Modeling Covid-19 in the US: Can system dynamics help?

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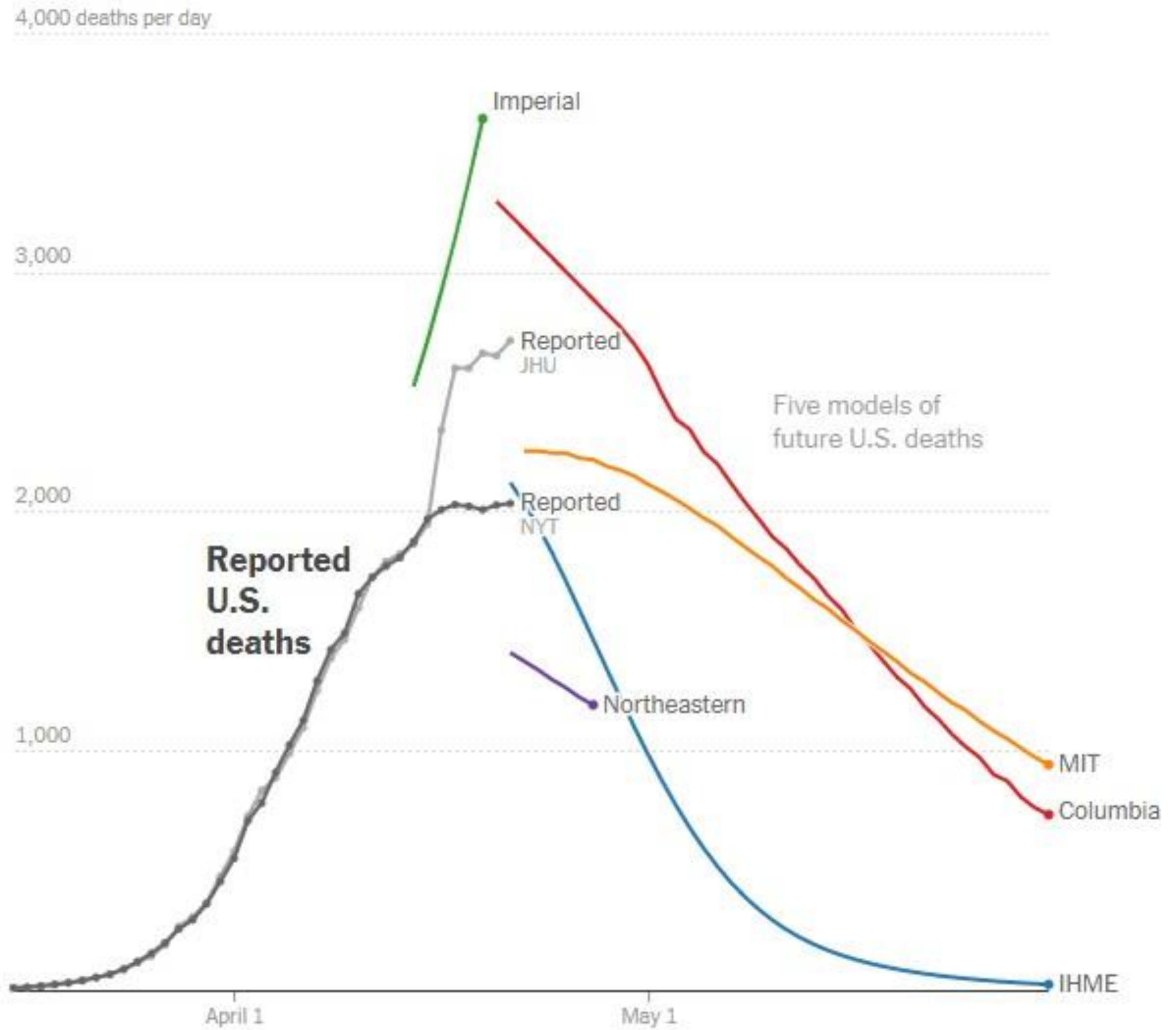
STOP
THE
SHUTDOWN
THE MODELS
ARE ALL
WRONG

U.S. coronavirus deaths in five different forecasts through May 30



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.

Critiques of the models

NY Times review (April 22) of 5 leading models: https://nyti.ms/2KsxXa0

> "These models use different techniques to project the future. But most share an important basic assumption: that the current regimen of stay-at-home orders and social distancing will continue. And almost all cut off their predictions after two months or less, even though epidemiologists believe the coronavirus pandemic will be with us for far longer…because their researchers worry that policy and norms could change quickly."

NY Times Op-Ed (Aaron Carroll, April 22): https://nyti.ms/2xHcsz0

> "Some governors believe they are over the worst of their local outbreaks. Some of their assurance is because they've been looking at models that show that once an outbreak has peaked, it resolves about as quickly as it began... Few models, if any, predicted the flattening or stalling we're seeing in Europe…Those countries are perilously close to seeing cases start to rise. When the realities don't fit the models, it's time to re-evaluate the models' usefulness."

The modelers' defense (Say what?)

Jeffrey Shaman, co-author of the Columbia model:

> "We want [models] to provide more information than they can. We have uncertainty on top of uncertainty on top of uncertainty."

Dimitris Bertsimas, co-author of the MIT model:

> "We are reasonably certain until approximately June 15 there will be significant measures [to contain the virus]. After that, God knows."

Is this really the best that Covid modelers can tell us?

Would we accept it if climate modelers told us: "This stuff is really uncertain, so we're only looking 8 years into the future instead of 80"?

Don't we want models to reflect the changing behavior we've already seen and project the consequences (one year or more, not one month) of future behavioral change (uncertainties and all)?

This is where SD (with its behavioral feedback loops) can contribute.

What we want to know: requirements for a useful US Covid-19 policy model

Our questions:

What can we expect? How bad might it get?

What policies should be pursued? How fast and effective can they be?

Is it still possible to “smash the curve, not just flatten it”*?

A useful US Covid policy model should:

Replicate the time series data on reported cases and fatalities.

Identify what the data imply about behavioral response and what’s still uncertain.

Show to what extent (and under what conditions) the contact tracing approach could work.

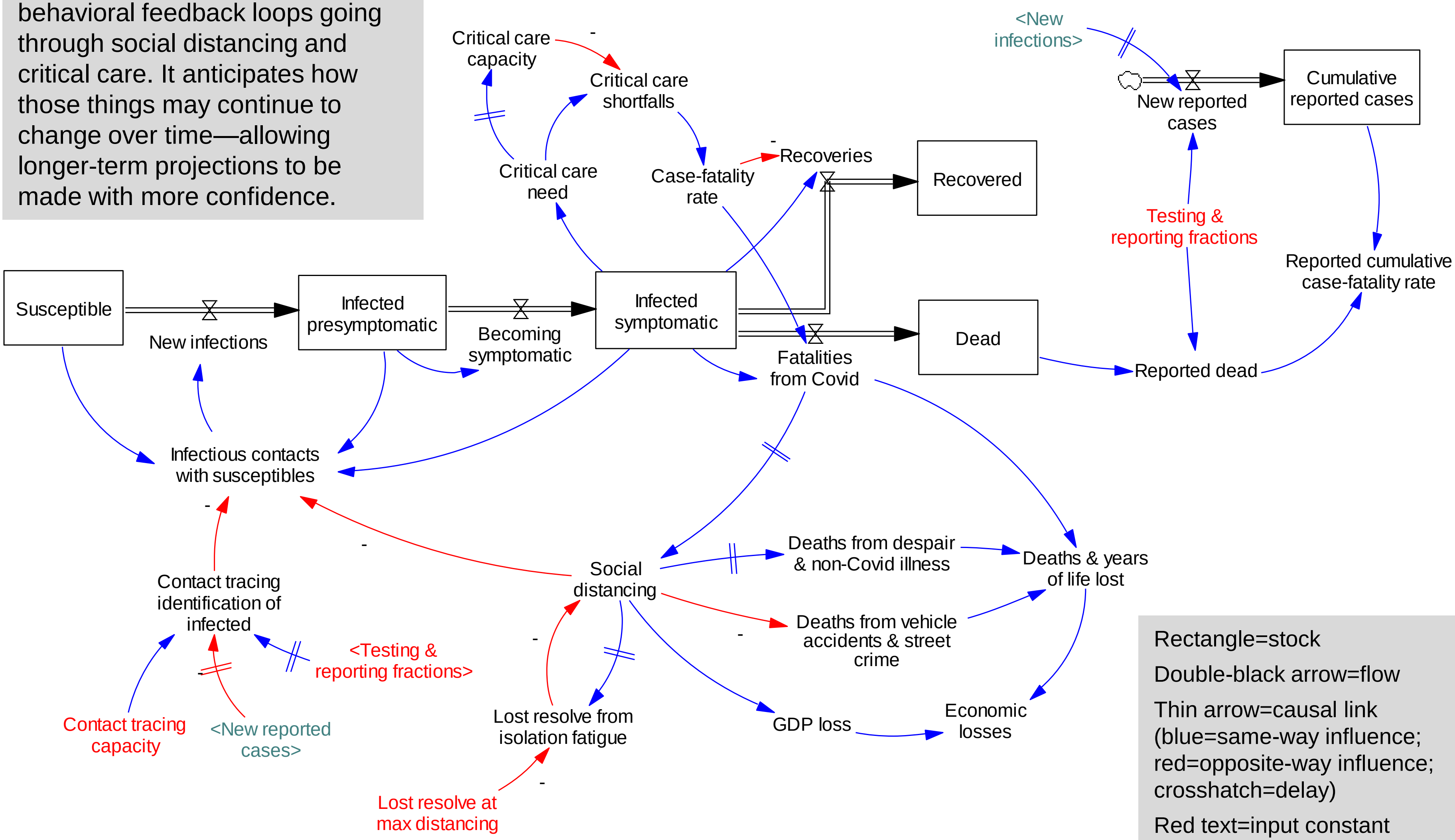
Quantify both the benefits and costs of social distancing.

Project out at least one year from now so we can understand the full weight of what’s coming prior to effective vaccine or treatment.

*Prof. Ashish Jha, Harvard T.H. Chan School of Public Health

Model overview (v8)

Like many Covid-19 models, this is “SEIR”. But this model includes behavioral feedback loops going through social distancing and critical care. It anticipates how those things may continue to change over time—allowing longer-term projections to be made with more confidence.



Rectangle=stock

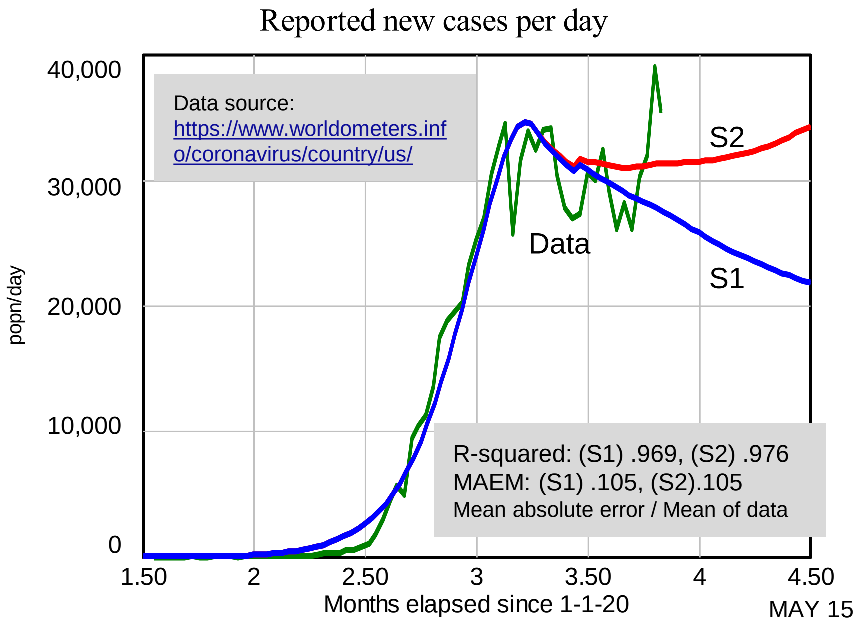
Double-black arrow=flow

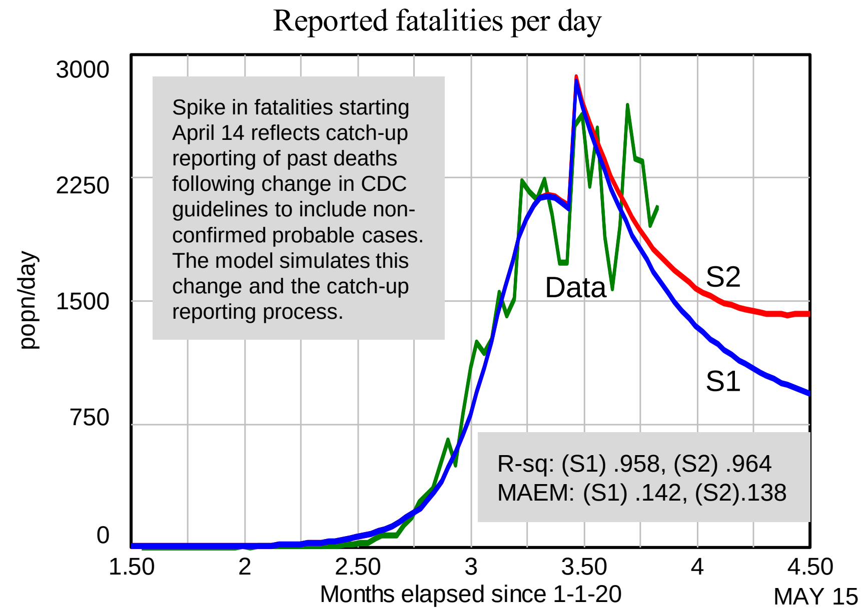
Thin arrow=causal link (blue=same-way influence; red=opposite-way influence; crosshatch=delay)

Red text=input constant

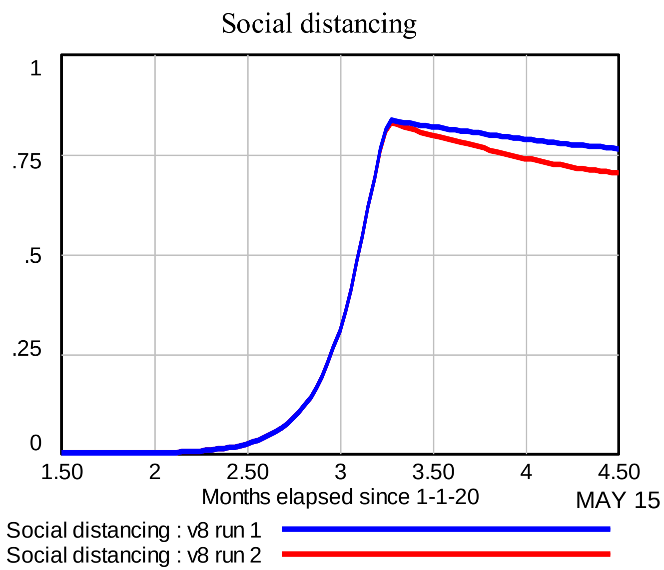
<bracketed text>=defined elsewhere in diagram

Two possible settings (S1, S2*) giving good overall model fit to daily data** through April 25 (N=70 days)





By mid-May, the two settings produce trajectories of cases and fatalities that are diverging, although both settings provide a statistically good fit to history.

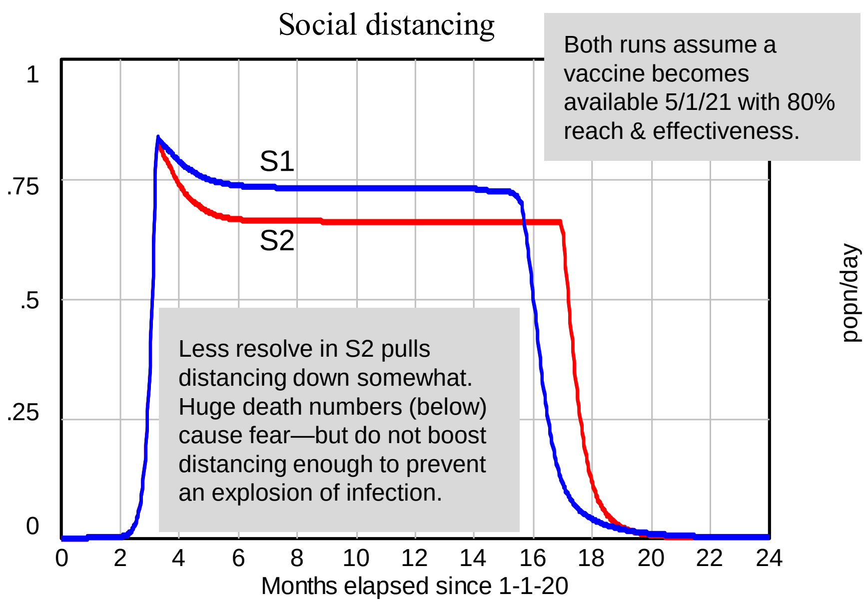


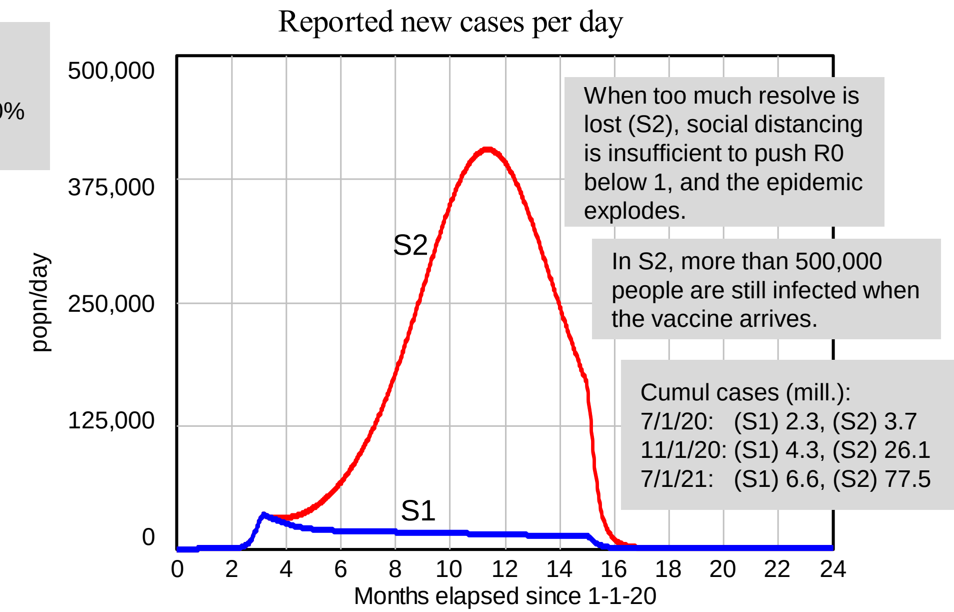
*The two runs differ on the setting of a single parameter: “lost resolve at max distancing”: S1=0.25 (more resolute), S2=0.5 (less resolute).

By mid-May, projected social distancing (graph at left) does not seem all that different for the two settings. But this difference matters and is playing with fire.

**Fit-to-daily is a better test than fit-to-cumulative. Cumulative measures tend to obscure meaningful inflection and turning points seen in the daily data. (Data on cumulative cases and fatalities look like nearly straight lines from late March to late April.)

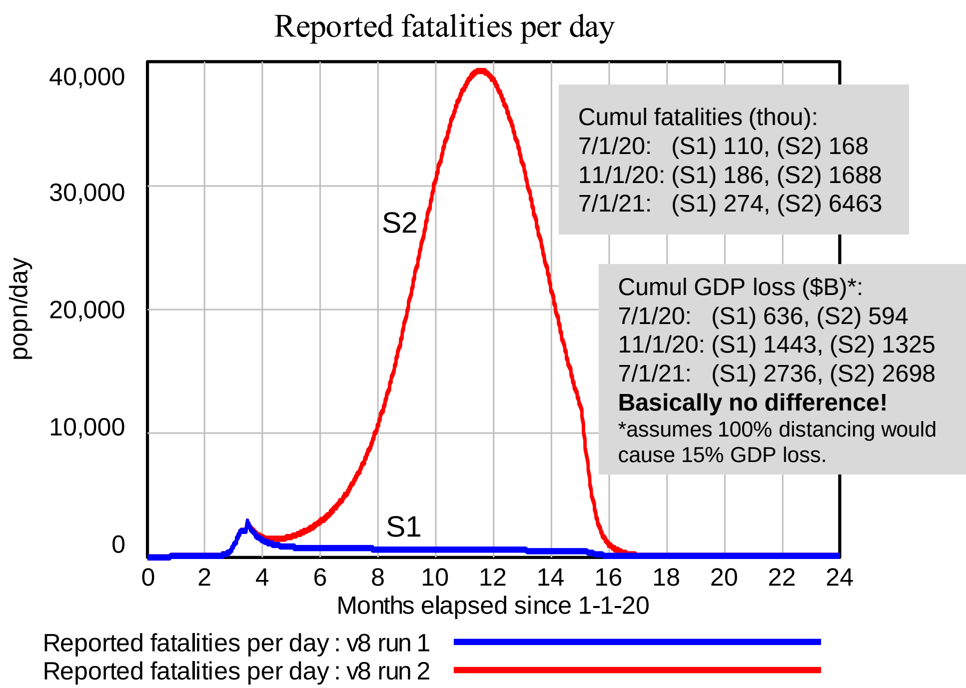
Alternative futures through 2021 under the two settings





By the time the epidemic is curtailed in mid-2021, it has killed 274,000 under S1, and nearly 6.5 million under S2.

(The 1918 Spanish Flu killed 675,000 in the US out of a population of 103 million. That would be nearly 2.2 million today.)



S2 kills 24 times the number of people of S1 while barely reducing economic losses. It extends the epidemic (and the period of distancing) another month beyond vaccine launch.

Even in terms of GDP (box at left), "let's get back out there" is a strategy that backfires. By causing an explosion of death, it would make most of us fearful and unwilling to keep getting out there.

Simulating contact tracing: "an army of 100,000"

On April 10, Johns Hopkins School of Public Health published a plan to employ 100,000 contact tracers to limit spread of COVID-19 in the US.

https://www.centerforhealthsecurity.org/our-work/pubs_archive/pubs-pdfs/2020/200410-national-plan-to-contact-tracing.pdf

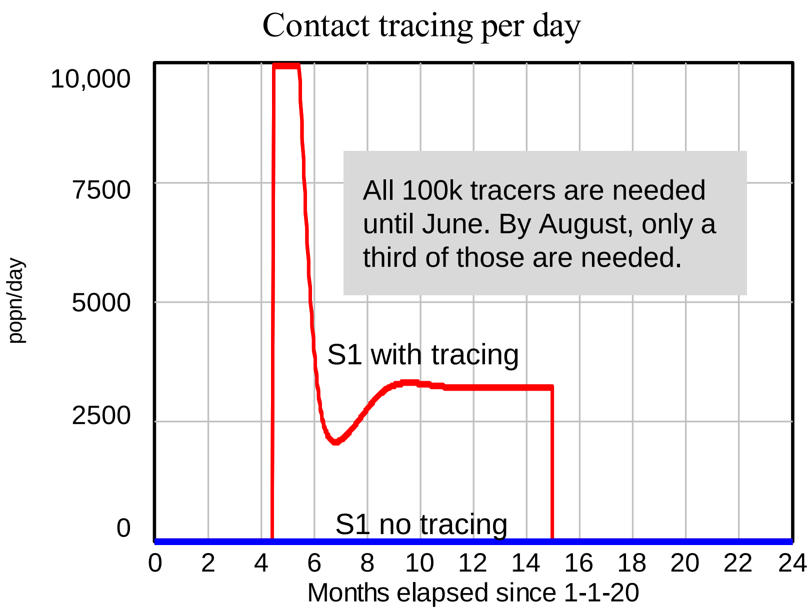
This is 300 tracers per million US population, twice the ratio of what Massachusetts has tried on its own.

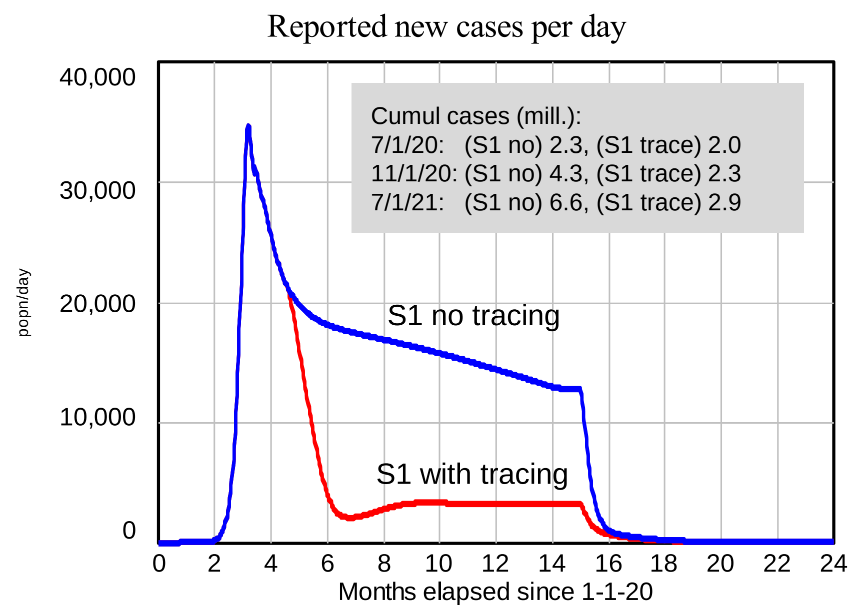
Could it work?

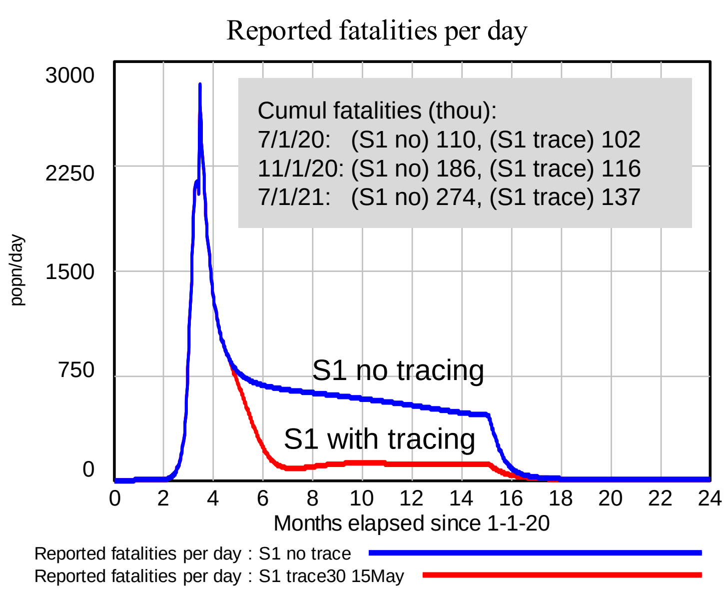
Let's assume the 100,000 are hired and ready by May 15, and that a tracer can complete one fully-traced case in 10 days, going through the steps described in this graphic.

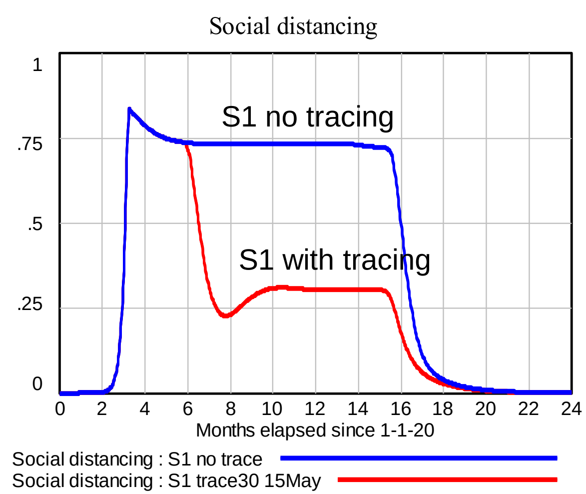
We can simulate the plan under two different conditions—the two alternative assumptions for lost resolve (next two slides).

Contact tracing impact under S1 (more resolute)



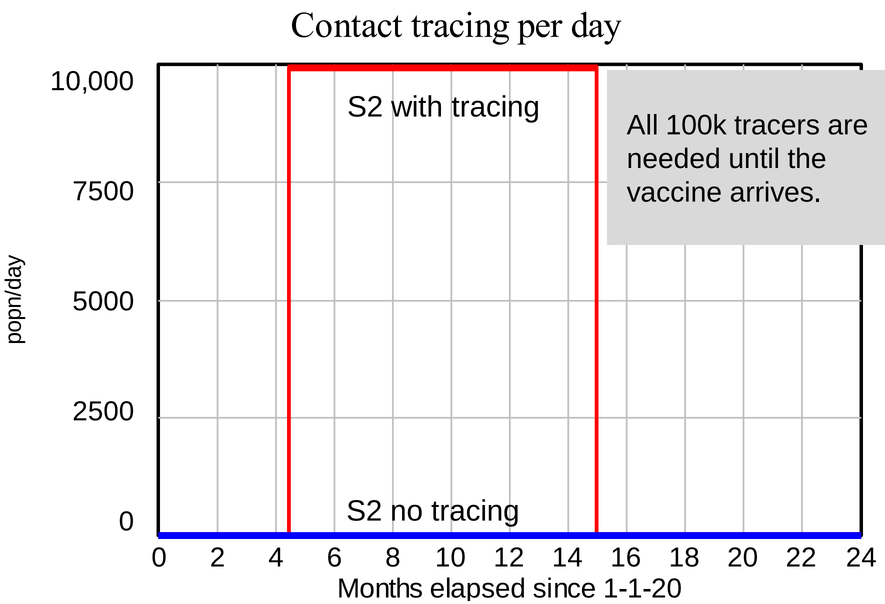


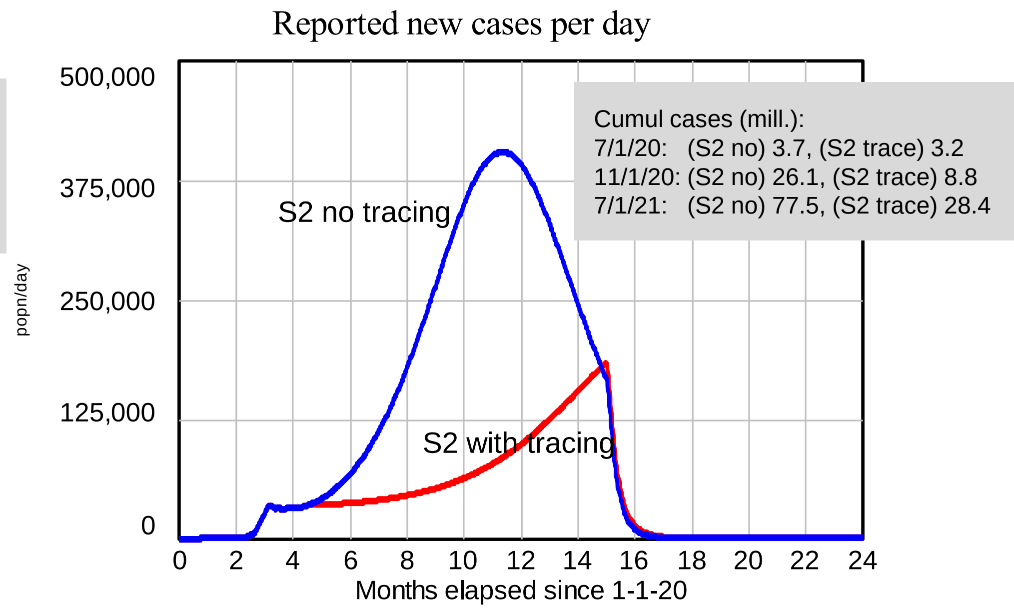


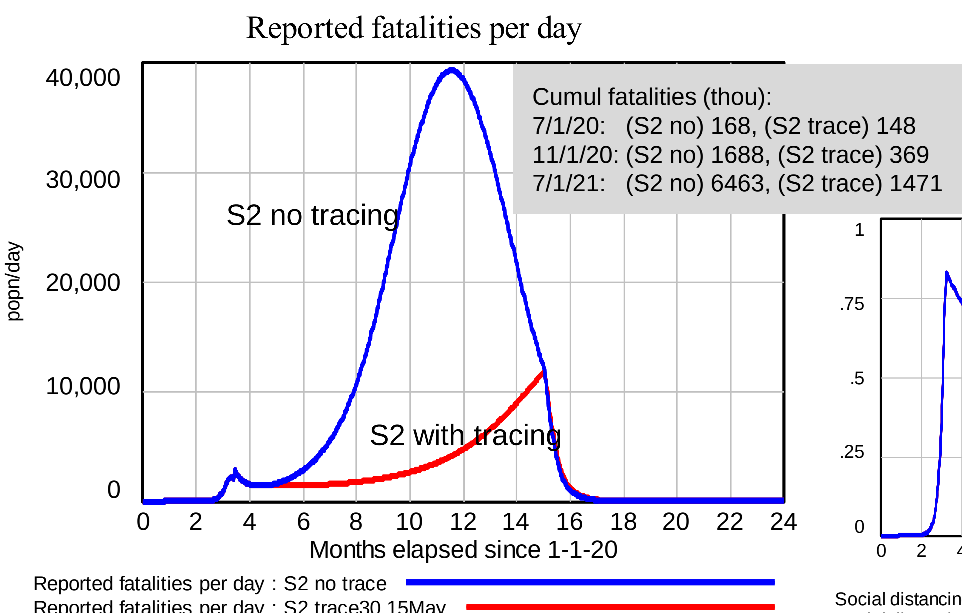


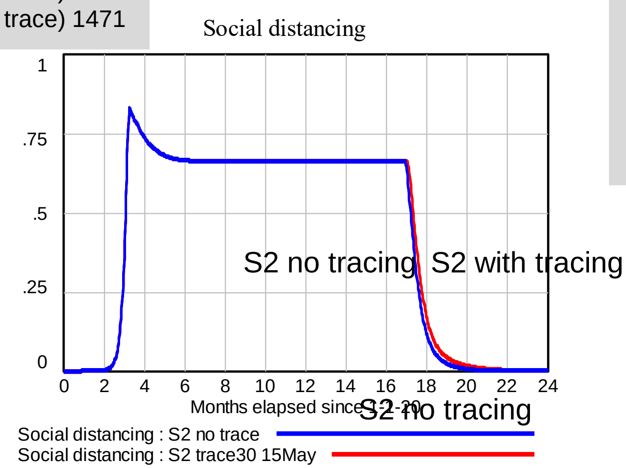
Under S1, contact tracing drives new cases and fatalities down 80%, leading to less fear and permitting reduced social distancing.

Contact tracing impact under S2 (less resolute)









Under S2, contact tracing slows the explosion of cases and deaths by about 70% but does not contain it. Fear runs high until the vaccine arrives.

Discussion

Covid-19 is fast-spreading but can be suppressed through resolute social distancing combined with contact tracing.

It's still too early to say whether we have enough resolve in the US to continue social distancing at the level and duration necessary to avoid the death of millions. The latest data are not promising and suggest we are facing a long slog ahead, as in Western Europe. Or worse, an explosion of new cases that overwhelm the healthcare system.

Even if our resolve is not great, large-scale contact tracing can still reduce the ultimate death count.

Longer-term projections and policy findings like these can be made responsibly if one has a model that accurately reflects the sociology of distancing and other changeable behaviors.

We can estimate how strong these behavioral responses are (within a range of uncertainty) by adjusting their strength and seeing whether a good fit to the latest data can be achieved.

Policy modeling should be done despite the unavoidable uncertainties. But only dynamic models with sufficient breadth and feedback structure should be used for longer-term projection.