

Update on COVID-19 Epidemiology and Management Strategies



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

The pandemic is global



Global Cases

47,423,447

Cases by Country/Region/Sovereignty

9,323,852 US

8,267,623 India

5,554,206 Brazil

1,661,096 Russia

1,460,745 France

1,307,922 Colombia

1,259,366 Spain

1,183,131 Argentina

1,057,022 United Kingdom

Admin0

Last Updated at (M/D/YYYY)

5 PM

https://coronavirus.jhu.edu



Esri, FAO, NOAA

Cumulative Cases

Active Cases

Incidence Rate

Case-Fatality Ratio

Testing Rate

190

countries/regions

Lancet Inf Dis Article: [Here](#). Mobile Version: [Here](#). Data sources: [Full list](#). Downloadable database: [GitHub](#), [Feature Layer](#).

Lead by [JHU CSSE](#). Technical Support: [Esri Living Atlas team](#) and [JHU APL](#). Financial Support:

Global Deaths

1,209,927

231,968 deaths
US

160,253 deaths
Brazil

123,097 deaths
India

92,100 deaths
Mexico

46,943 deaths

Global Deaths

US State Level

Deaths, Recovered

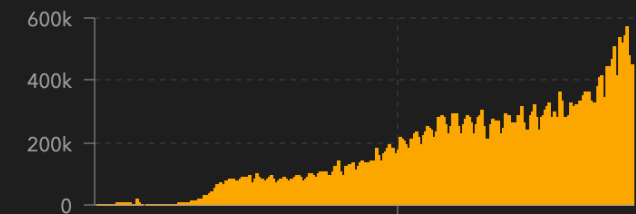
33,543 deaths, 79,831
recovered
New York US

18,542 deaths, 787,685
recovered
Texas US

17,702 deaths,
recovered
California US

16,834 deaths.

US Deaths, Rec...



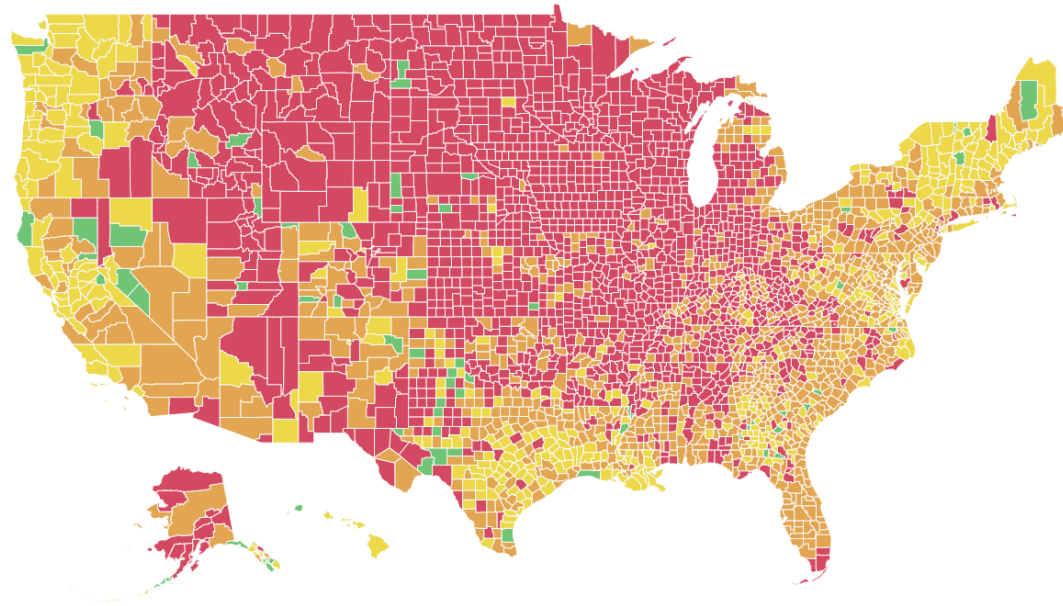
Daily Cases

The pandemic is hyper-local

This map displays COVID Risk Levels for each county in the United States. Hover over a county for detailed information on cases and deaths counts. Risk Levels are calculated based on daily cases per 100,000 population (7 day rolling average). See Daily New Cases for actual number of confirmed cases (7 day rolling average).

[Learn more](#)

Risk Levels by County



Risk Levels: ■ Green ■ Yellow ■ Orange ■ Red

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

Microsoft
[AI for Health](#)

Information about Sources
[Click Here](#)

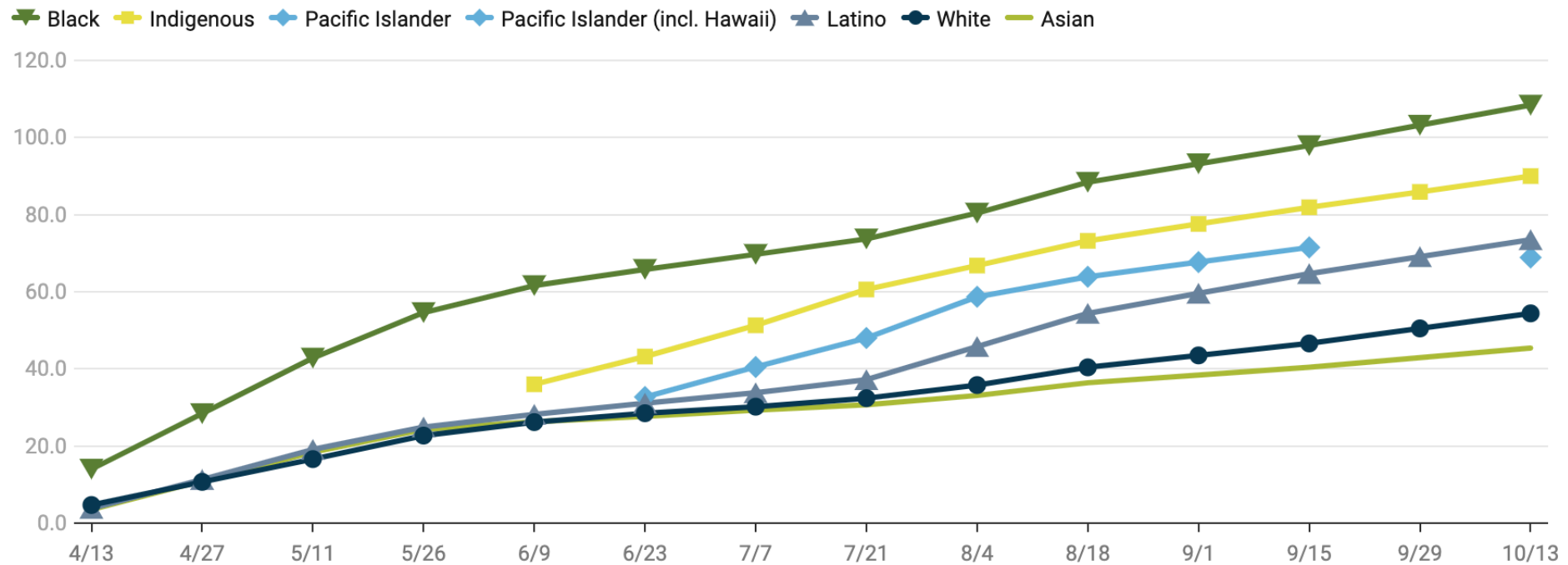
Contact us at:
ai4hc19@microsoft.com

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

Horrorific racial/ethnic disparities

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 [Datavrapper](#)

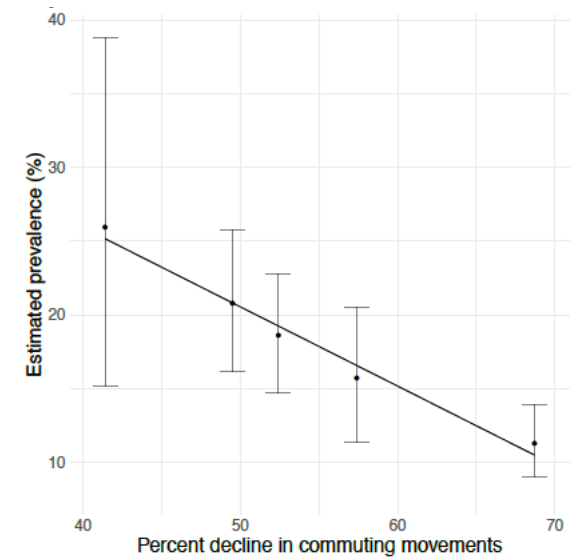
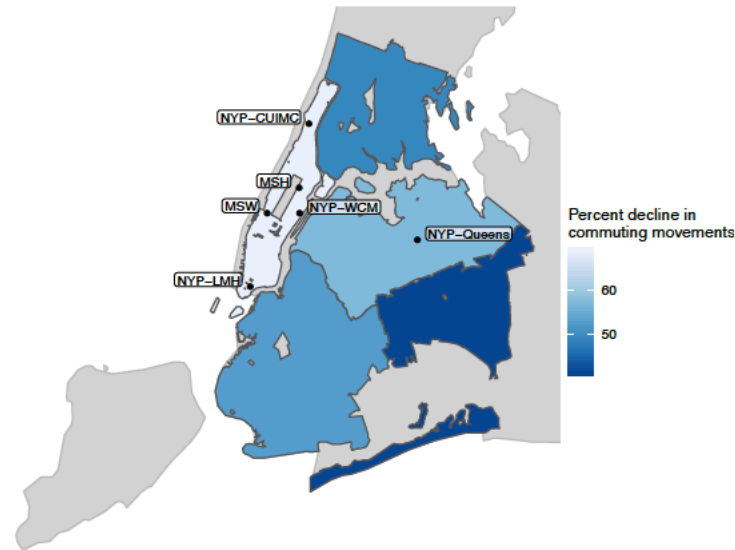
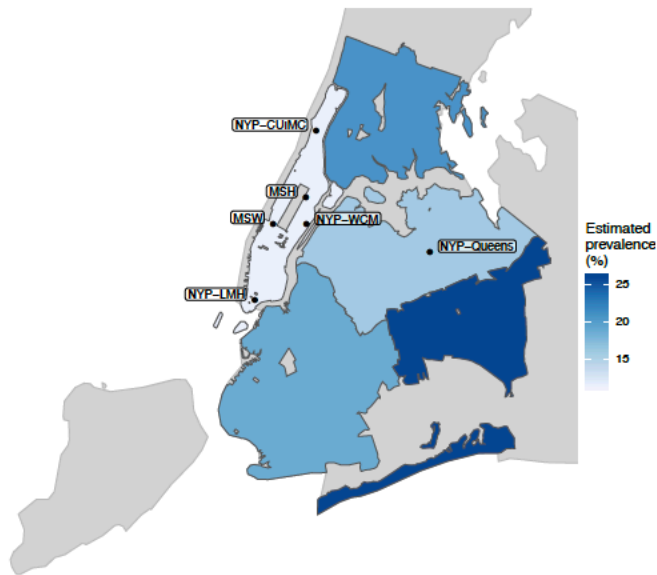
Spread has depended on individual & local responses and risk factors

New York City virus PCR in delivering mothers
Maternal virus prevalence, Mar-Apr

Maternal virus prevalence

Reduction in movement

Correlation



Where we left off...

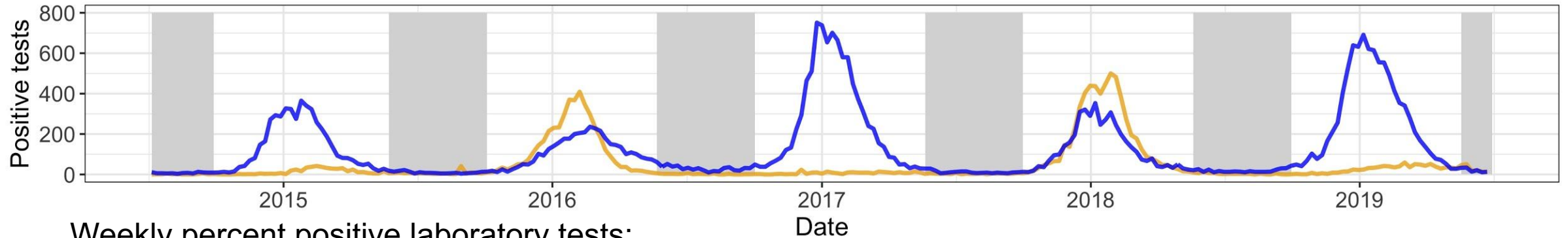
Spring, 2020:

- 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

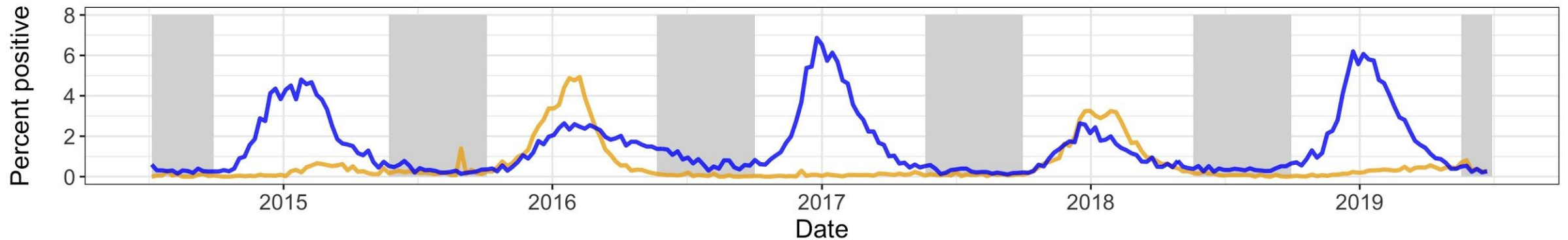
Is there seasonality?

What about for the other human coronaviruses?

Weekly number of positive tests from NREVSS:

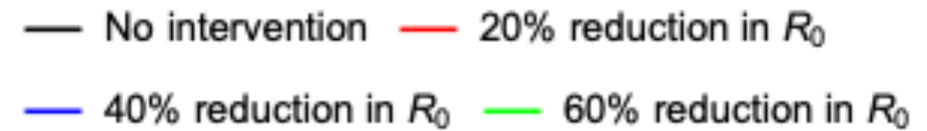
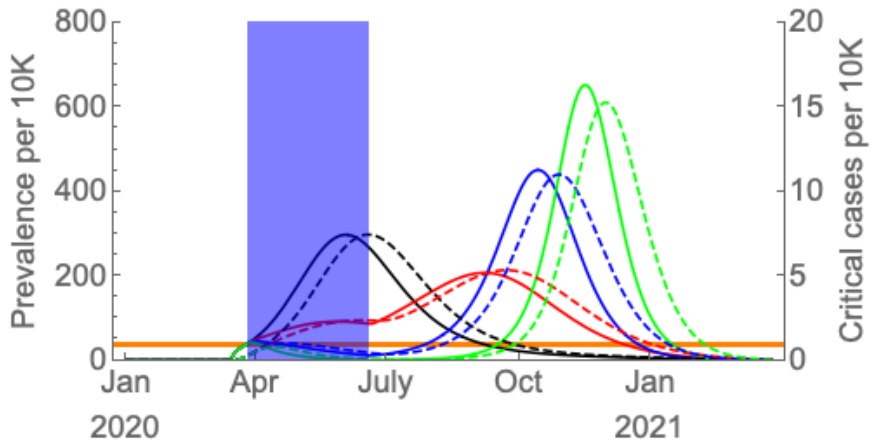
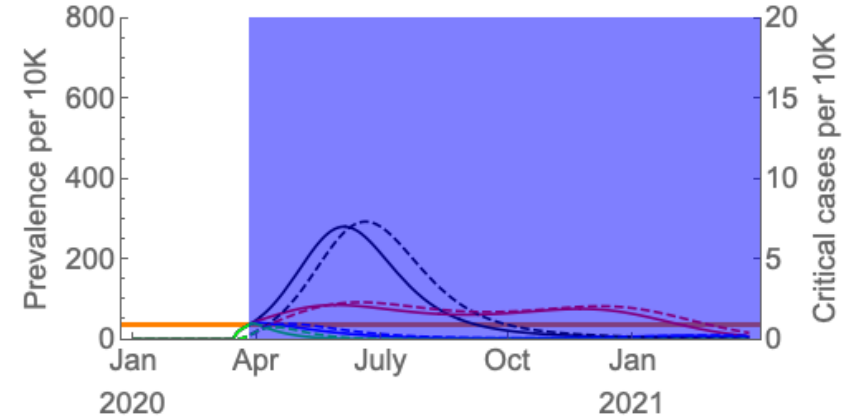
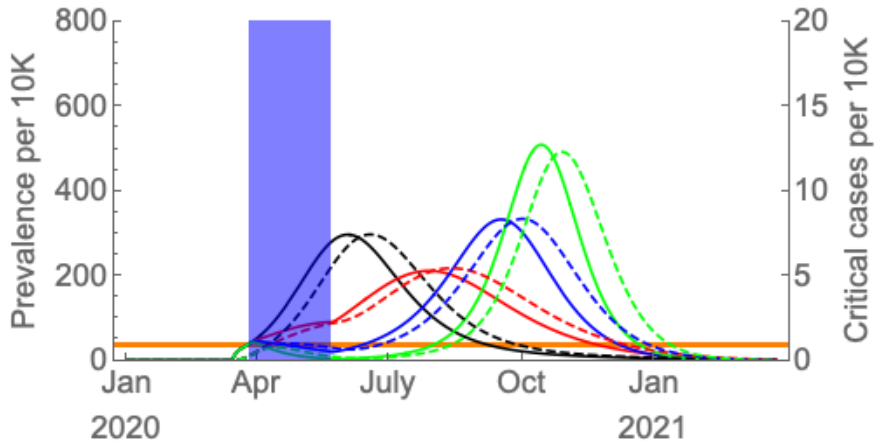
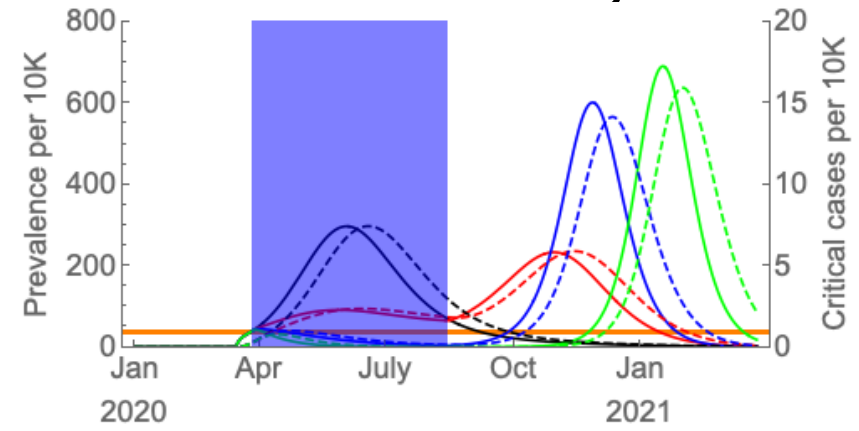
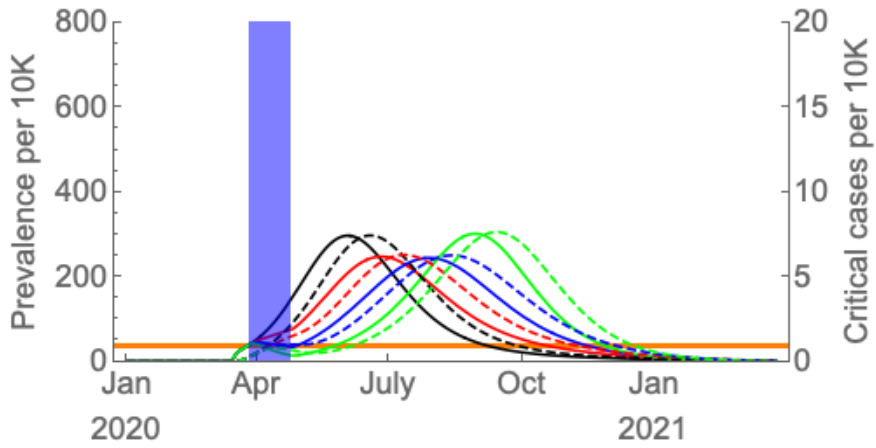


Weekly percent positive laboratory tests:

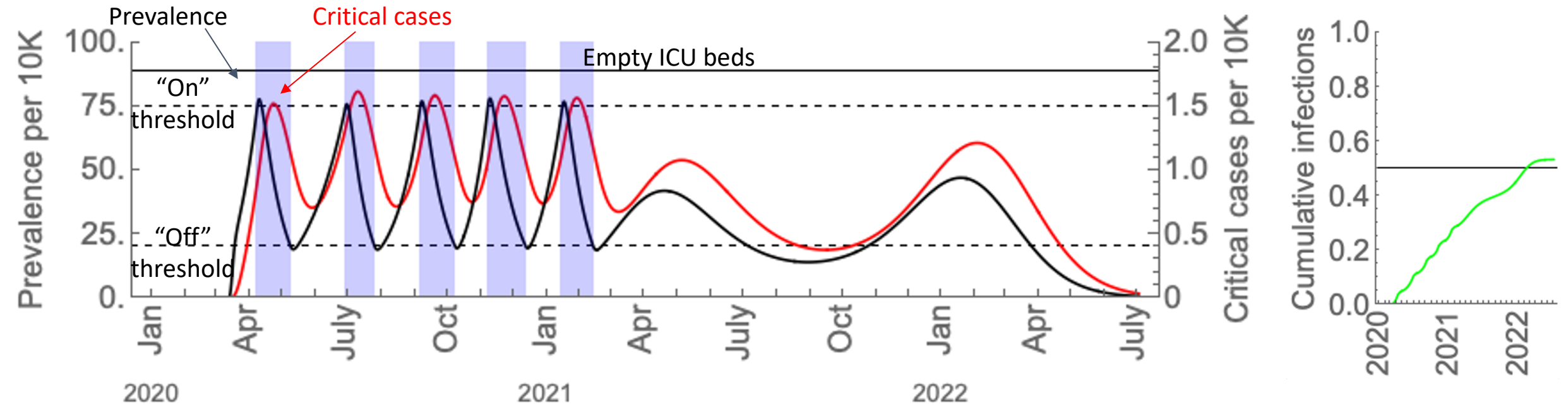


strain — CoVHKU1 — CoVOC43

Incidence for interventions with seasonality



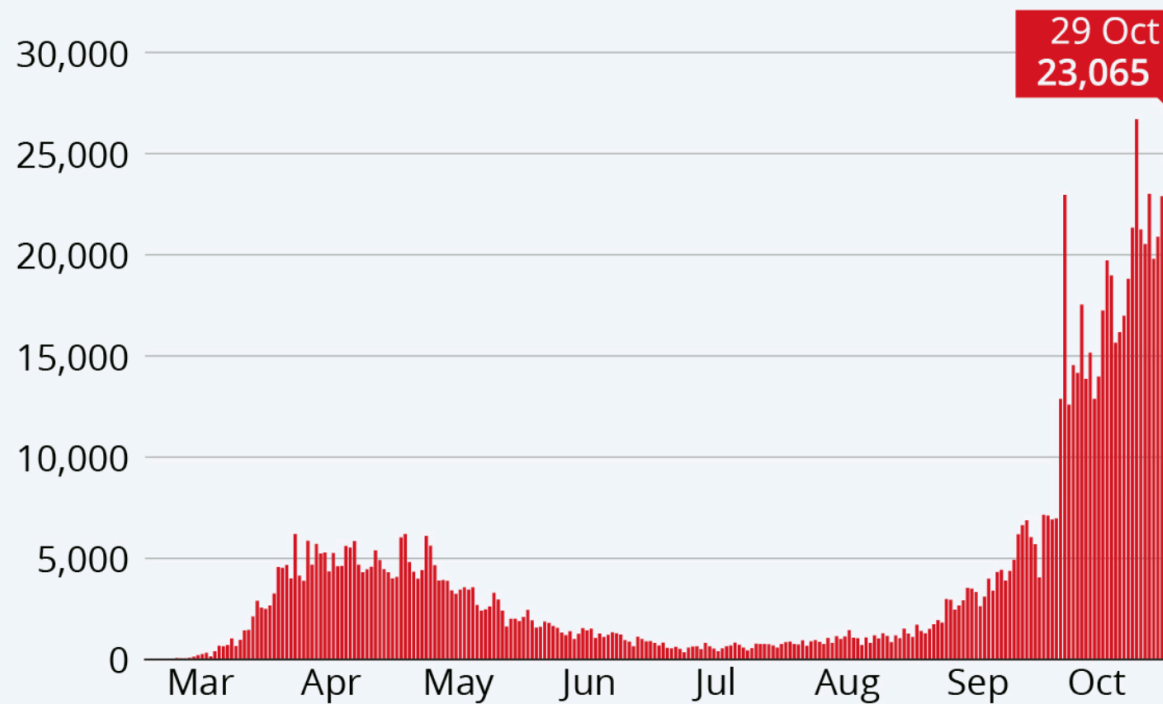
Cycles of lockdowns...



Example from the UK

Daily UK Covid-19 cases

Daily reported lab-confirmed Covid-19 cases in the United Kingdom*



* Figures represent the date on which cases were recorded, not the date of the test.
Source: data.gov.uk

Example from Israel

Daily new confirmed COVID-19 cases

The number of confirmed cases is lower than the number of actual cases; the main reason for that is limited testing.

Our World
in Data

LINEAR

LOG

+ Add country



“Reduce. Relax. Repeat”



Kai Kupferschmidt 

@kakape



Replying to [@kakape](#)

Europe meanwhile is using lockdowns to avoid health care system from collapsing. The strategy if there is one seems to be: Reduce numbers to manageable levels, then relax measures. I call it the 3Re ,strategy': Reduce. Relax. Repeat.

6:26 AM · Nov 3, 2020 · Twitter for iPhone

Other examples:



Mainland China



Vietnam



Taiwan



South Korea



Australia

So what do we do now?

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

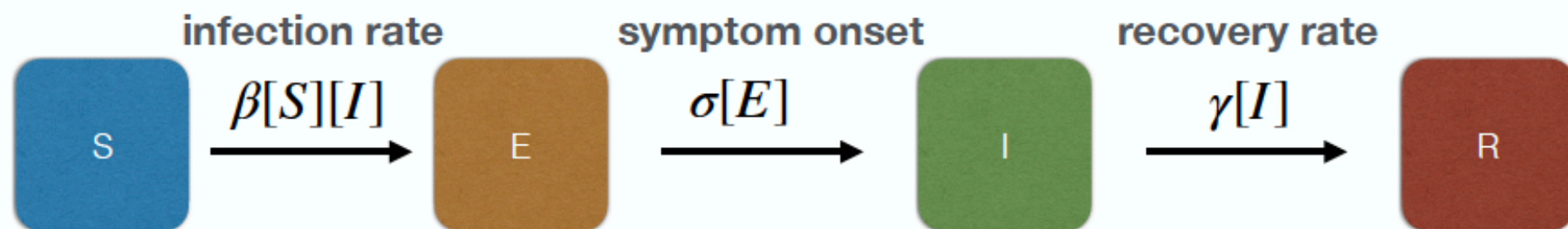
Model-informed COVID-19 vaccine prioritization strategies by age and serostatus

Kate M. Bubar,^{1,2*} Stephen M. Kissler,³ Marc Lipsitch^{3,4}, Sarah Cobey⁵,
Yonatan H. Grad³, 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

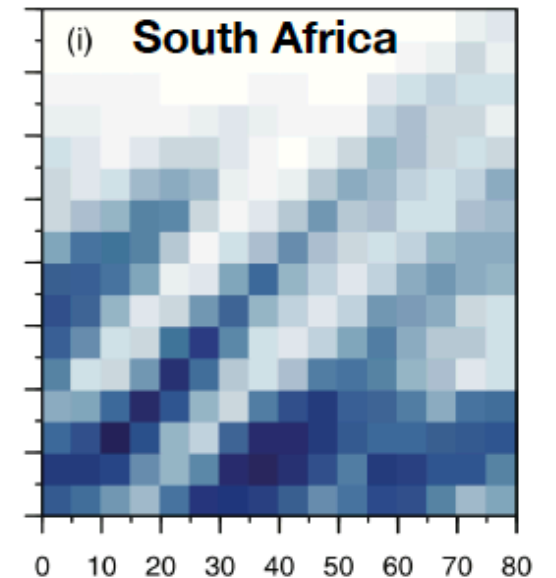
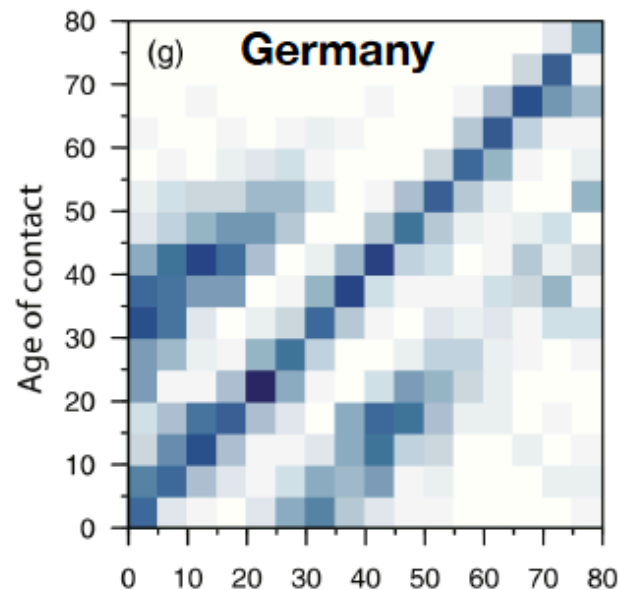
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PLOS MEDICINE

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

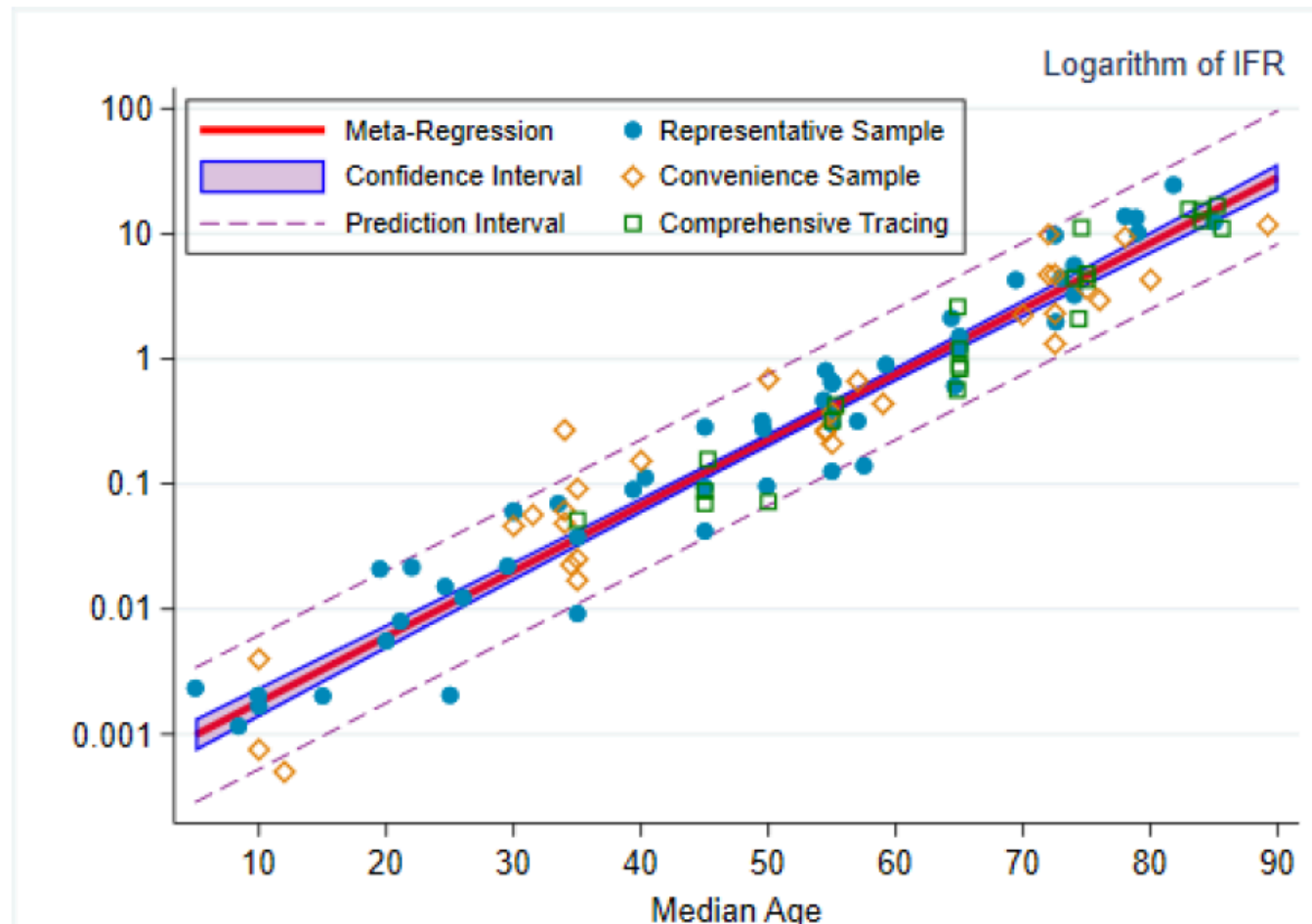
Joël Mossong^{1,2*}, Niel Hens³, Mark Jit⁴, Philippe Beutels⁵, Kari Auranen⁶, Rafael Mikolajczyk⁷, Marco Massari⁸, Stefania Salmaso⁹, Gianpaolo Scalia Tomba⁹, Jacco Wallinga¹⁰, Janneke Heljne¹⁰, Malgorzata Sadkowska-Todys¹¹, Magdalena Rosinska¹¹, W. John Edmunds⁴

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



knowns:

1. The vaccine will initially be scarce.

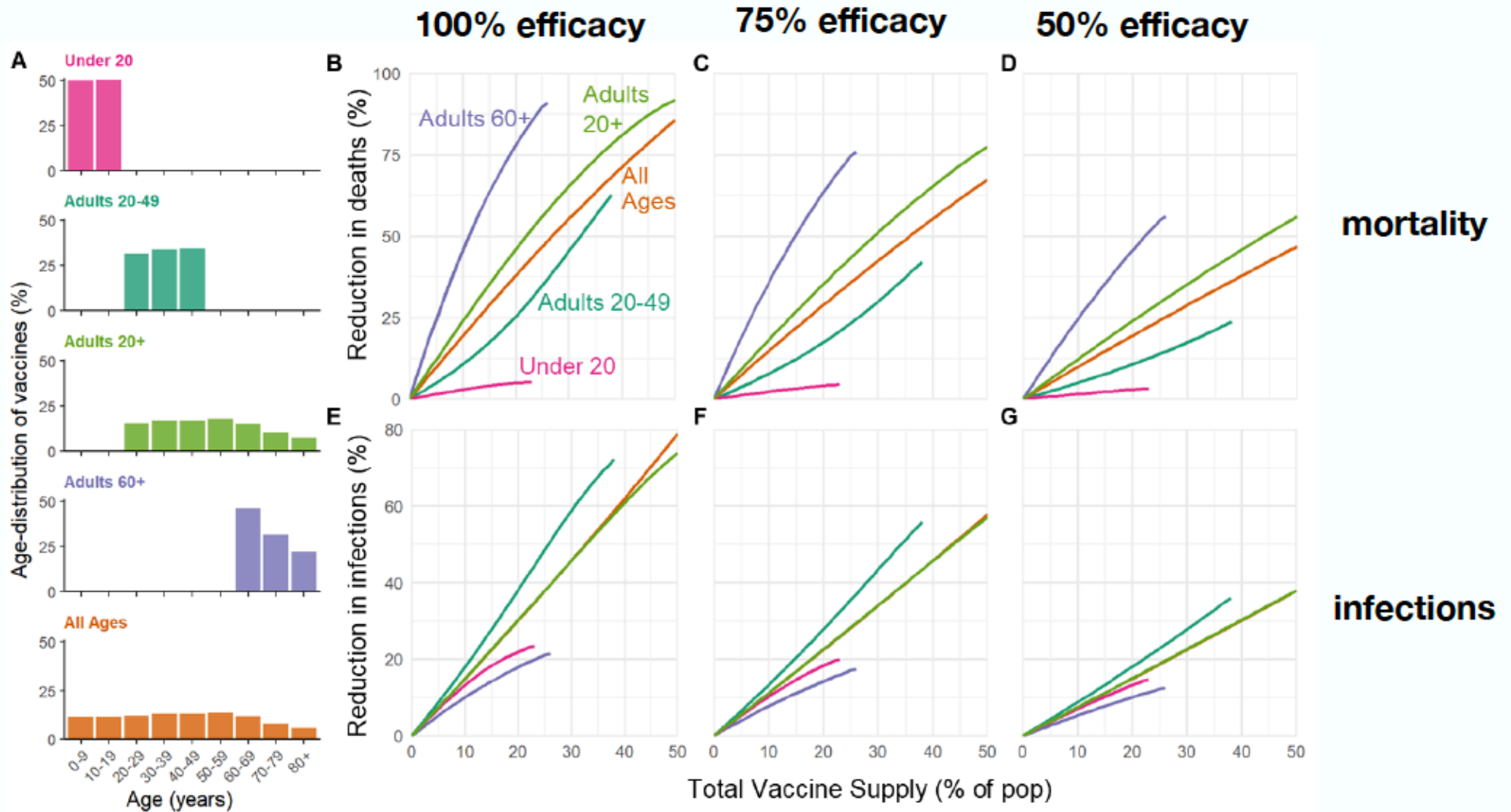
unknowns:

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?

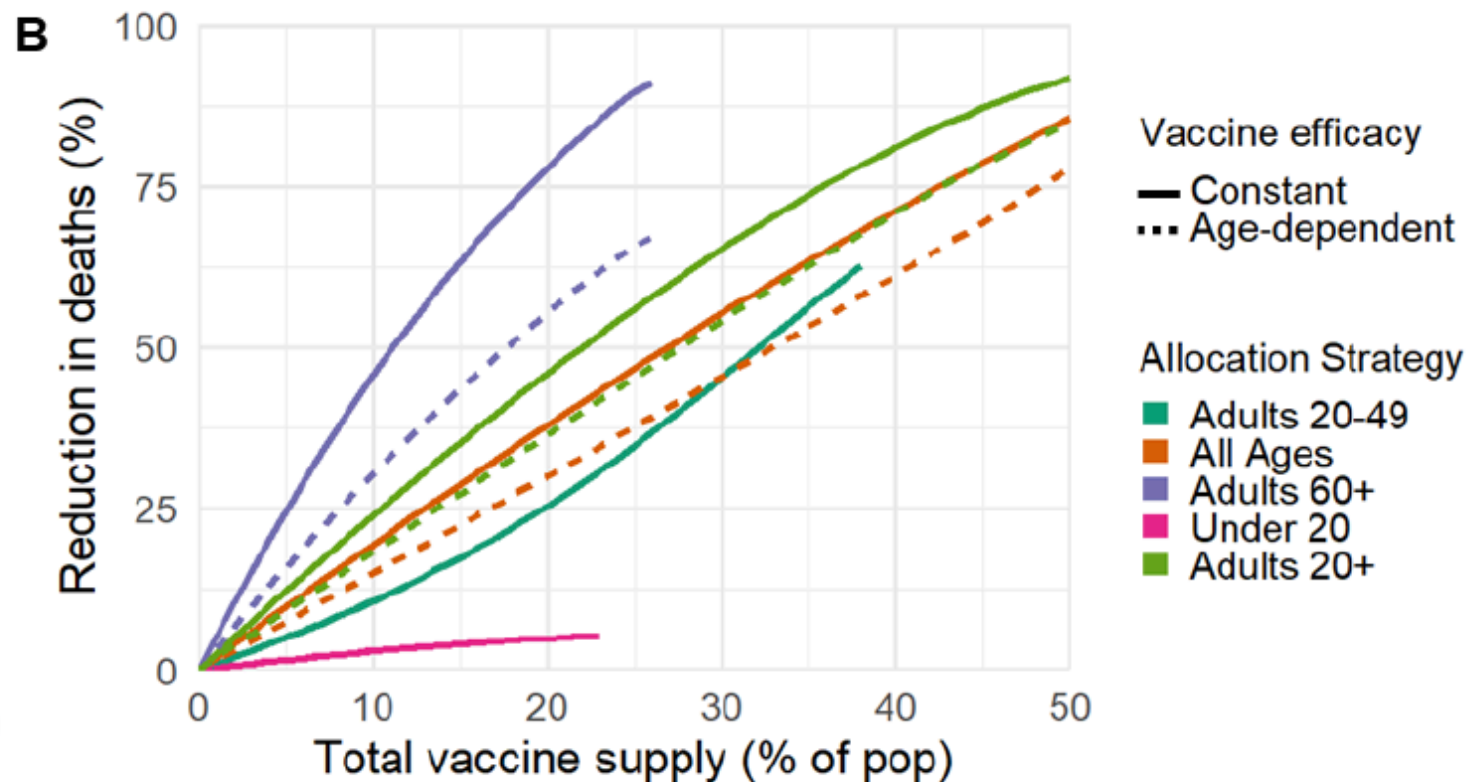
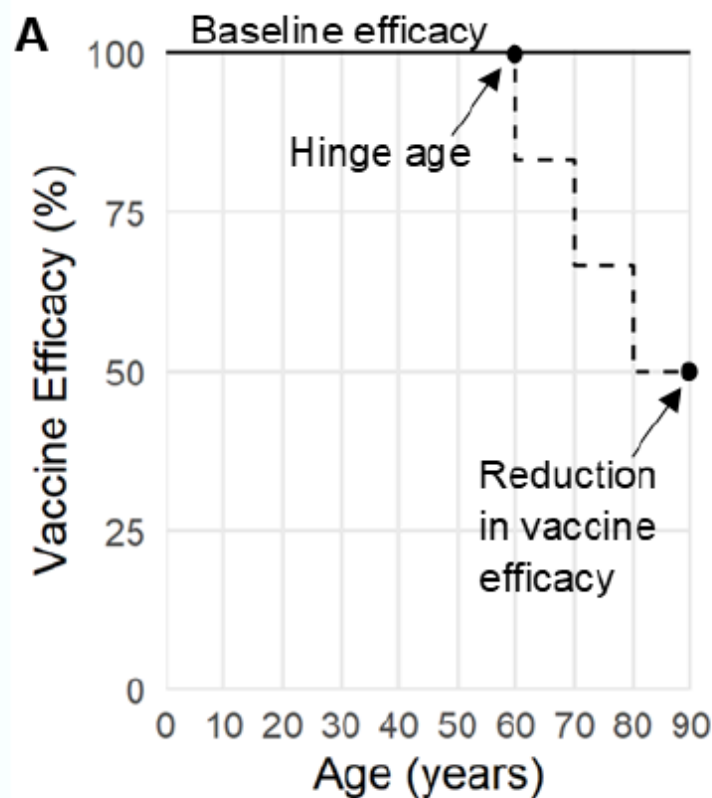
variables:

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:

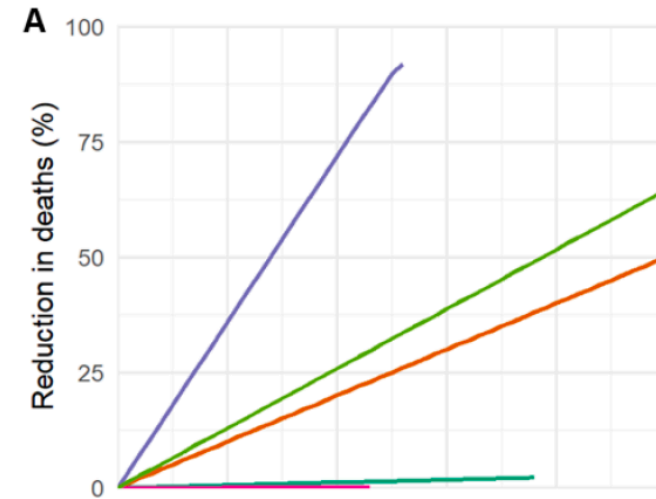
Variations in efficacy by age

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

$$VE_S = 0, VE_I = 0, VE_P = 1$$

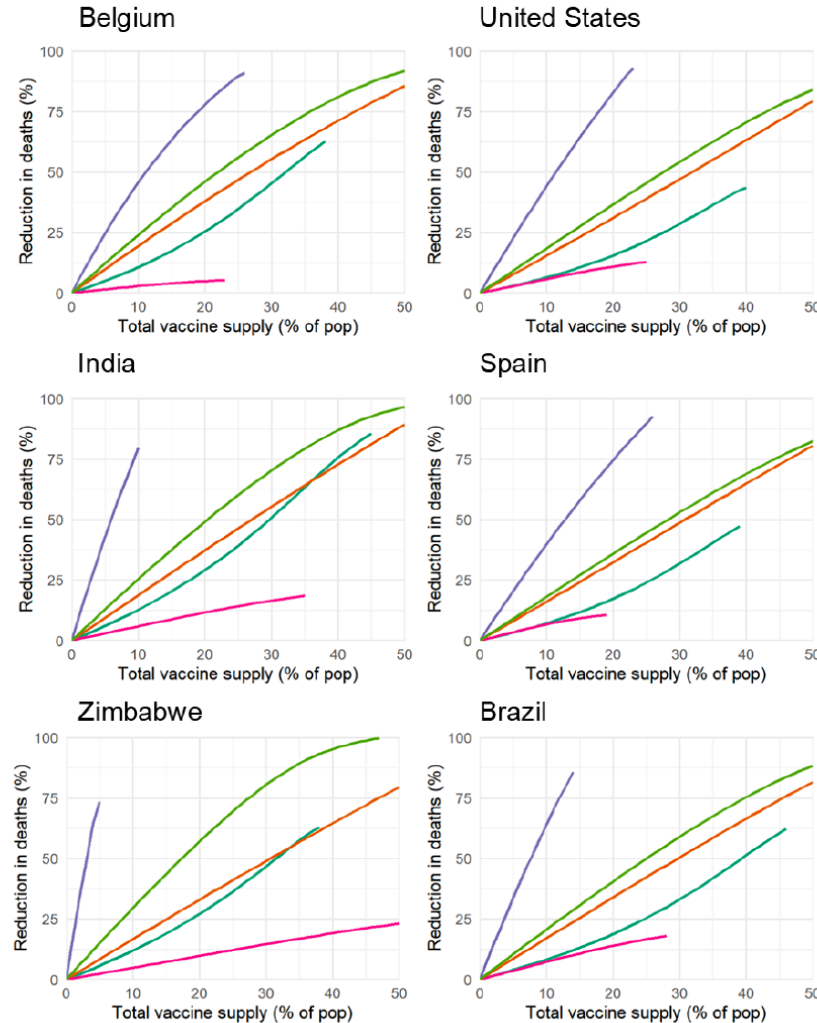
$$(\alpha = 1, \omega = 1)$$



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

VE = 100%

Demography



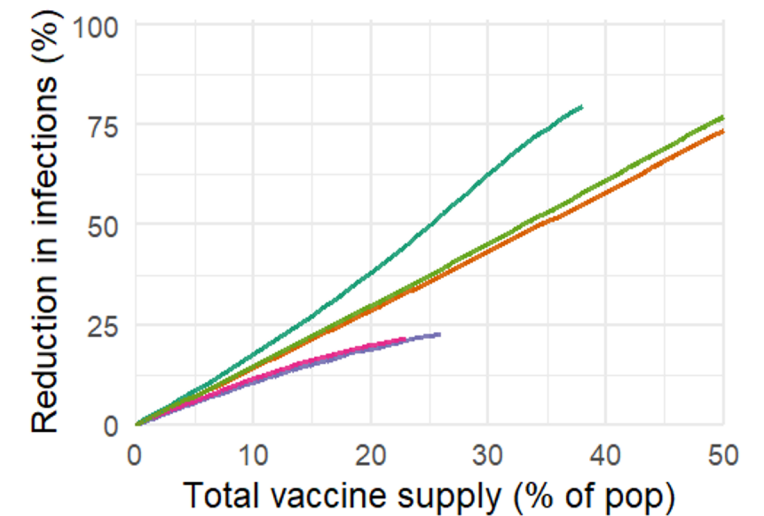
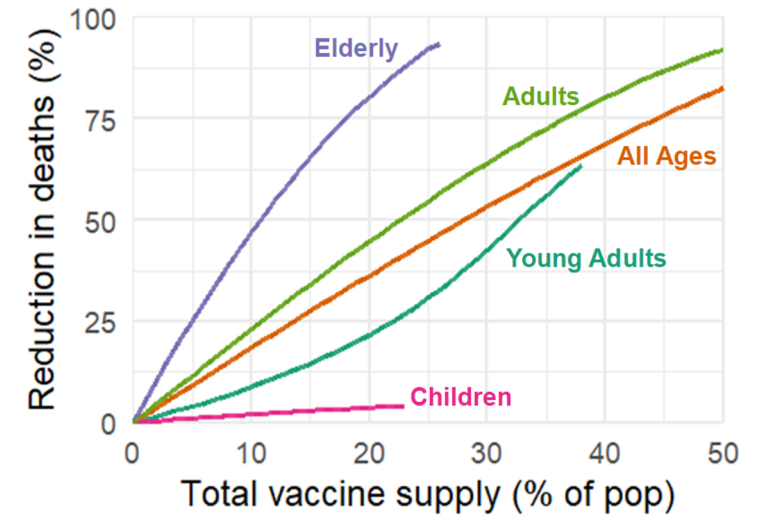
Also to leaky or all-or-nothing vaccine

Current model includes:

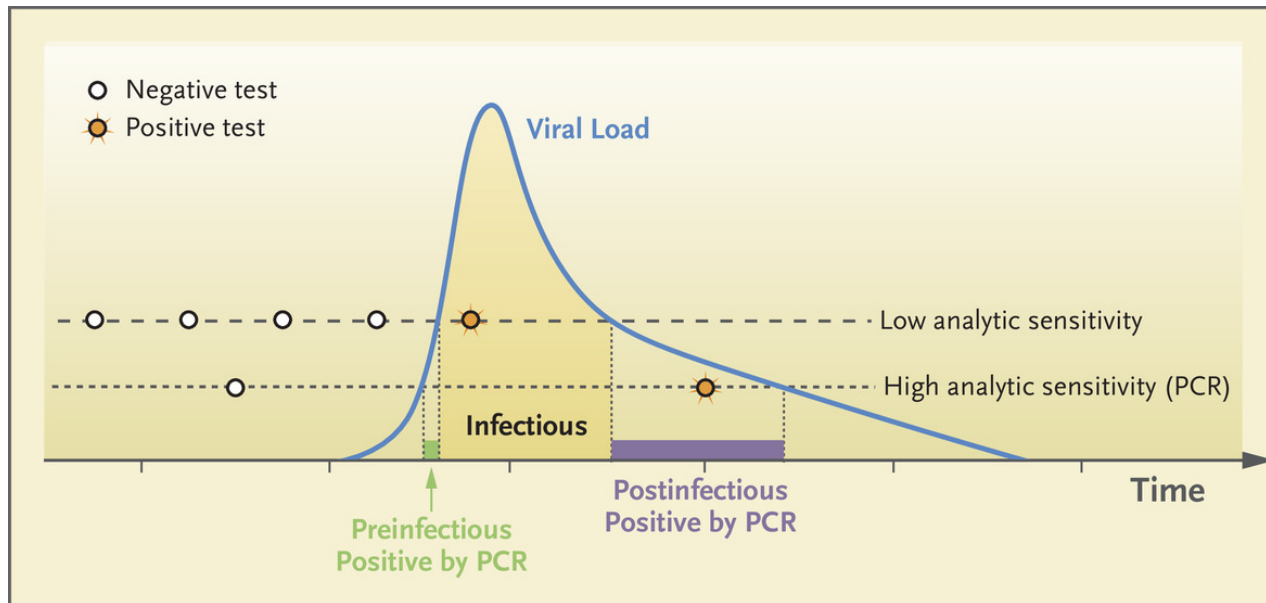
- Contact patterns by age
- Demographics
- Susceptibility by age
- Serology
- Age-variation in vaccine effectiveness
- IFR

Framework enables sensitivity testing.

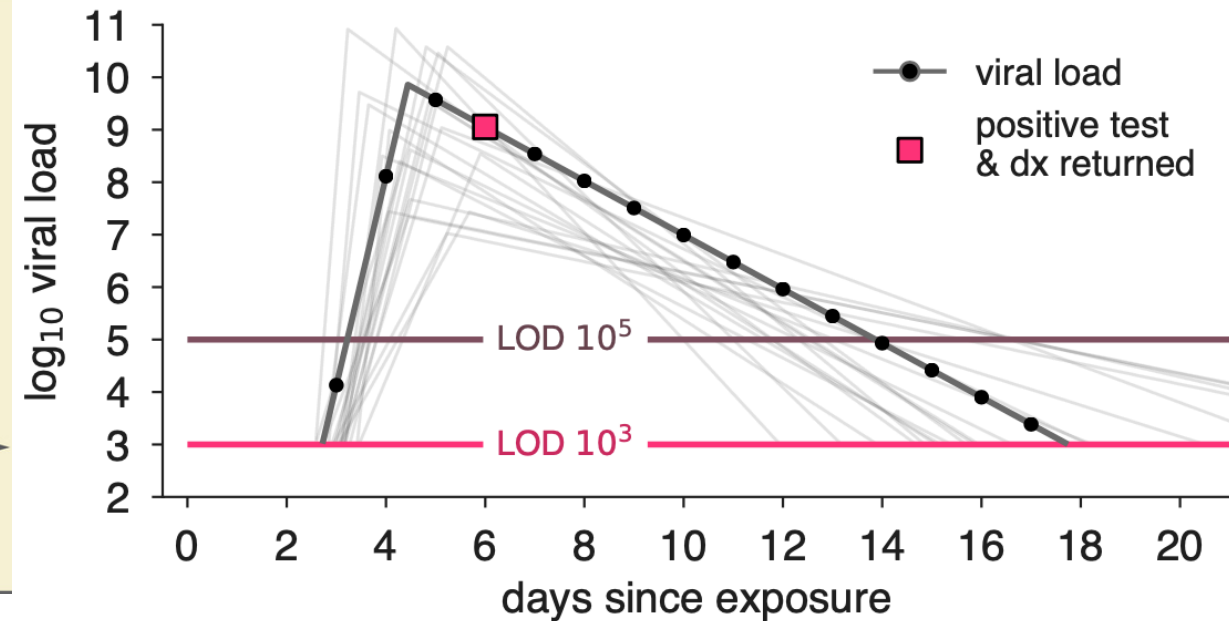
Next: vary R , the timing of vaccine roll-out



Charting the course of SARS-CoV-2 infection

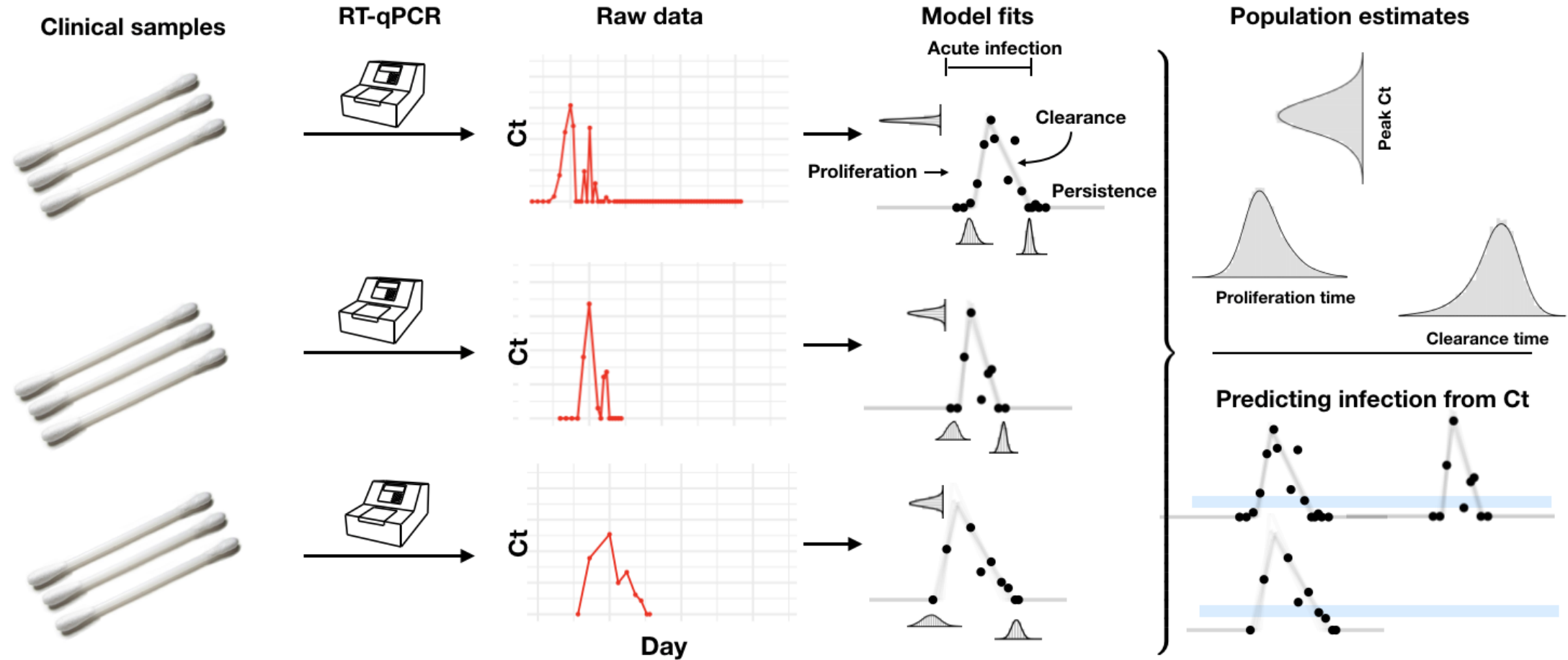


Mina, Parker, Larremore. *NEJM*. 2020



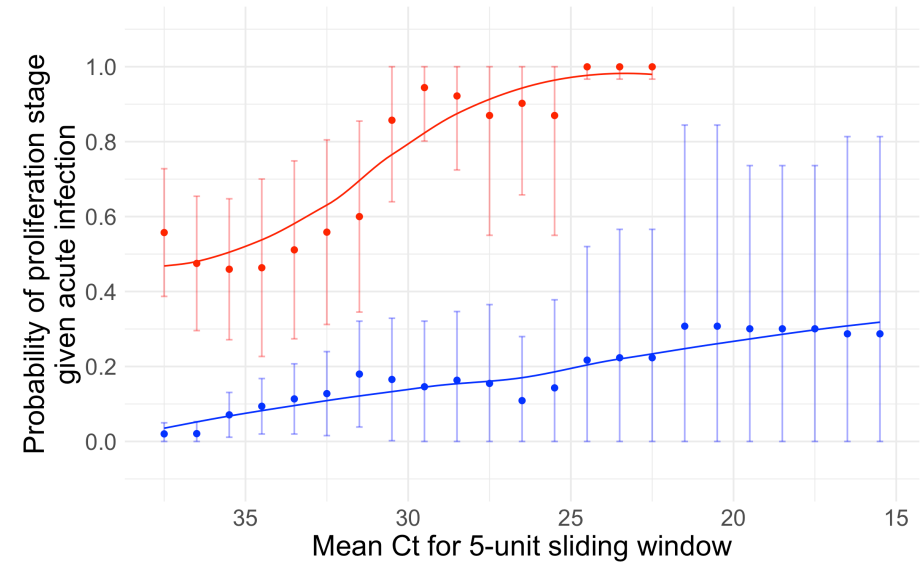
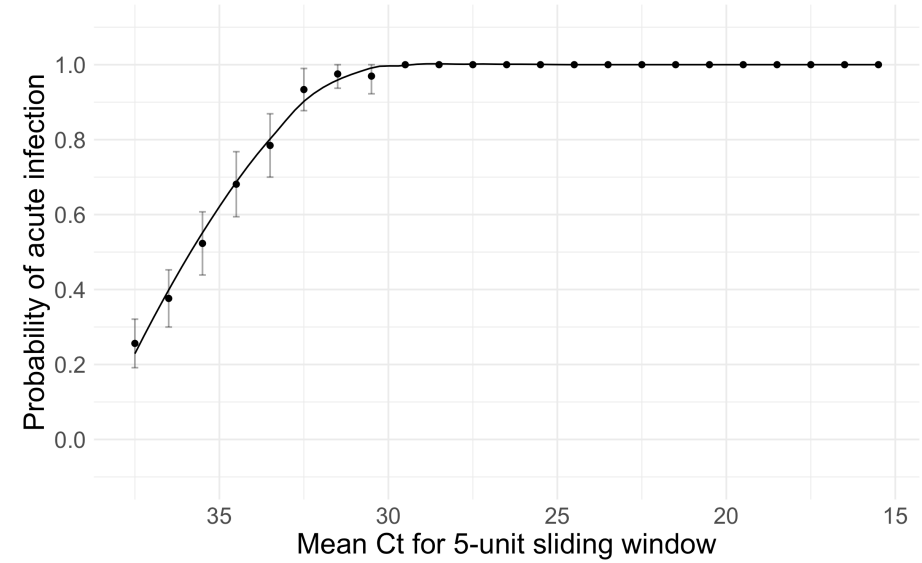
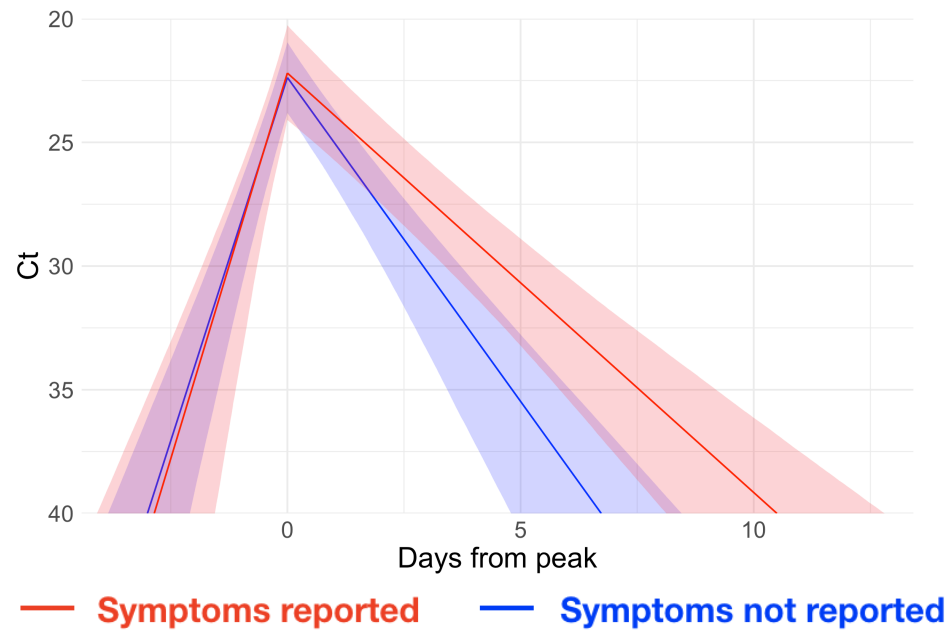
Larremore et al., *Science Advances*. In press.

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

Quantitative tests can inform clinical and public health decision-making



Acknowledgements and citations

Bubar KM, Kissler SM, Lipsitch M, Cobey S, Grad YH, Larremore DB. [Model-informed COVID-19 vaccine prioritization strategies by age and serostatus](#). *medRxiv*. 2020.

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

Kissler SM, Kishore N, Prabhu M, Goffman D, Beilin Y, Landau R, Gyamfi-Bannerman C, Bateman BT, Katz D, Gal J, Bianco A, Stone J, Larremore D, Buckee CO, Grad YH. [Reductions in commuting mobility correlate with geographic differences in SARS-CoV-2 prevalence in New York City](#). *Nature Communications*. 2020. 11:4674
doi.org/10.1038/s41467-020-18271

Kissler SM, Fauver JR, Mack C, Tai C, Shiue KY, Kalinich CC, Jednak S, Ott IM, Vogels CBF, Wohlgemuth J, Weisberger J, DiFiori J, Anderson DJ, Mancell J, Ho DD, Grubaugh ND*, Grad YH*. [Viral dynamics of SARS-CoV-2 infection and the predictive value of repeat testing](#). *medRxiv*. 2020. *co-senior authors.