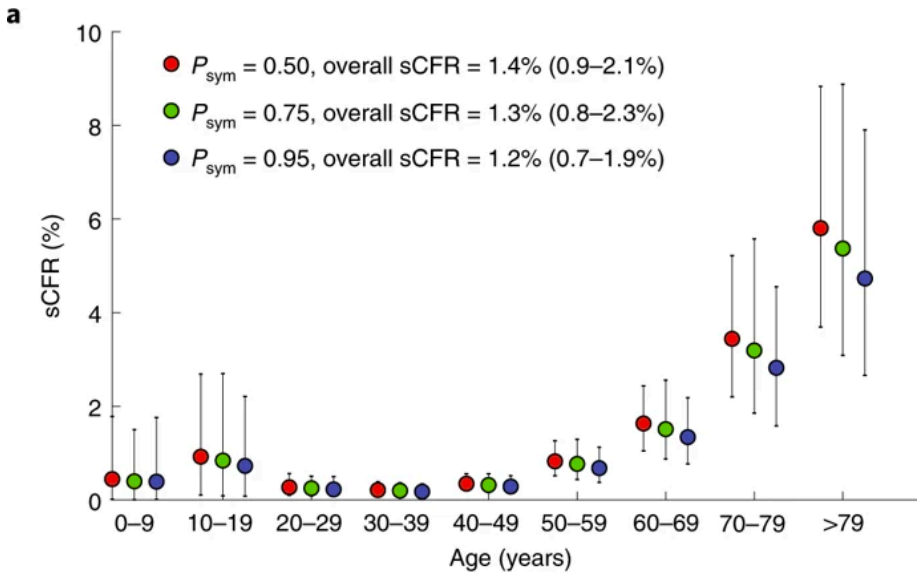


Goal: Establish fatality rates

1. IFR defines a case as a person who would, if tested, be counted as infected and rendered (at least temporarily) immune, as usually demonstrated by seroconversion or other immune response[13]. Such cases may or may not be symptomatic.

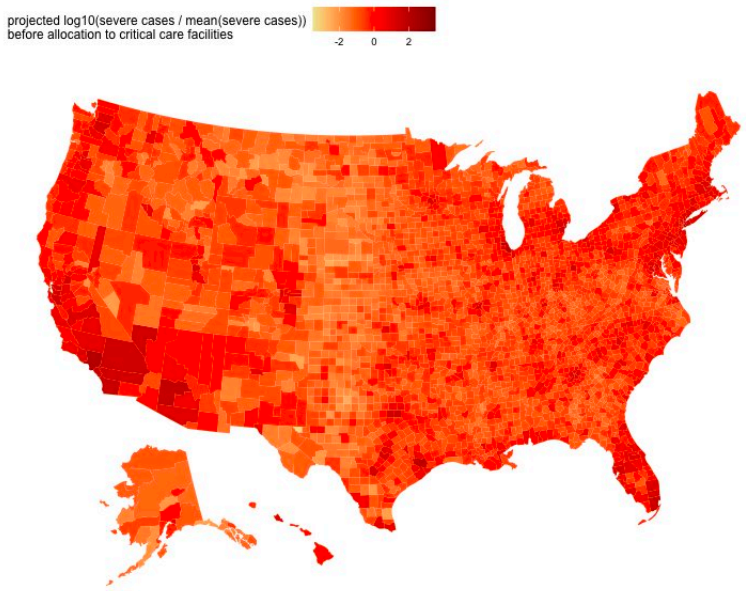
2. sCFR defines a case as someone who is infected and shows certain symptoms.

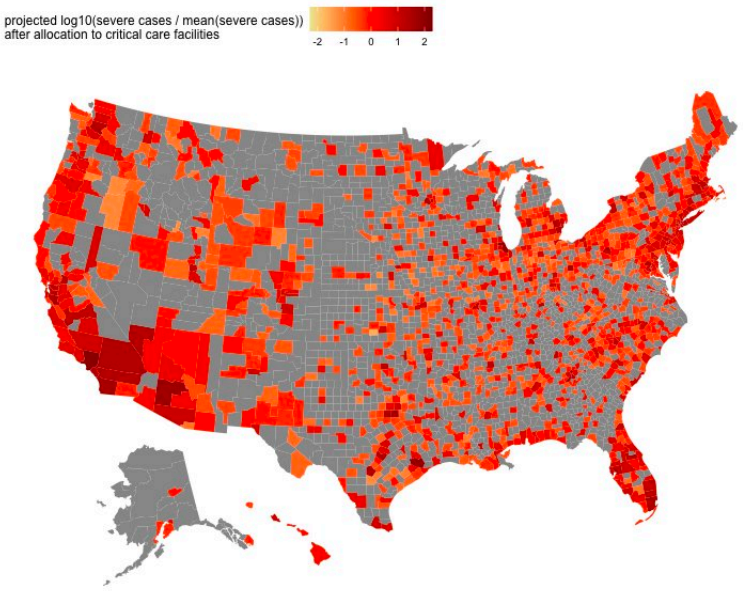
3. HFR defines a case as someone who is infected and hospitalized. It is typically assumed in such estimates that the hospitalization is for treatment rather than isolation purposes.



Wu et al (2020) Nature Med

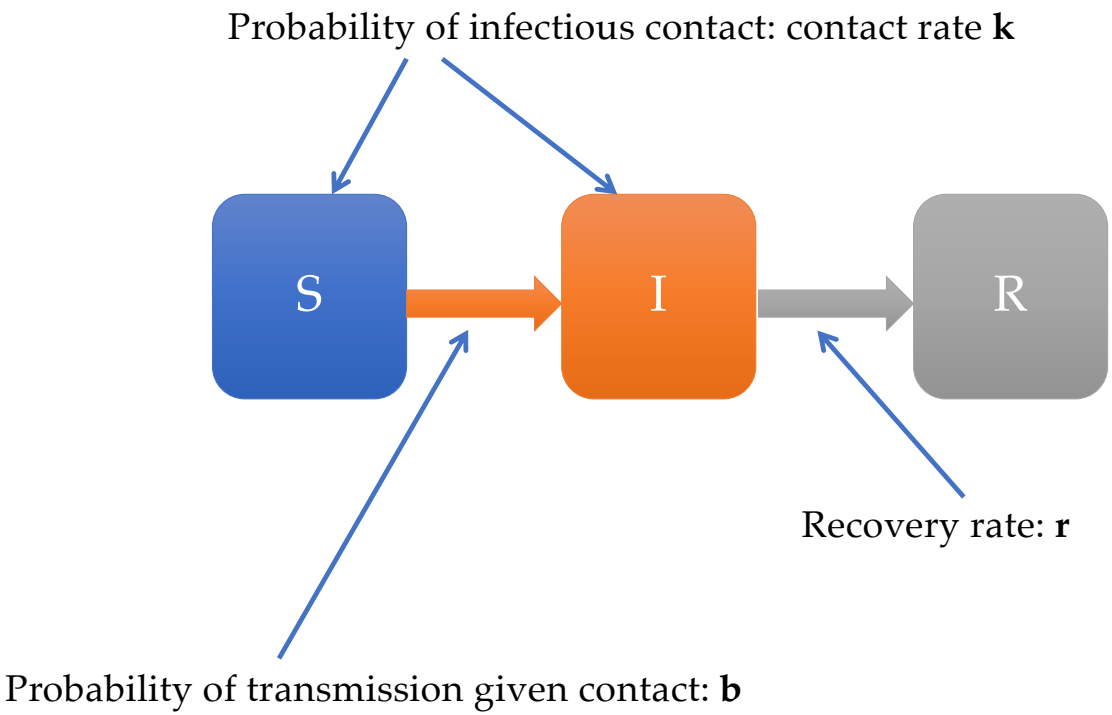
Goal: Understand demographic and health system risk profiles for COVID-19





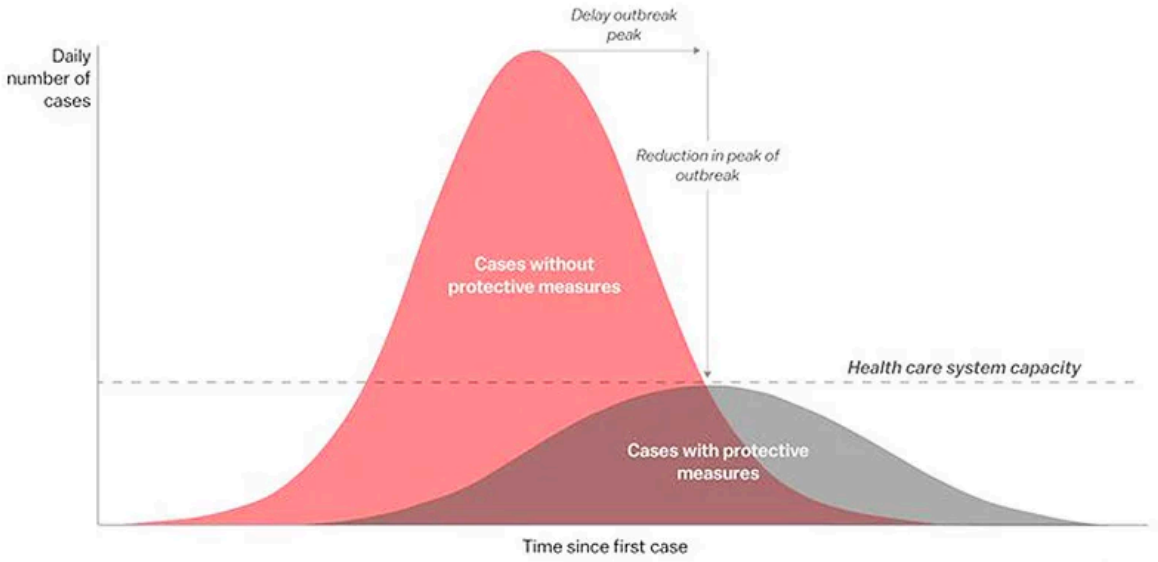
Ian Miller, Alex Becker, Bryan Grenfell, and Jess Metcalf of Princeton University.

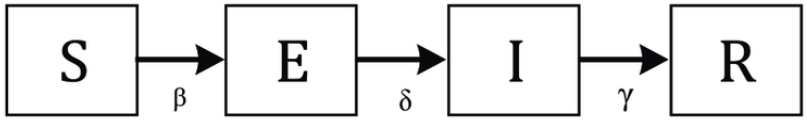
S(E)IR model basics

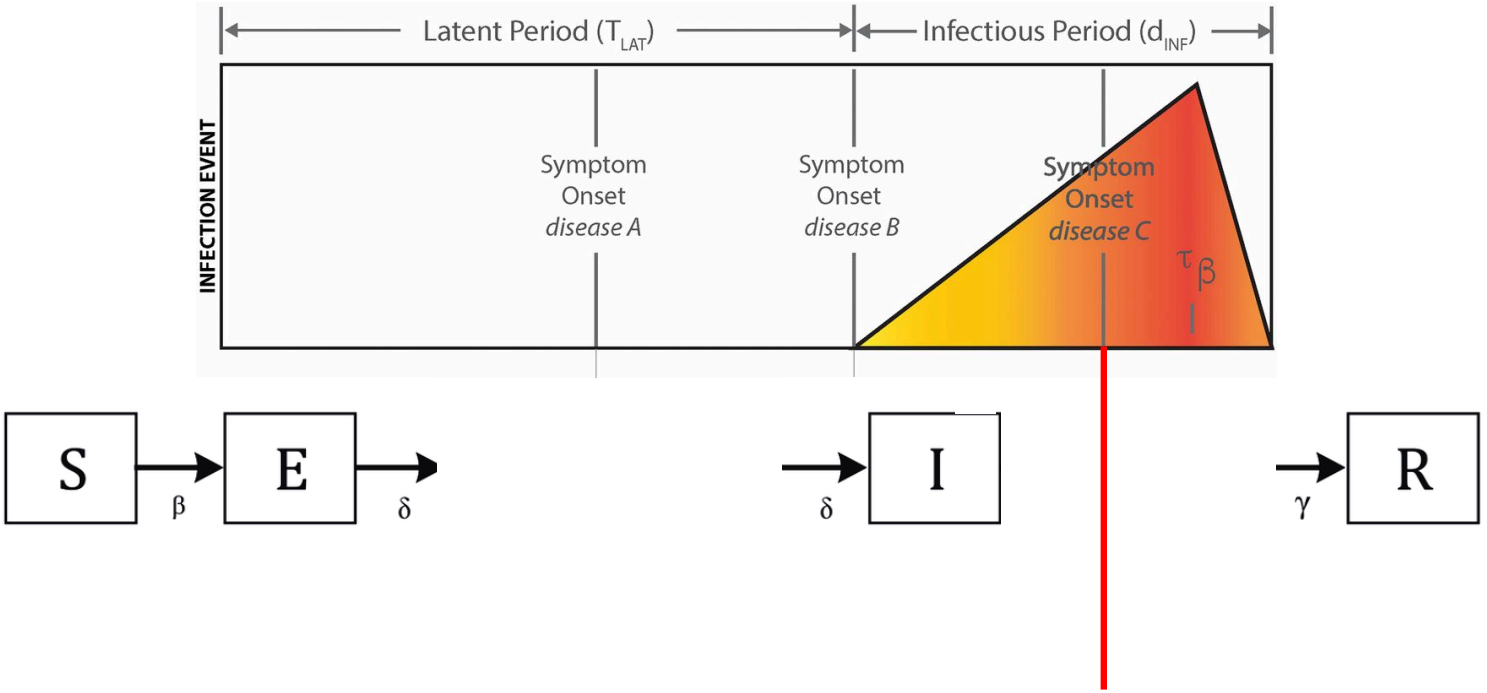


$$R0 = bk/r$$

The premise of flattening the curve through social distancing is to reduce **k**

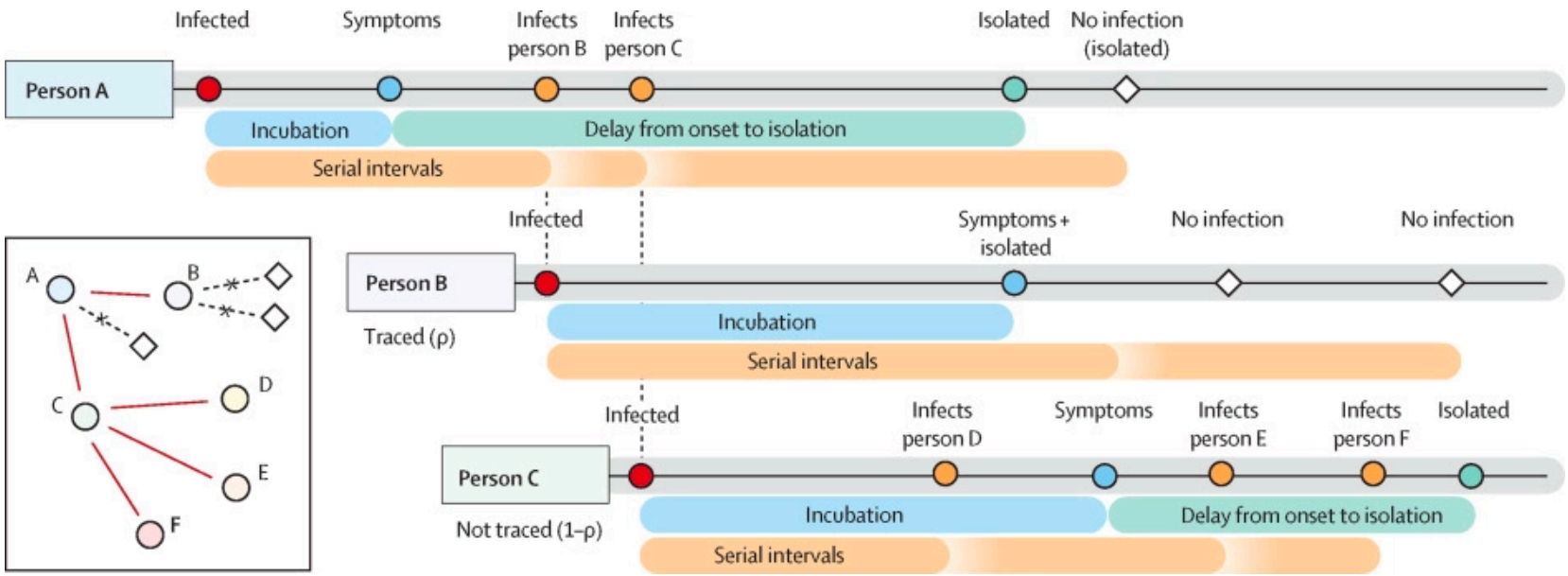




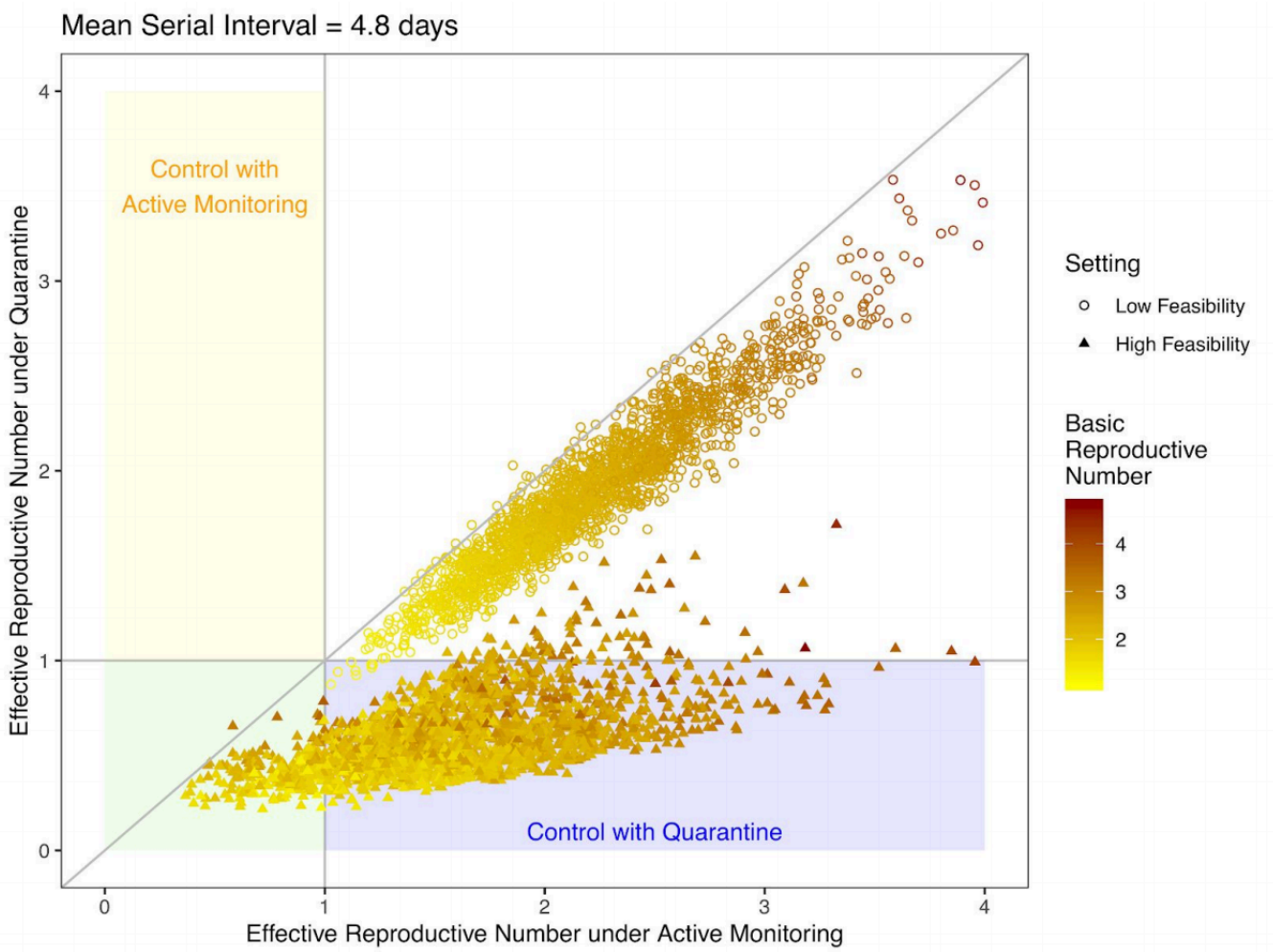


Peak et al (2017) PNAS

Think through what interventions might work

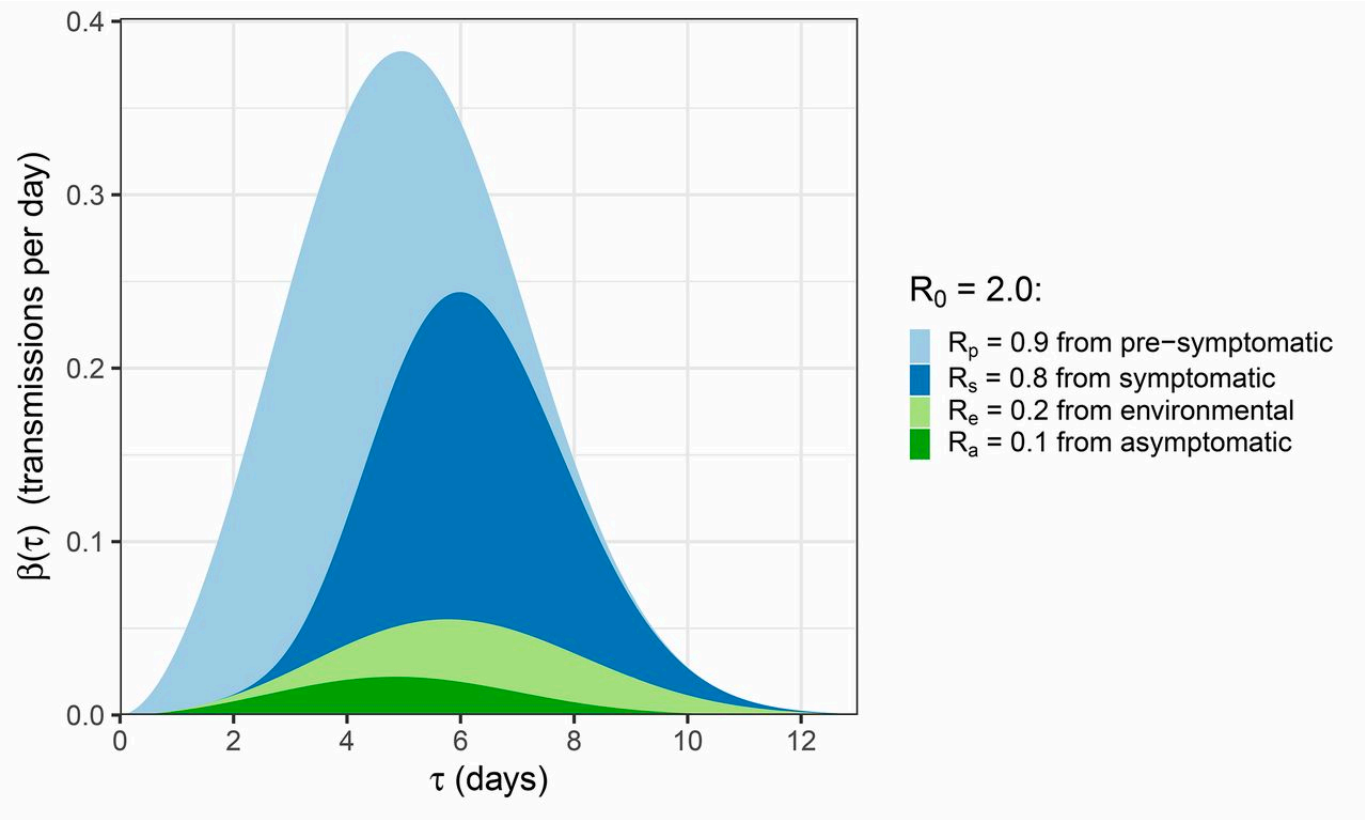


Hellewell et al (2020) Lancet Global Health



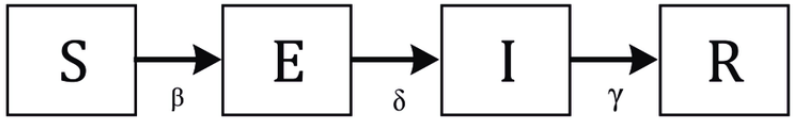
Peak et al (2020) MedRxiv

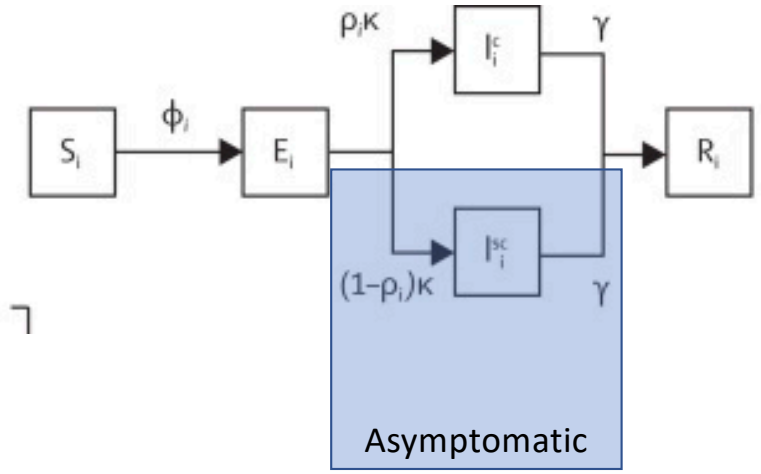
Goal: understand transmission routes, implications for contact tracing

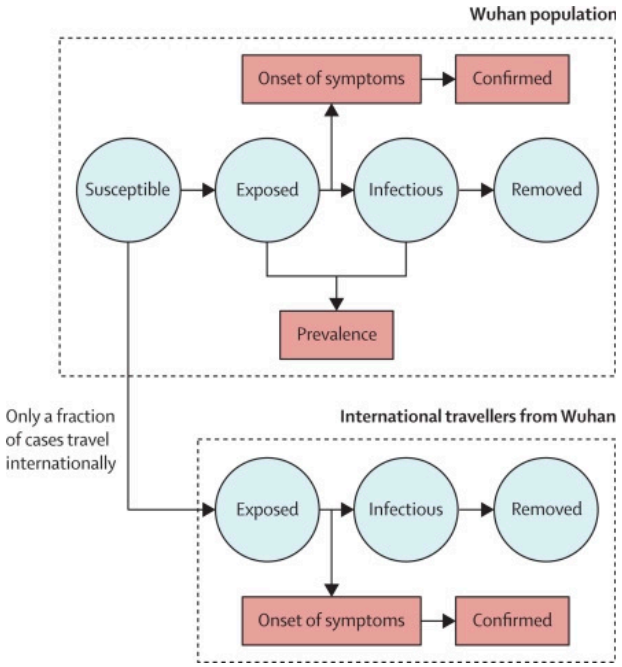


Ferreti et al (2020) Science

Mechanistic models for scenario planning

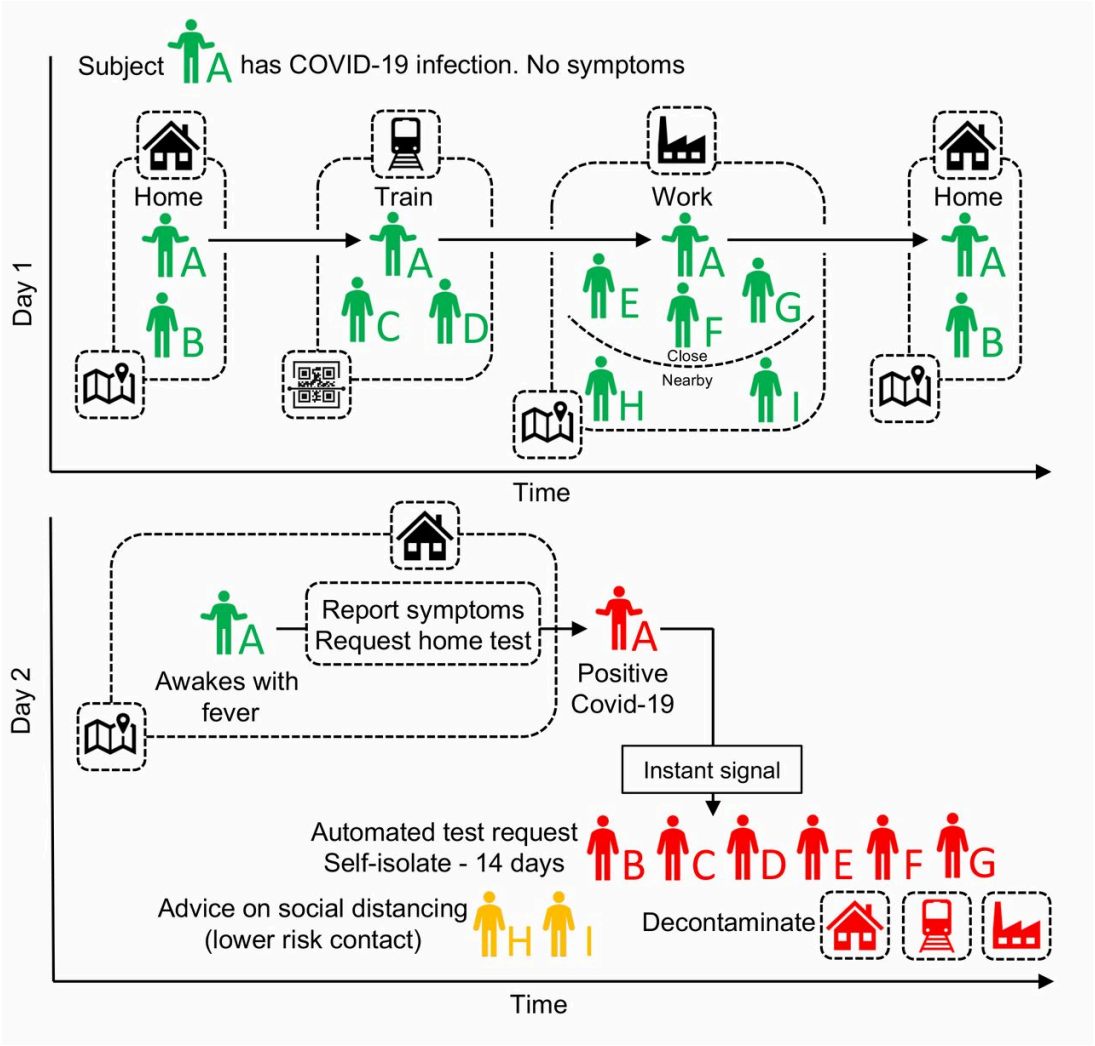






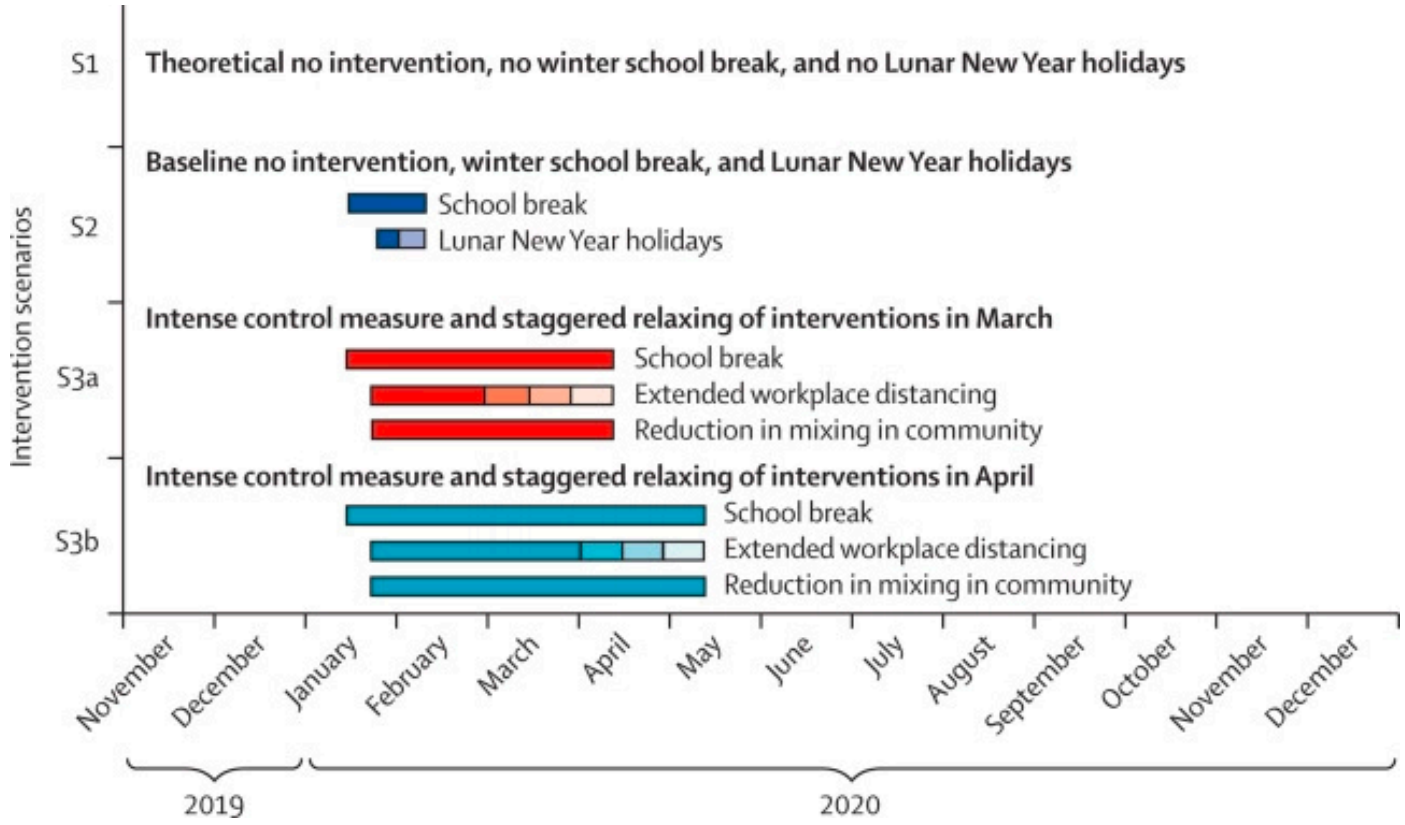
Prem et al. (2020) Lancet

Kucharski et al. (2020) Lancet Inf Dis

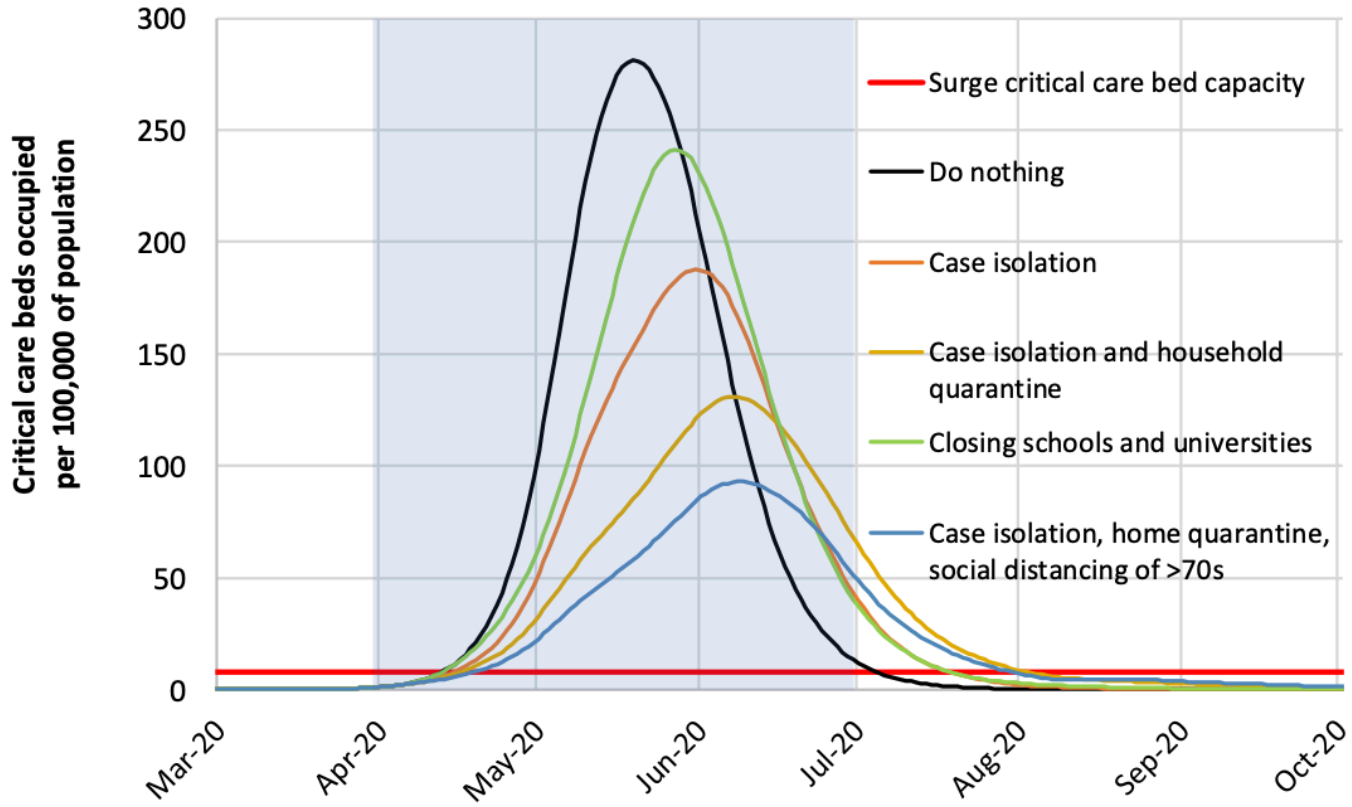


Ferreti et al (2020) Science

Goal: scenario planning

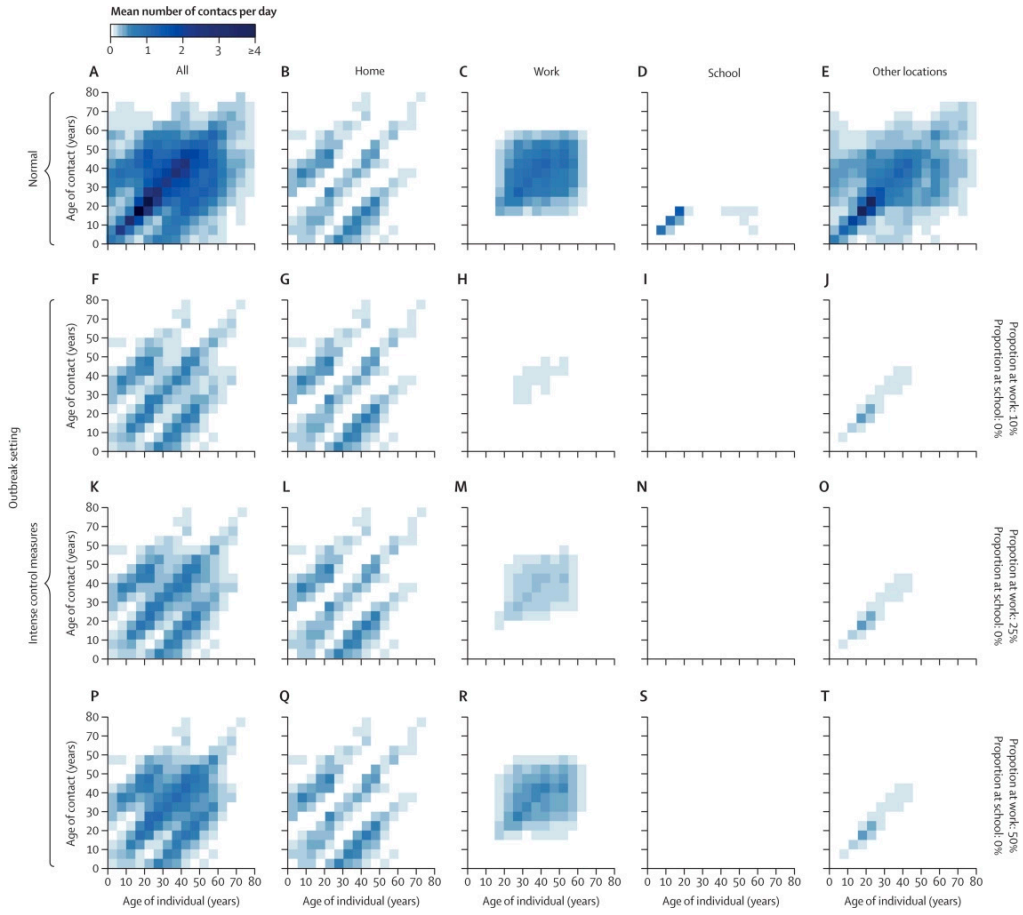


Prem et al. (2020) Lancet



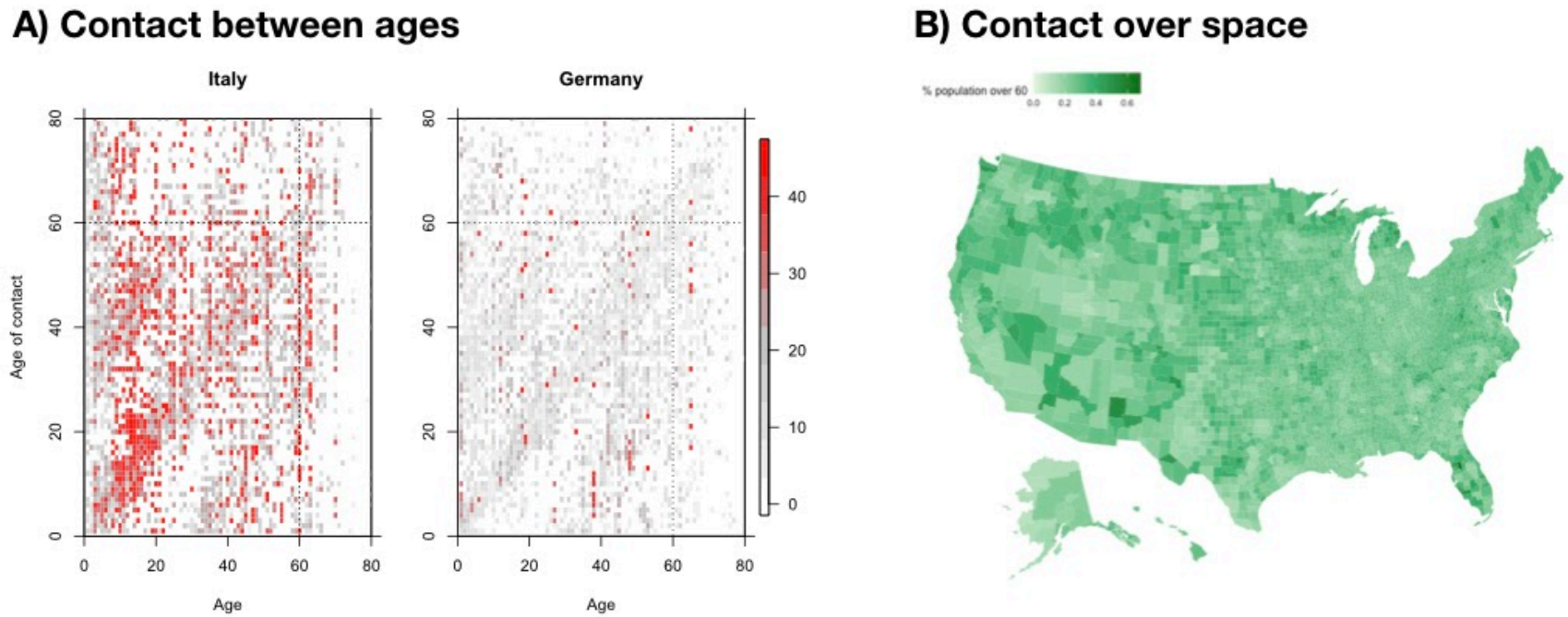
Ferguson et al (March 16 2020) Imperial College COVID-19 Response Team

How to parameterize contact rates?



Prem et al. (2020) Lancet

How to parameterize contact rates?

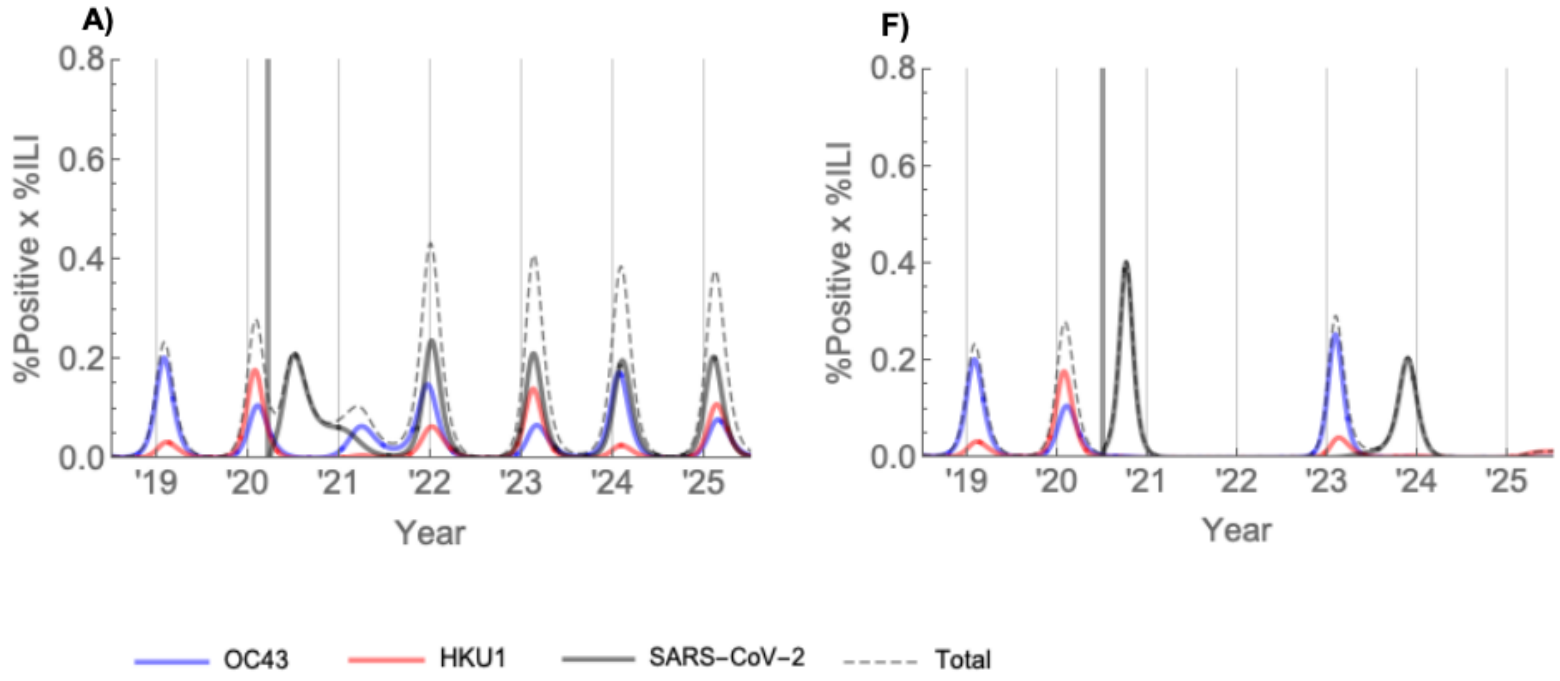


Courtesy of Jessica Metcalf (age structures from POLYMOD study)

What impact is social distancing having?

Ainslie, Walters, Fu et al (March 24 2020) Imperial College COVID-19 Response Team Report

Goal: thinking through the endgame - how long will this last?



Kissler et al (2020)

Summary

- Forecasting very challenging because of testing heterogeneities and difficulty understanding contact rate changes under social distancing
- Models useful for understanding what interventions might work under different assumptions
- Scenario planning useful for thinking through **qualitative** dynamics of this pandemic
- Models highlight data gaps and identify key uncertainties (measures of social distancing, need for serology to establish asymptomatics)
- Important to use context-specific parameters and consider indirect effects of interventions