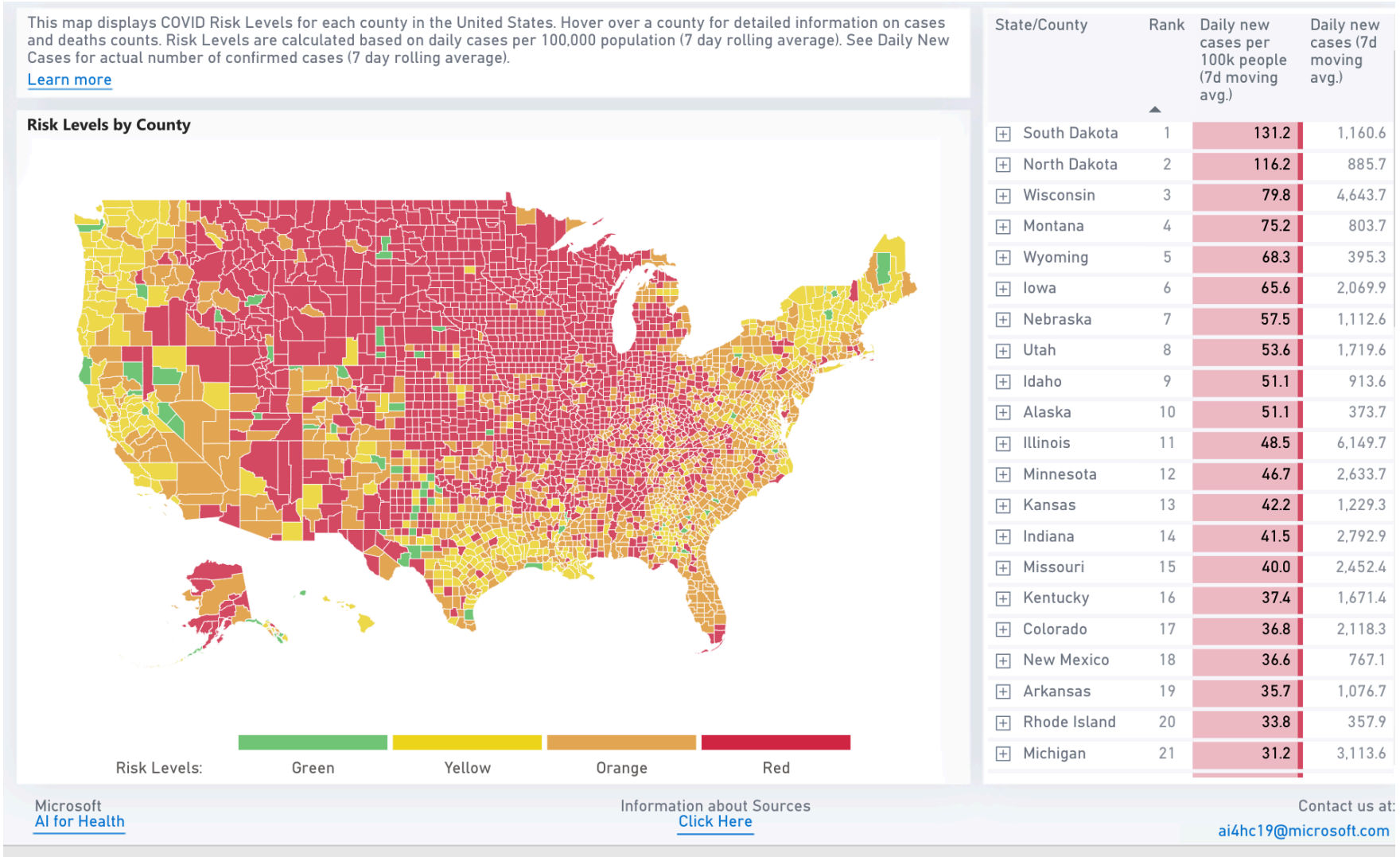
Update on COVID-19 Epidemiology and Management Strategies

Harvard T.H. Chan School of Public Health, United States

The pandemic is global

The pandemic is hyper-local



State/County	Rank	Daily new cases per 100k people (7d moving avg.)	Daily new cases (7d moving avg.)
South Dakota	1	131.2	1,160.6
North Dakota	2	116.2	885.7
Wisconsin	3	79.8	4,643.7
Montana	4	75.2	803.7
Wyoming	5	68.3	395.3
Iowa	6	65.6	2,069.9
Nebraska	7	57.5	1,112.6
Utah	8	53.6	1,719.6
Idaho	9	51.1	913.6
Alaska	10	51.1	373.7
Illinois	11	48.5	6,149.7
Minnesota	12	46.7	2,633.7
Kansas	13	42.2	1,229.3
Indiana	14	41.5	2,792.9
Missouri	15	40.0	2,452.4
Kentucky	16	37.4	1,671.4
Colorado	17	36.8	2,118.3
New Mexico	18	36.6	767.1
Arkansas	19	35.7	1,076.7
Rhode Island	20	33.8	357.9
Michigan	21	31.2	3,113.6

https://globalepidemics.org/key-metrics-for-covid-suppression/

Horrific racial/ethnic disparities

APM RESEARCH LAB

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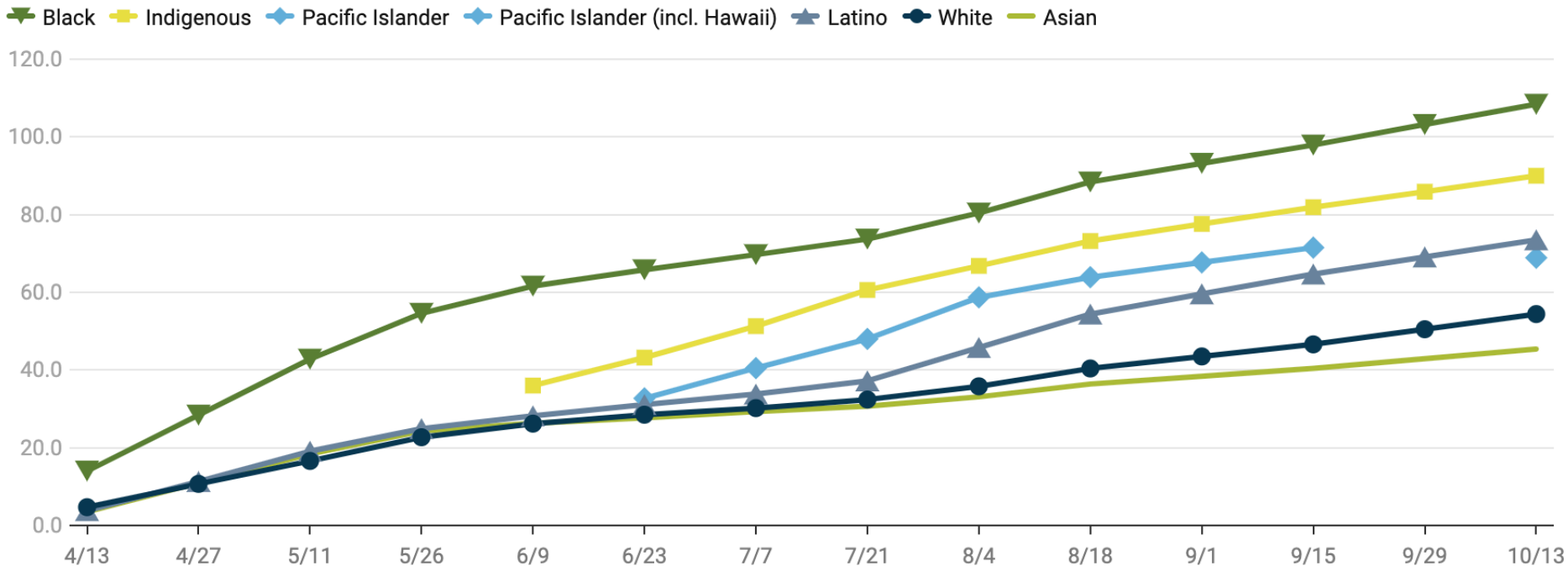
Black & Indigenous Americans experience highest death tolls from COVID-19

Cumulative actual COVID-19 mortality rates per 100,000, by race and ethnicity, April 13-Oct. 13, 2020



Note: All intervals are 14 days apart, except for 5/11-5/26, which is a 15-day period. 9/1 and 9/29 data has been interpolated. Pacific Islander data prior to 10/13 did not include Hawaii, as it was not releasing data; its inclusion resulted in an overall drop in the Pacific Islander rate, which begins a new series at 10/13.

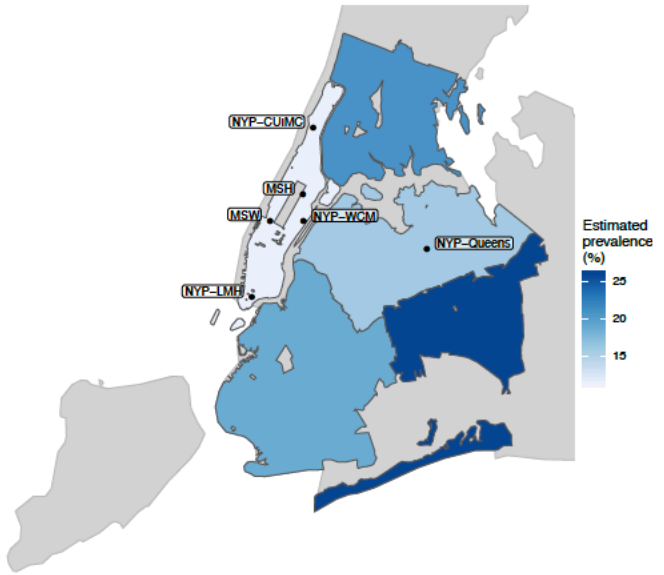
Source: APM Research Lab • Get the data • Created with Datawrapper

Spread has depended on individual & local responses and risk factors

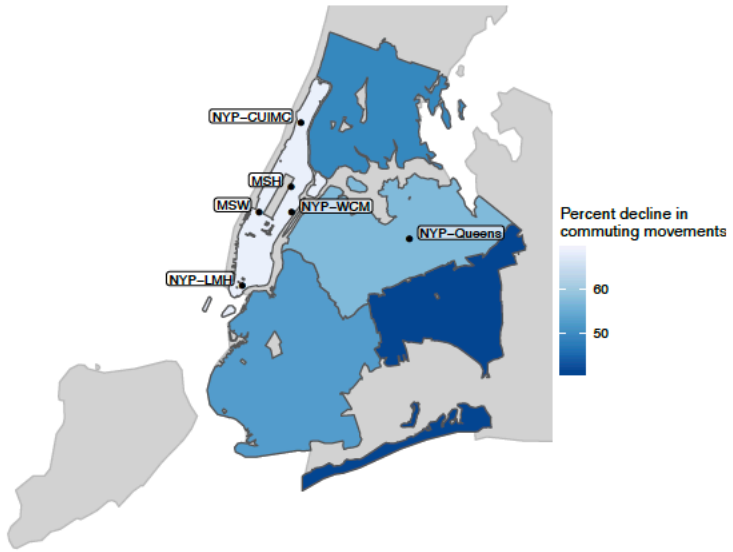
New York City virus PCR in delivering mothers

Maternal virus prevalence, Mar-Apr

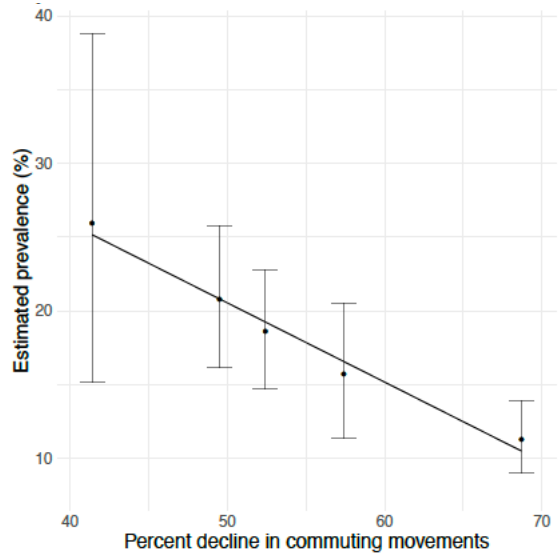
Maternal virus prevalence



Reduction in movement



Correlation

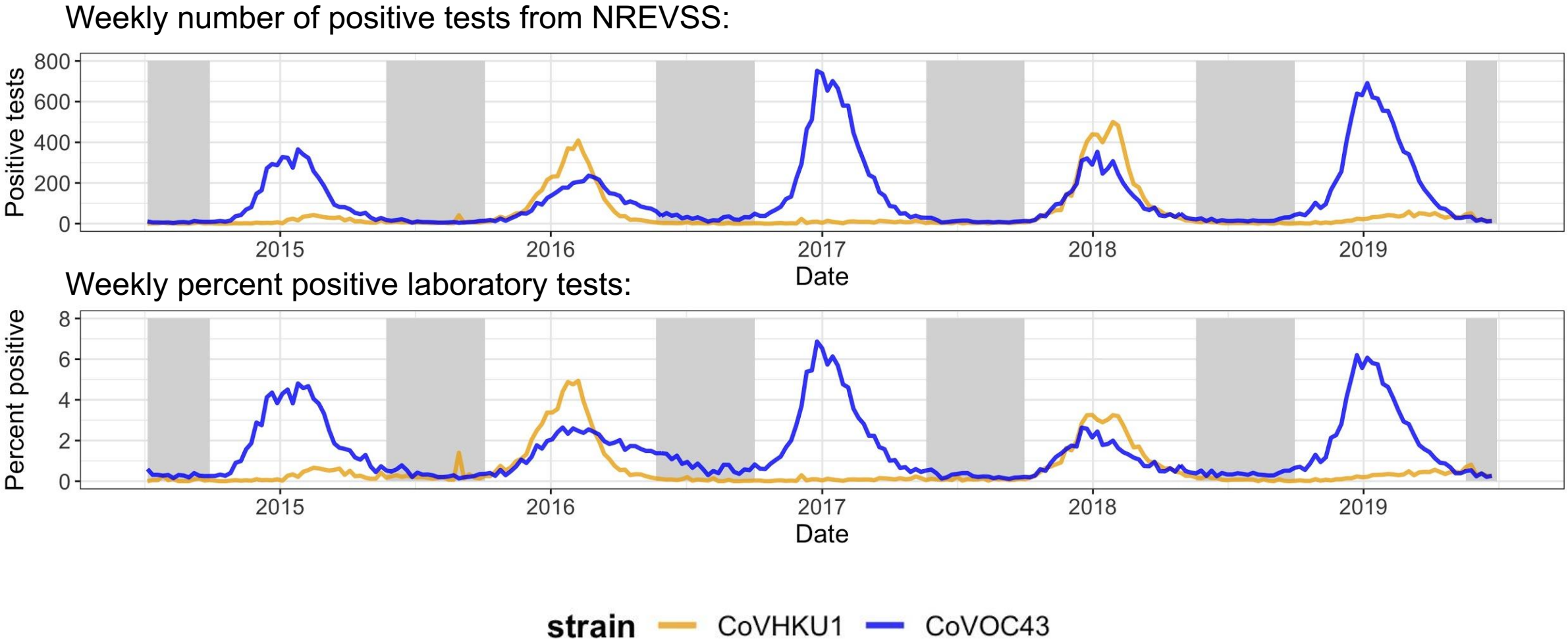


Kissler et al. *Nature Communications* 2020

Where we left off…

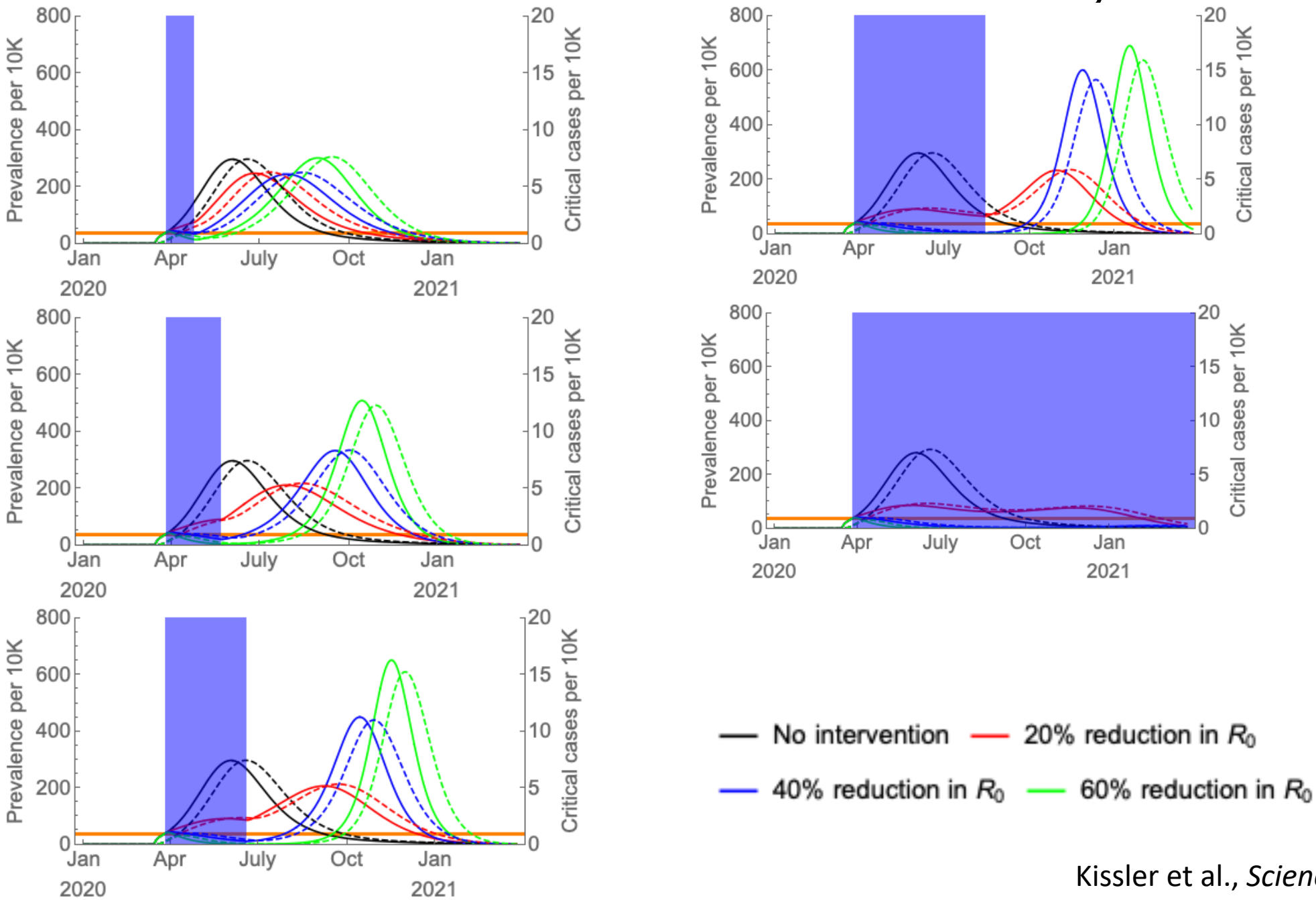
Spring, 2020:
- Some places “crushed the curve” using a combination of lockdown, masking, and extensive testing, tracing, and isolation/quarantine
- Other places used lockdowns to “flatten the curve”
- Questions on what will happen in the summer and fall

Is there seasonality?
What about for the other human coronaviruses?



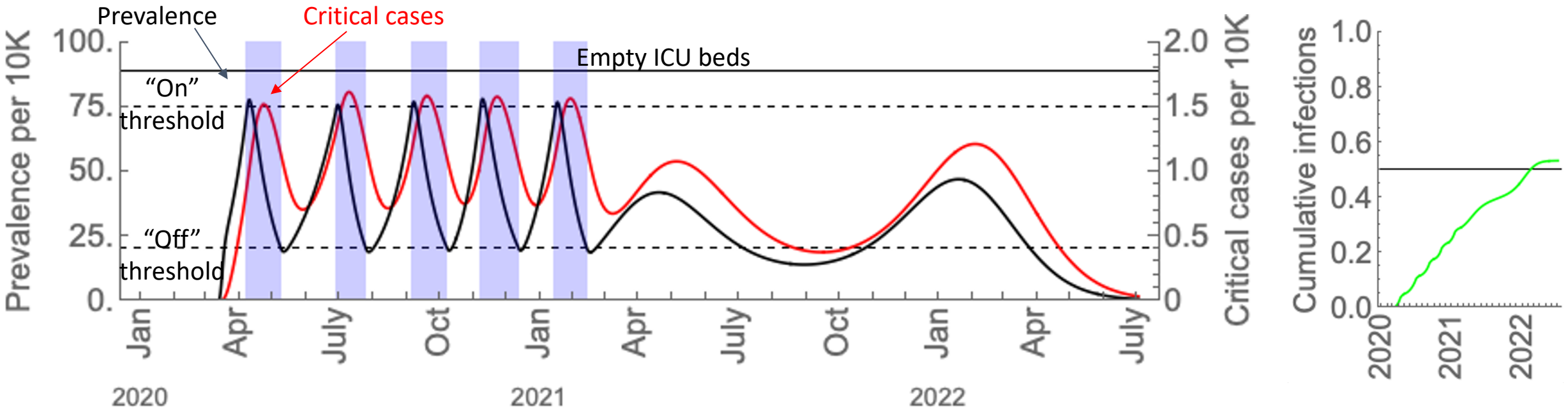
Kissler et al., *Science* 2020

Incidence for interventions with seasonality

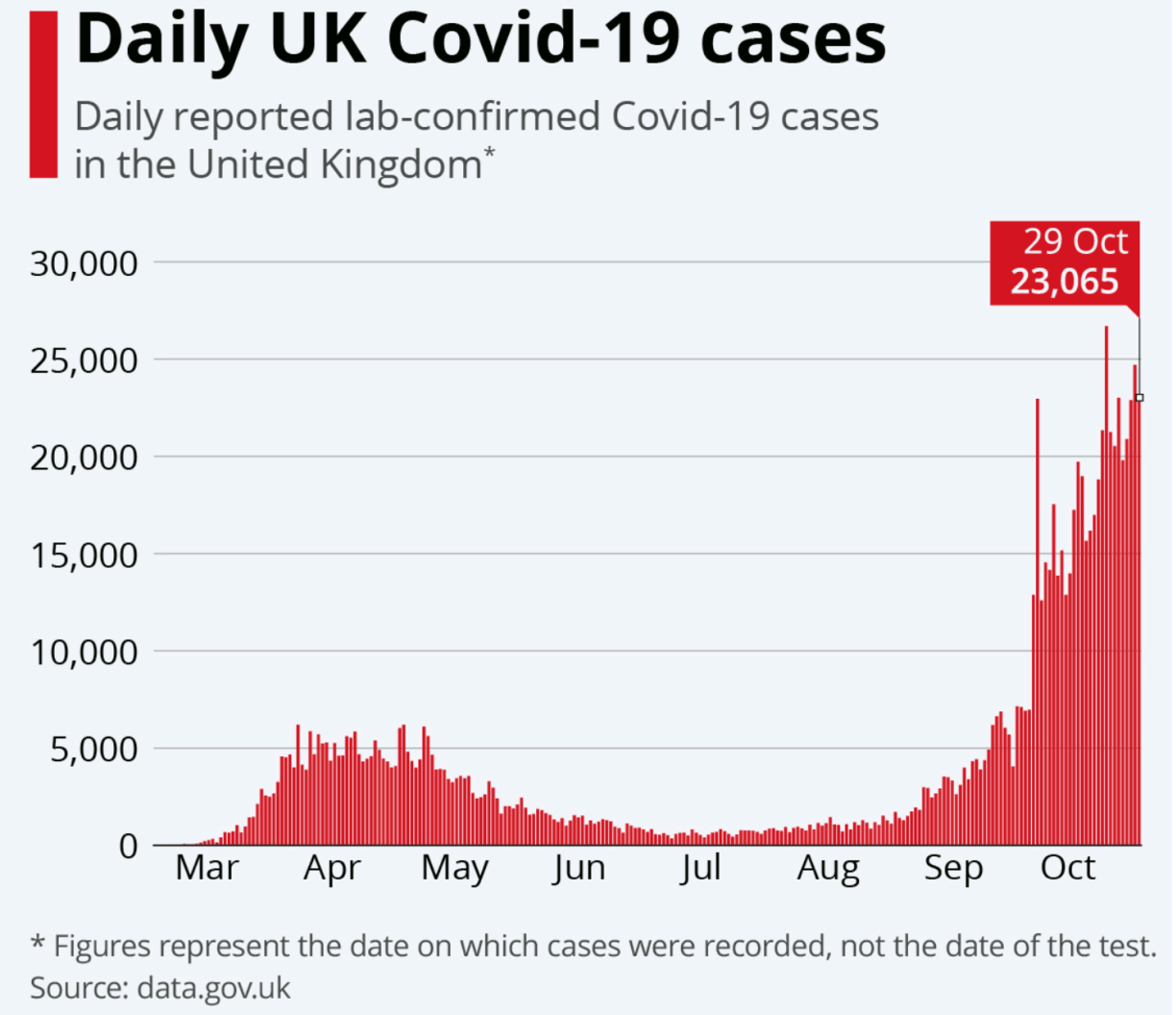


Kissler et al., *Science* 2020

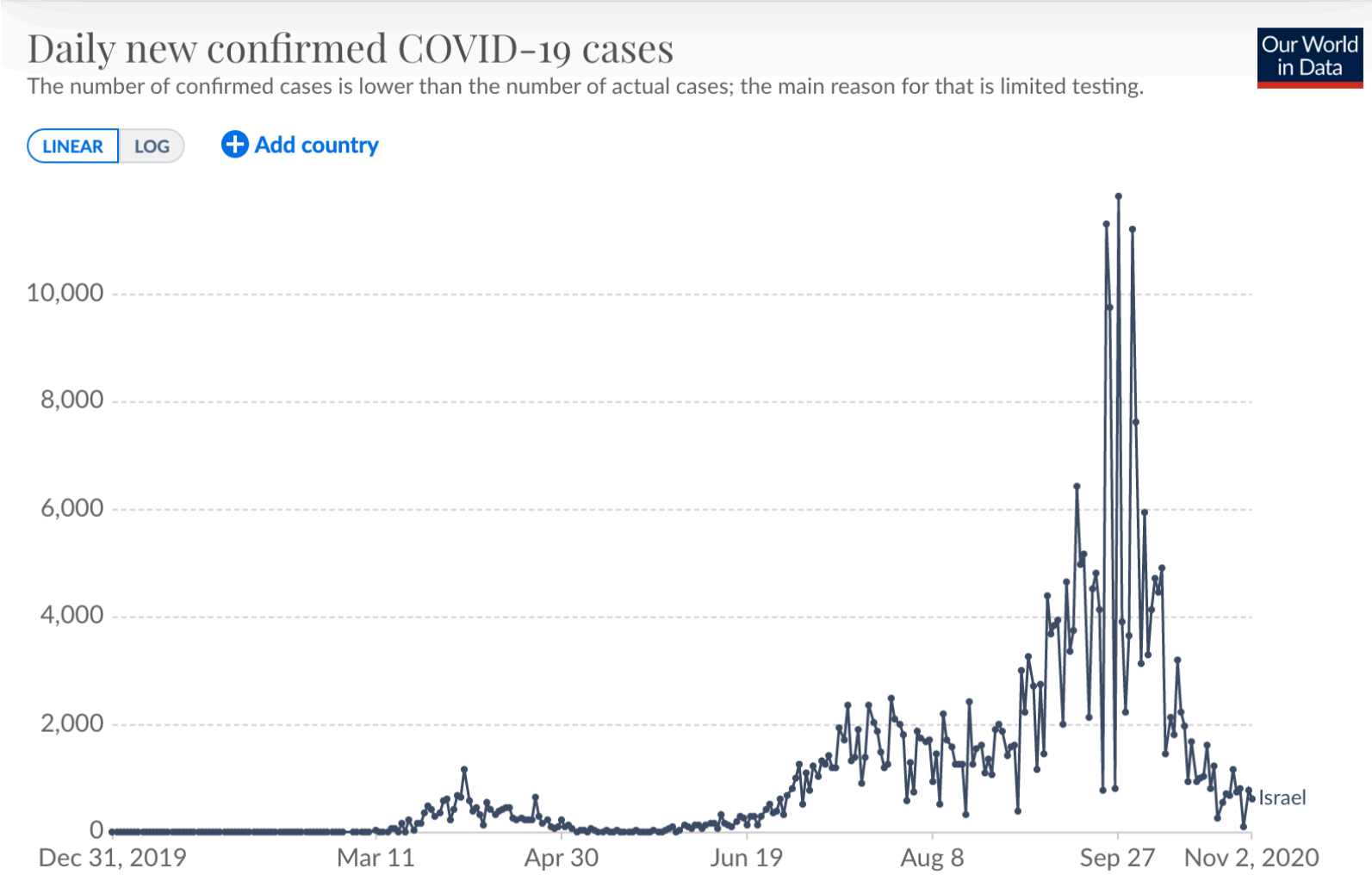
Cycles of lockdowns…



Example from the UK



Example from Israel



“Reduce. Relax. Repeat”

Other examples:

So what do we do now?

- Repeated lockdowns, masking, distancing
- Testing, testing, testing… together with supported isolation and quarantine
- Await effective vaccines and therapeutics

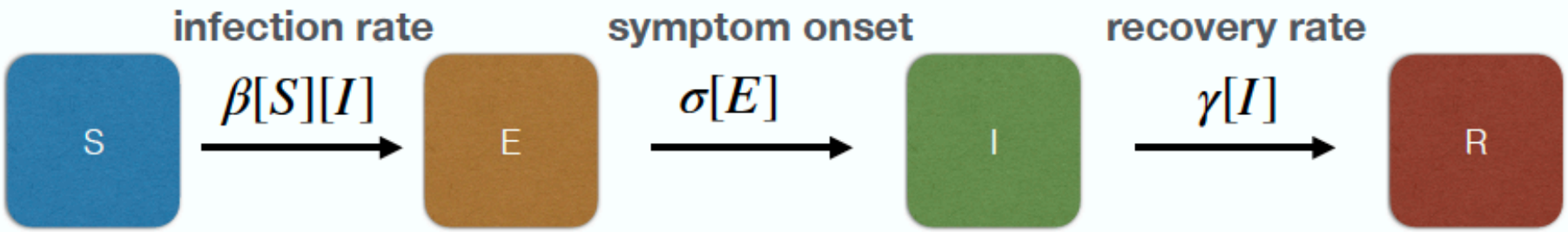
Model-informed COVID-19 vaccine prioritization strategies by age and serostatus

Kate M. Bubar,[1,2]* Stephen M. Kissler,[3] Marc Lipsitch[3,4], Sarah Cobey[5],
Yonatan H. Grad[3], Daniel B. Larremore[6,7]*

The model for SARS-CoV-2:

People move between the compartments of this “compartmental model”:

Susceptible **E**xposed **I**nfected **R**ecovered



But in this kind of model, everyone is the same. We need more structure!

Stratified compartmental models

e.g. POLYMOD-type age-structured SEIR models

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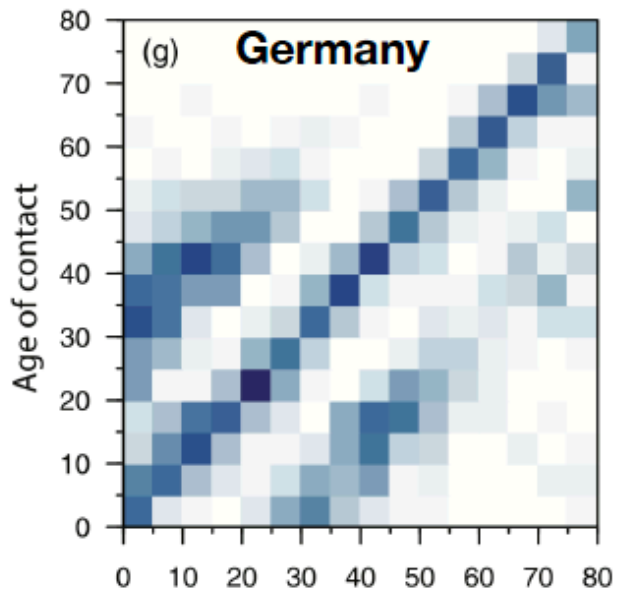
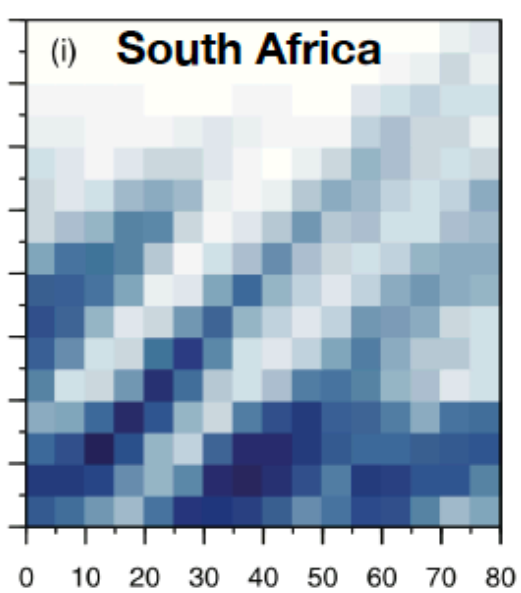
Social Contacts and Mixing Patterns Relevant to the Spread of Infectious Diseases

Joël Mossong[1,2*], Niel Hens[3], Mark Jit[4], Philippe Beutels[5], Kari Auranen[6], Rafael Mikolajczyk[7], Marco Massari[8], Stefania Salmaso[8], Gianpaolo Scalia Tomba[9], Jacco Wallinga[10], Janneke Heijne[10], Malgorzata Sadkowska-Todys[11], Magdalena Rosinska[11], W. John Edmunds[4]

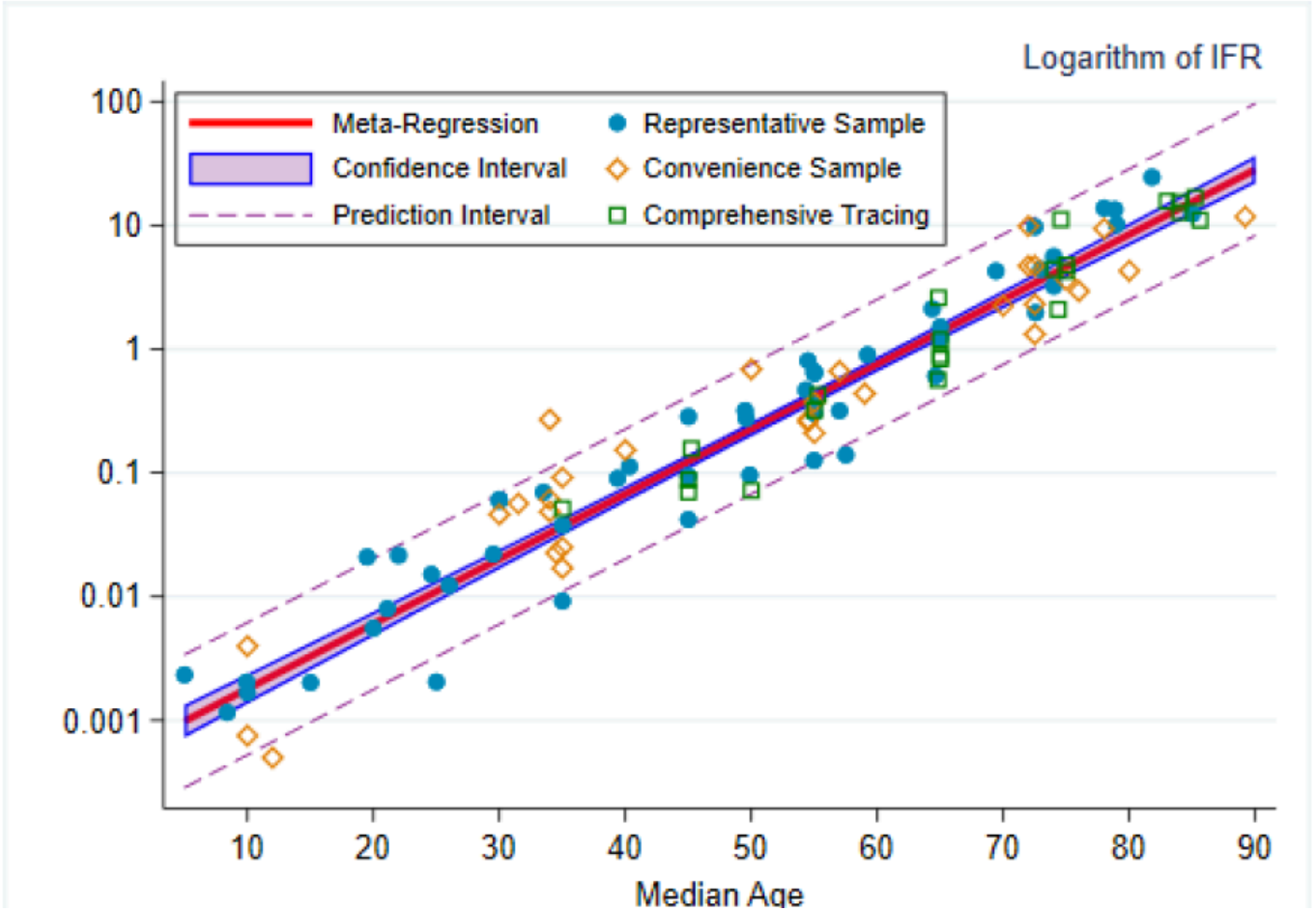
The POLYMOD study and others like it have mapped age-contact structure.





Age-stratified SEIR models allow us to ask more targeted questions!

Infection-Fatality Ratio (IFR) increases exponentially with age



Levin, Meyerowitz-Katz, *et al*., *medRxiv* https://www.medrxiv.org/content/10.1101/2020.07.23.20160895v6

knowns:

1. The vaccine will initially be scarce.

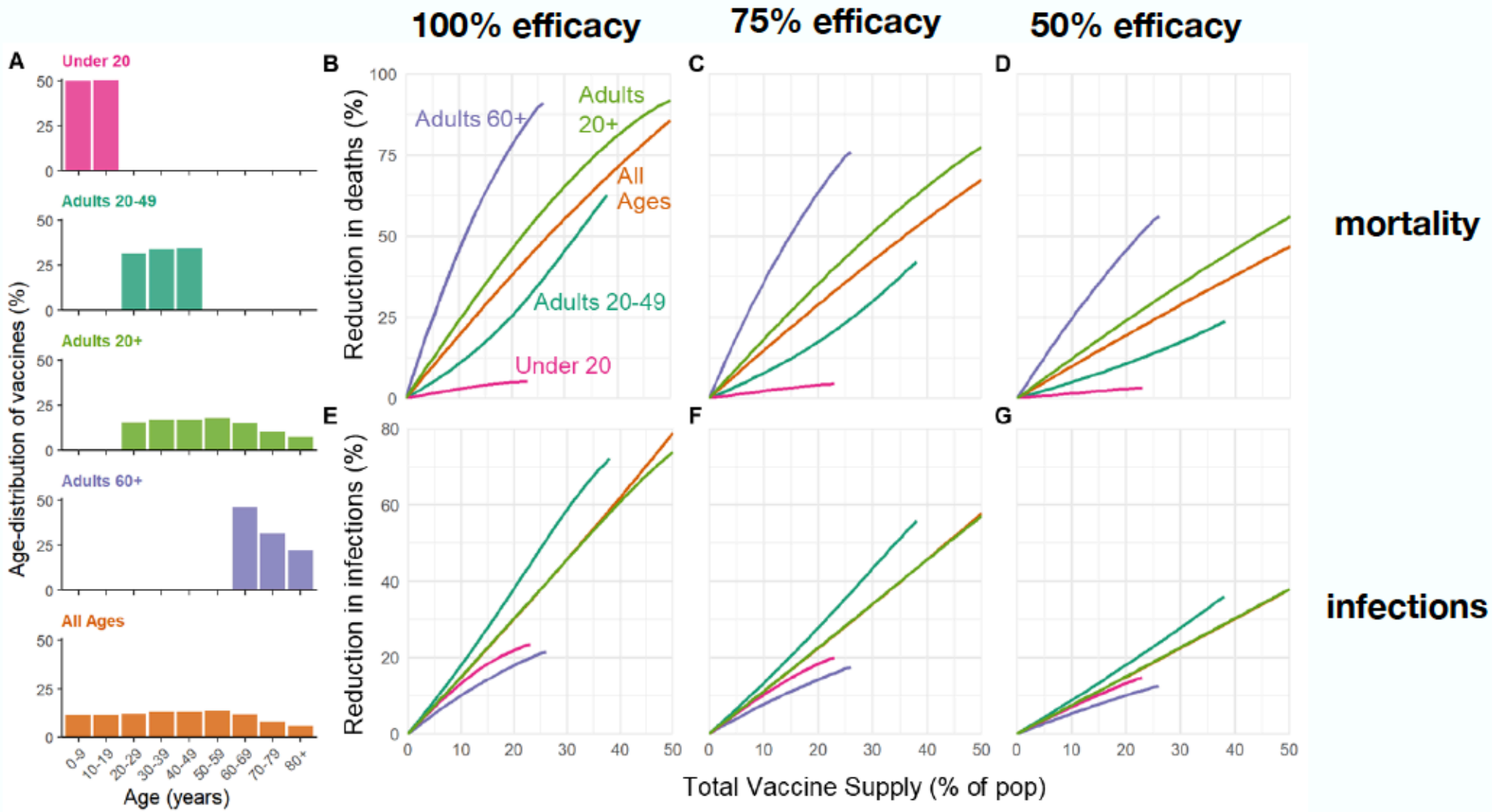
unknowns:

1. **Safety:** who is the vaccine approved for?
2. **Efficacy:** how protective is the vaccine?
3. **Age-related effects:** is the vaccine equally effective across ages?
4. **Vax properties:** transmission blocking?

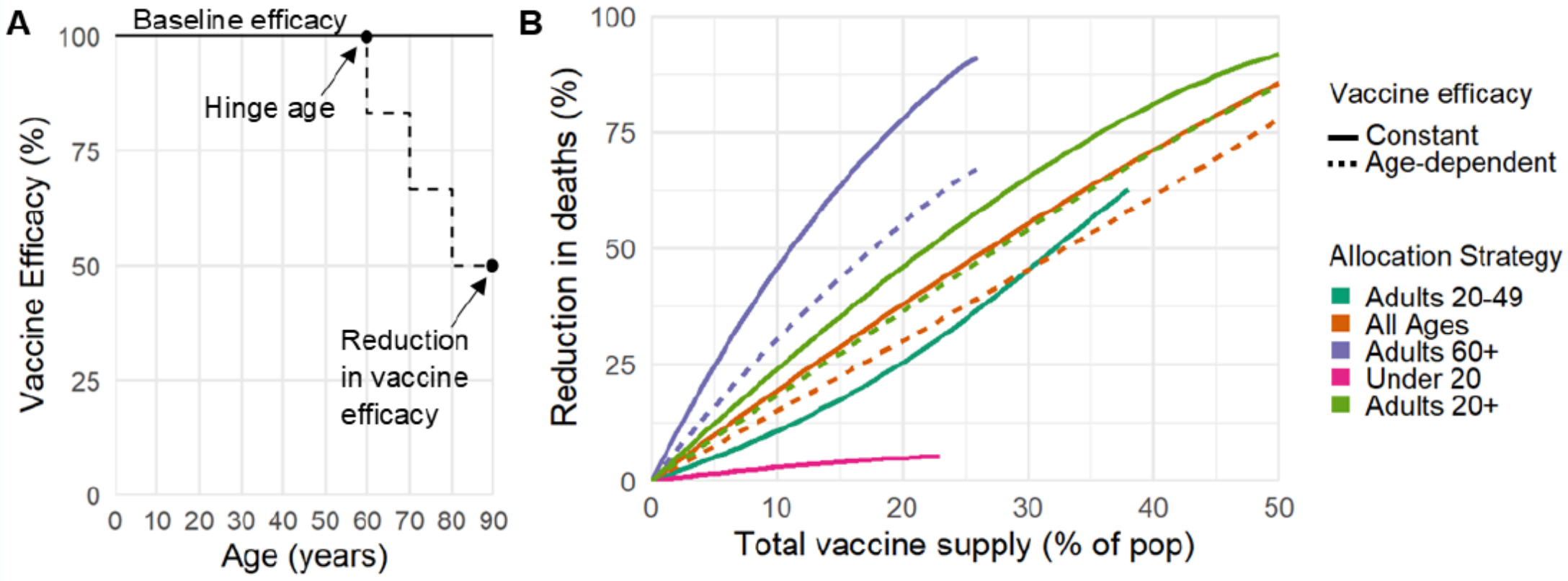
variables:

1. **Demographics:** what's the age distribution in the population?
2. **Age-contact structure:** are families multihousehold? Do people of all ages work? Strict retirement age?
3. **Seroprevalence:** what fraction of the population has antibodies already? And, do they correlate with protection?

How do different prioritizations play out?



What about variation in efficacy by age?

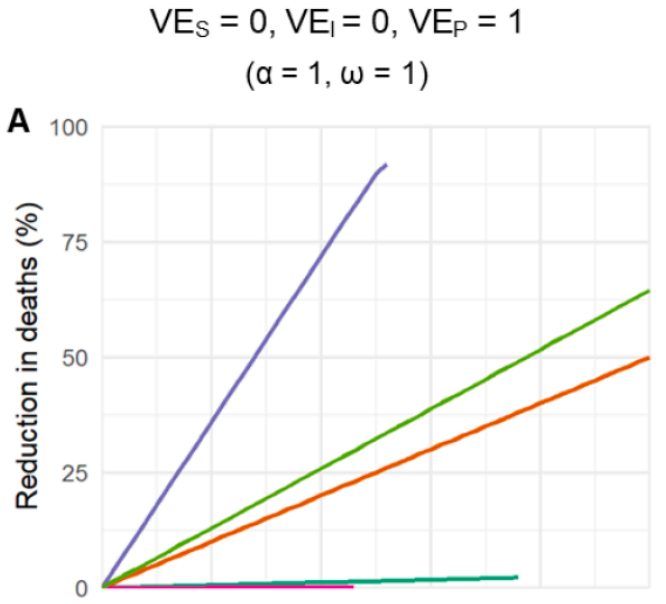


Prioritizing the elderly (similarly, comorbid) to reduce deaths is robust to:

Variations in efficacy by age

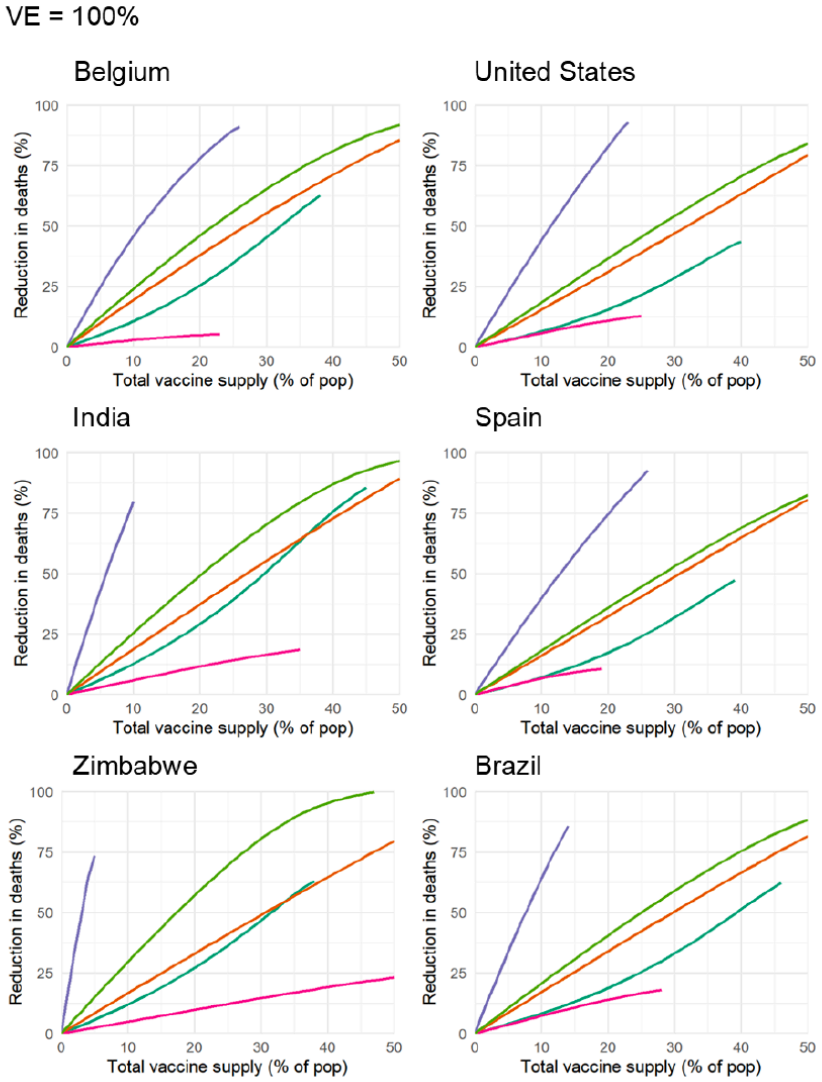
Baseline efficacy	Hinge Age	Assuming an all-or-nothing vaccine. Tipping point when vaccine supply is:		
		5% of pop	15% of pop	25% of pop
50%	59	-	-	-
	69	-	-	-
	79	-	-	-
75%	59	-	-	**0.8%**
	69	-	-	-
	79	-	-	-
100%	59	-	-	**3.9%**
	69	-	-	-
	79	-	-	-

Vaccine that protects only against symptoms/death: no effect on infections



Prioritizing the elderly (similarly, comorbid) to reduce deaths is robust to:

Demography



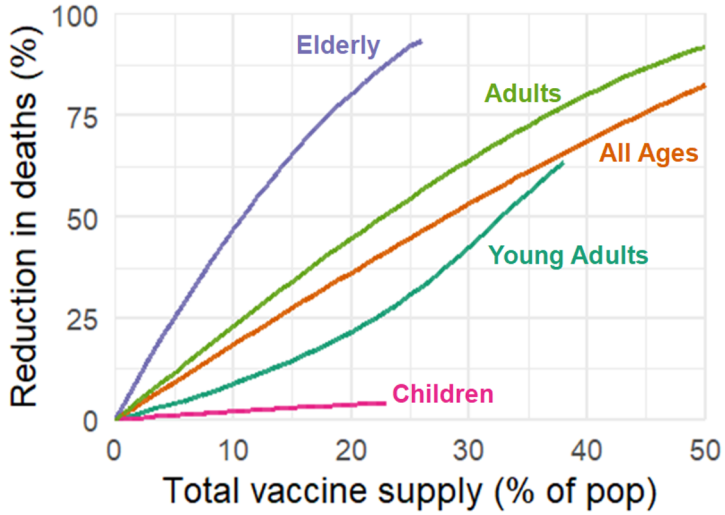
Also to leaky or all-or-nothing vaccine

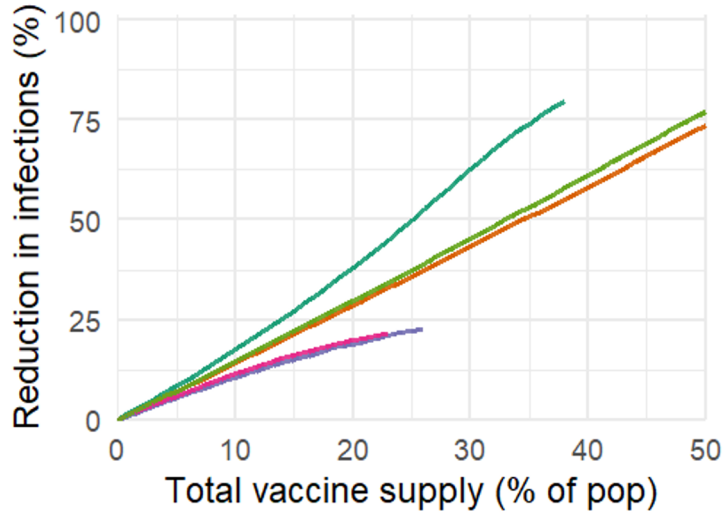
Current model includes:

- ➔Contact patterns by age
- ➔Demographics
- ➔Susceptibility by age
- ➔Serology
- ➔Age-variation in vaccine effectiveness
- ➔IFR

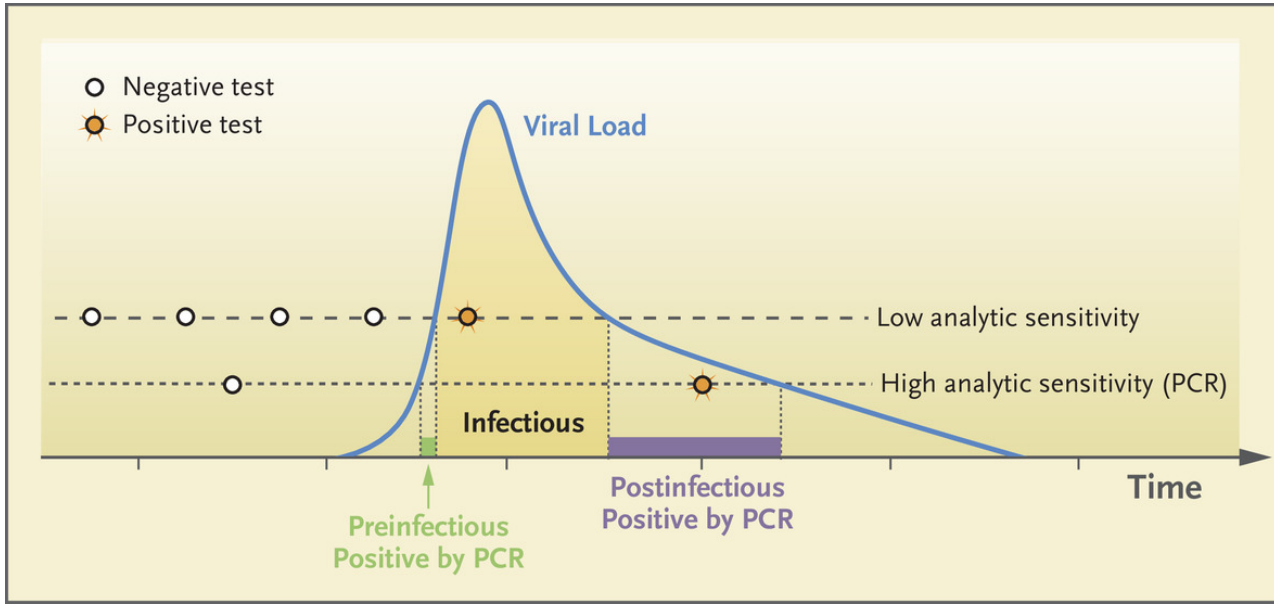
Framework enables sensitivity testing.

Next: vary *R*, the timing of vaccine roll-out

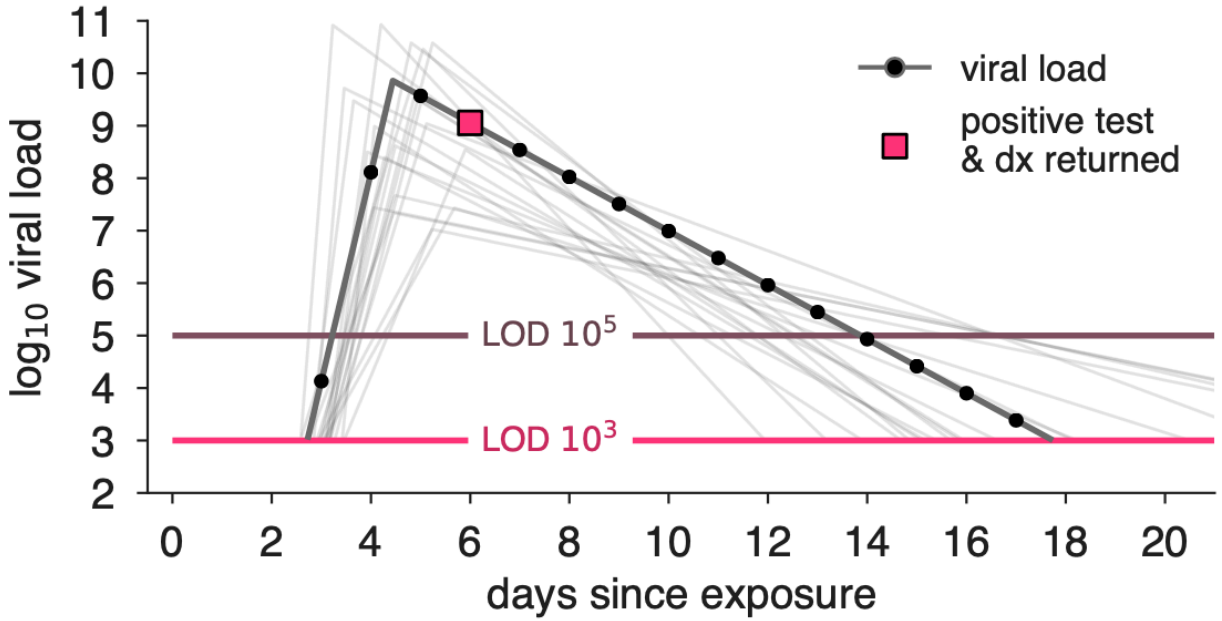




Charting the course of SARS-CoV-2 infection

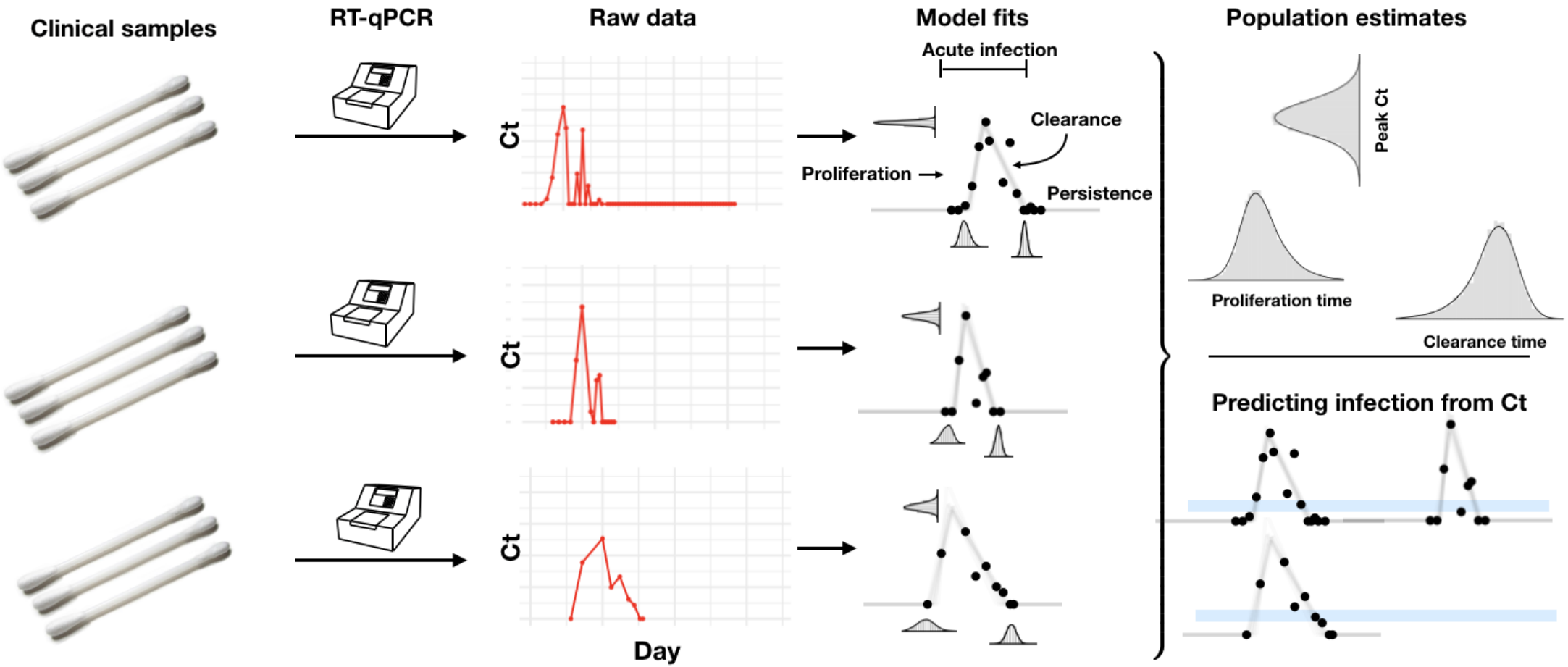


Mina, Parker, Larremore. *NEJM*. 2020



Larremore et al., *Science Advances*. In press.

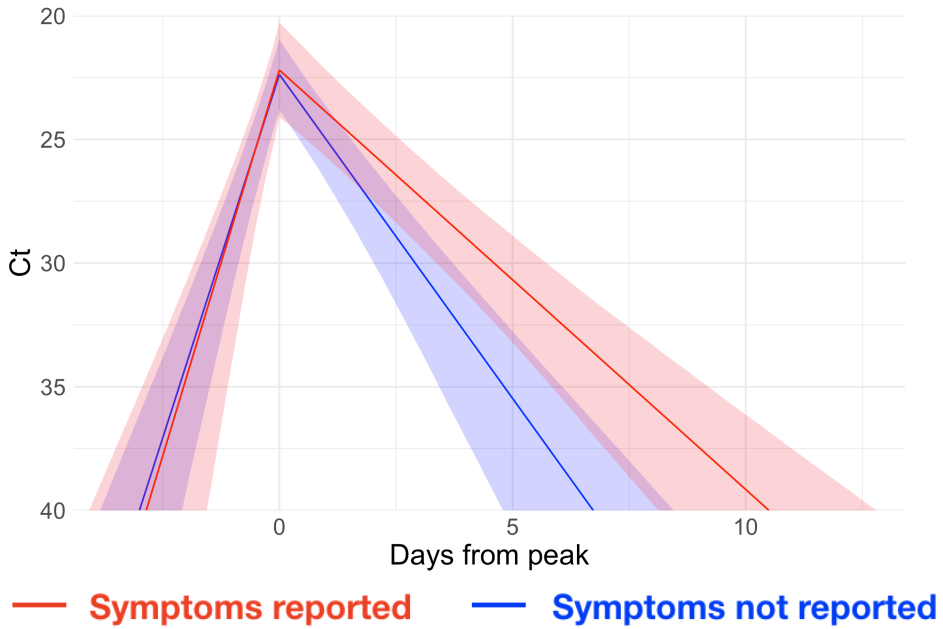
The quantitative prospective longitudinal NBA testing enables estimation of the full viral trajectory

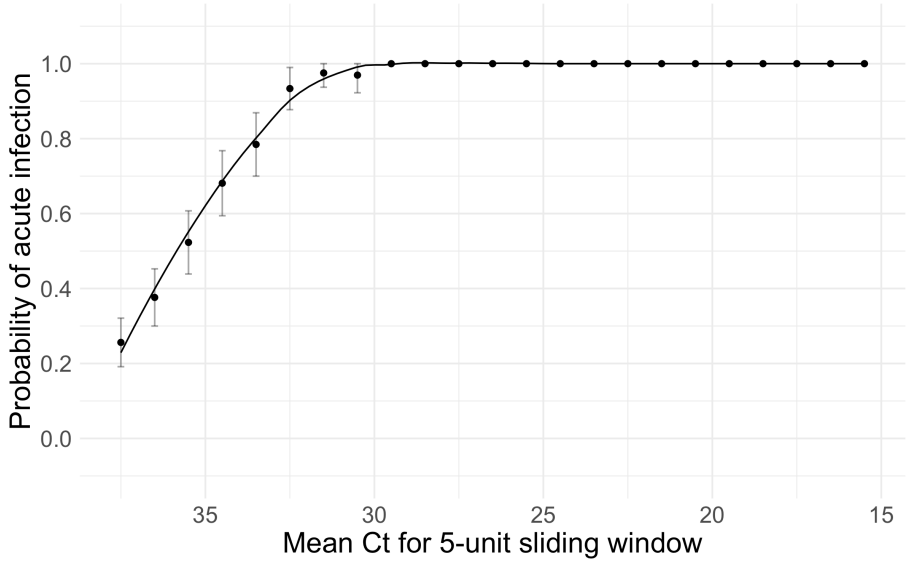


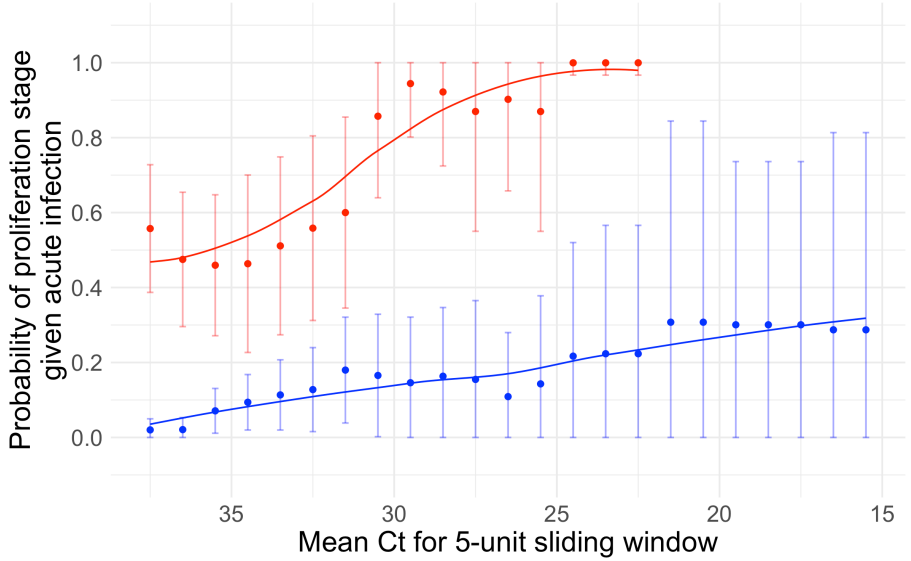
Data from 68 individuals, 46 with acute infections, 13 of whom reported symptoms

Kissler et al., *medRxiv* 2020

Quantitative tests can inform clinical and public health decision-making







Kissler et al., *medRxiv* 2020

Acknowledgements and citations

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Kissler SM, Tedijanto C, Goldstein E, Grad YH*, Lipsitch M*. Projecting the transmission dynamics of SARS-CoV-2 through the post-pandemic period. *Science*. 2020 May 22;368(6493):860-868. *co-senior authors

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