

COVID-19 Epidemiology and Paths Out of The Pandemic

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Acknowledgements and Disclosures

Work presented represents collaboration with Drs. Amy Greer (University of Guelph) and Ashleigh Tuite (University of Toronto).

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I have served on paid advisory boards for Pfizer, Astrazeneca, Sanofi-Pasteur and Seqirus vaccines.

I have served as a paid legal expert for the Ontario Nurses Association and the Elementary Teachers Federation of Ontario in legal actions related to COVID-19 and workplace safety.



Outline

Global update, variants, vaccines as a path out of the pandemic.

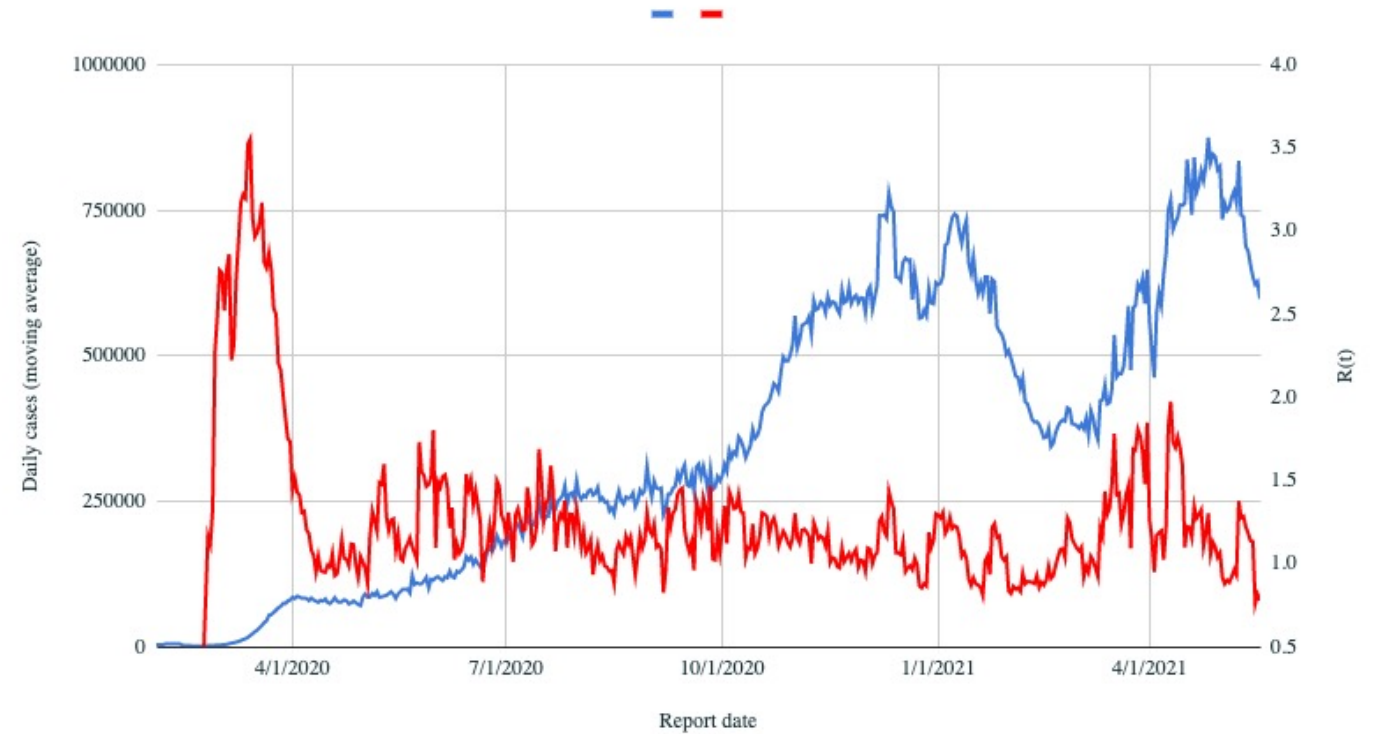
Schrödinger's coronavirus: overdispersion and its relation to aerosol.

Understanding transmission to inform exit strategies.

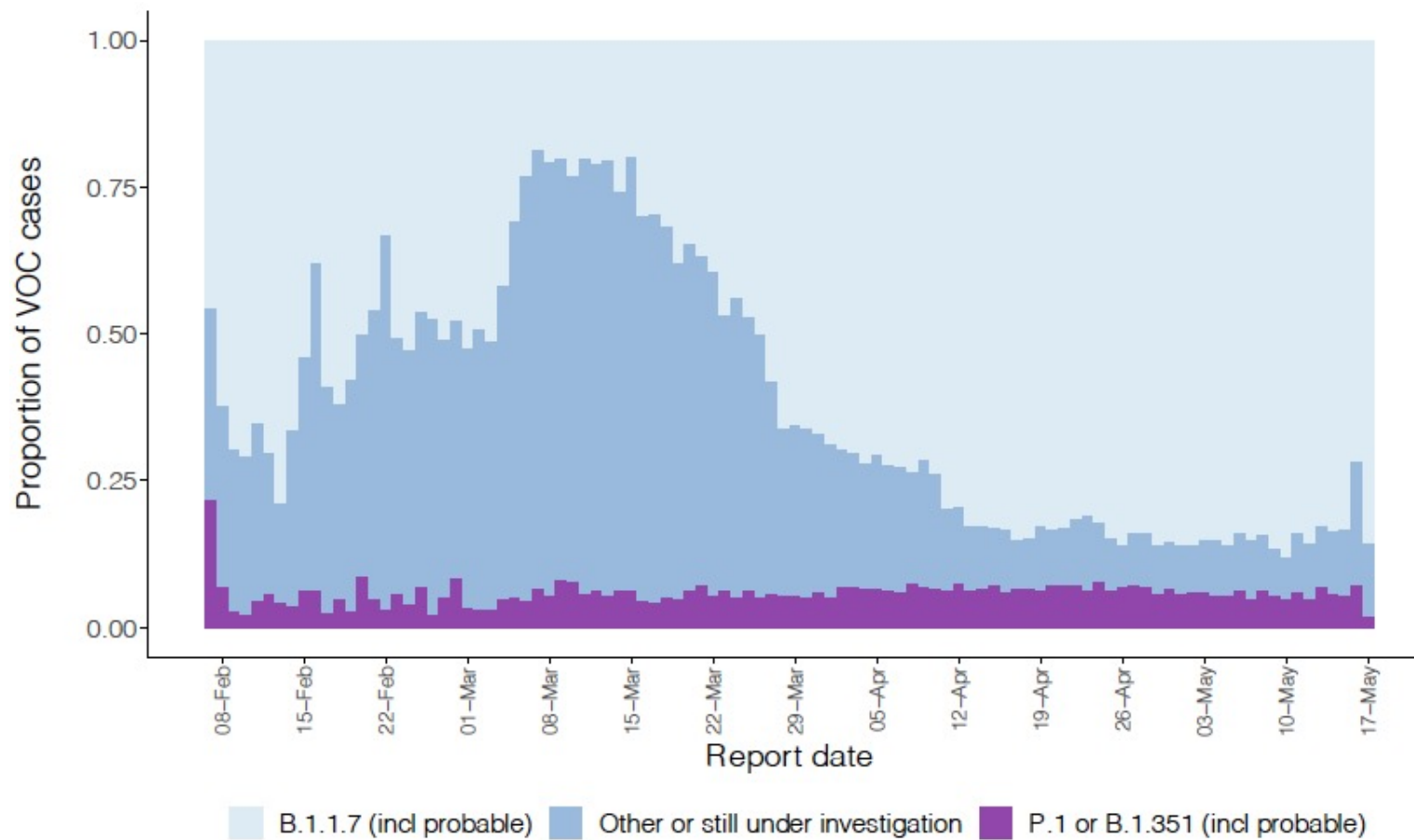


Global View, May 19, 2021

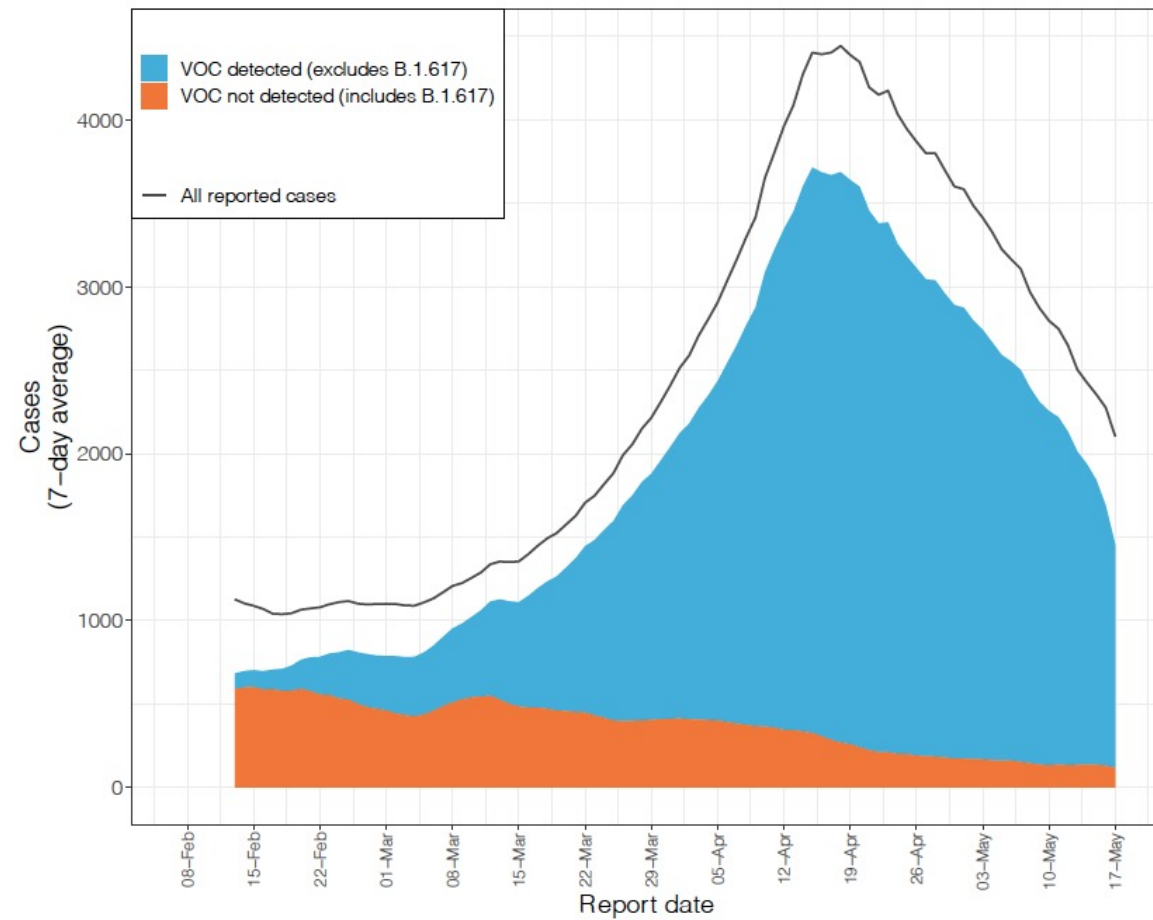
Global Daily Cases (smoothed, blue) and $R(t)$ (red)



Variants



Variants Are Controllable with NPI



MV Logistic Regression (to February 24, 2021)

- Adjusted for age, sex, geographical region, comorbidity, time trend, and pregnancy.

Hospitalization	1.76 (1.46 to 2.23)	1.70 (1.44 to 1.99)
ICU admission	2.76 (1.76 to 4.34)	2.59 (1.83 to 3.66)
Death	1.36 (0.84 to 2.20)	1.26 (0.95 to 1.88)

Enhanced Virulence of VOC (2)

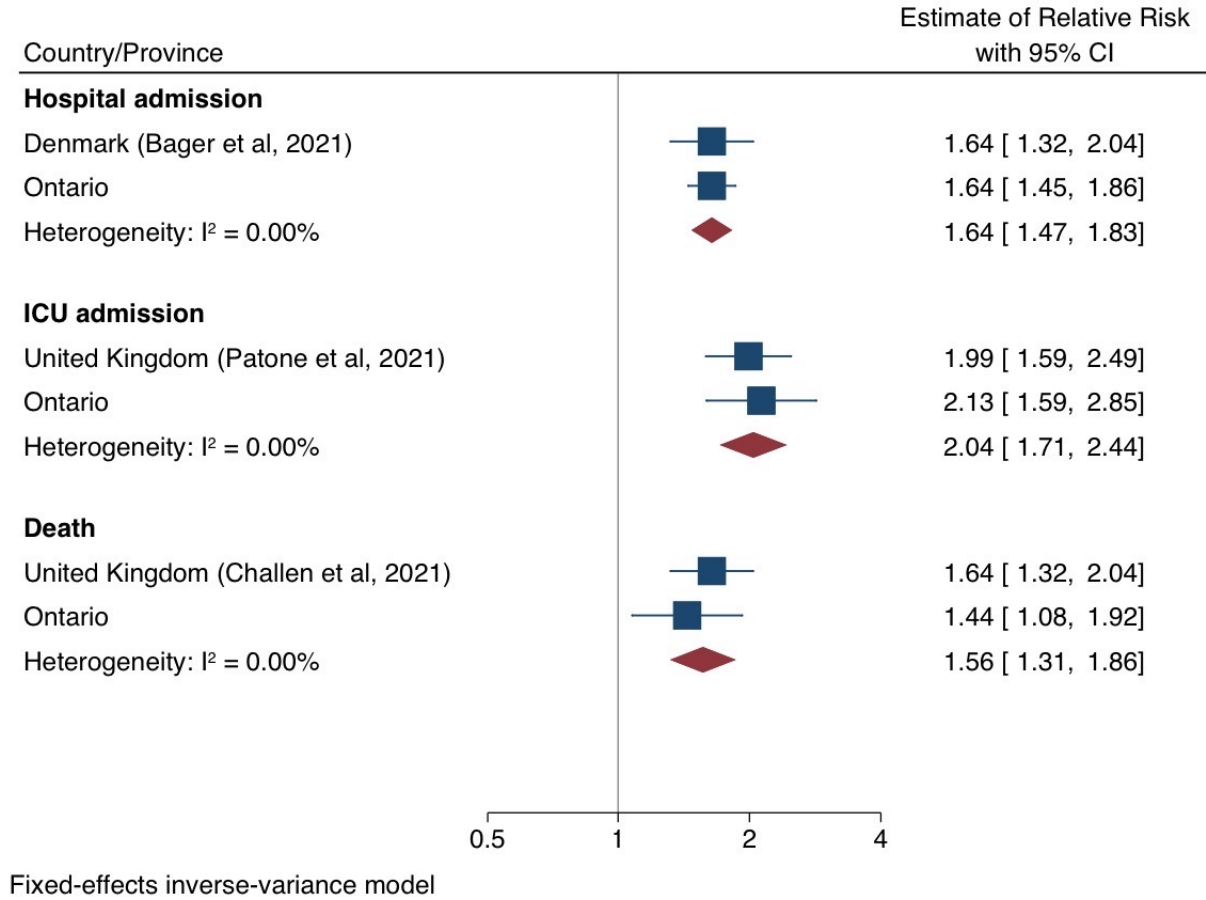
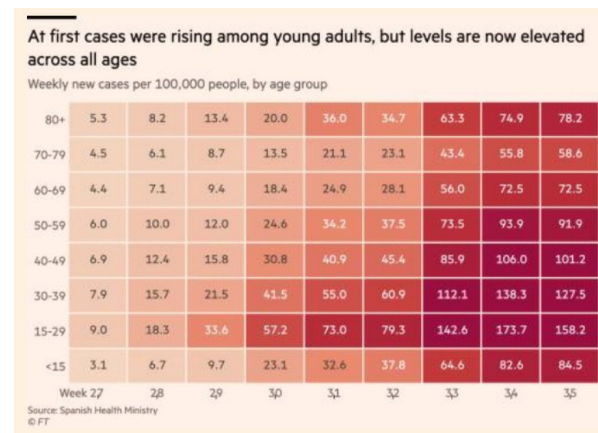
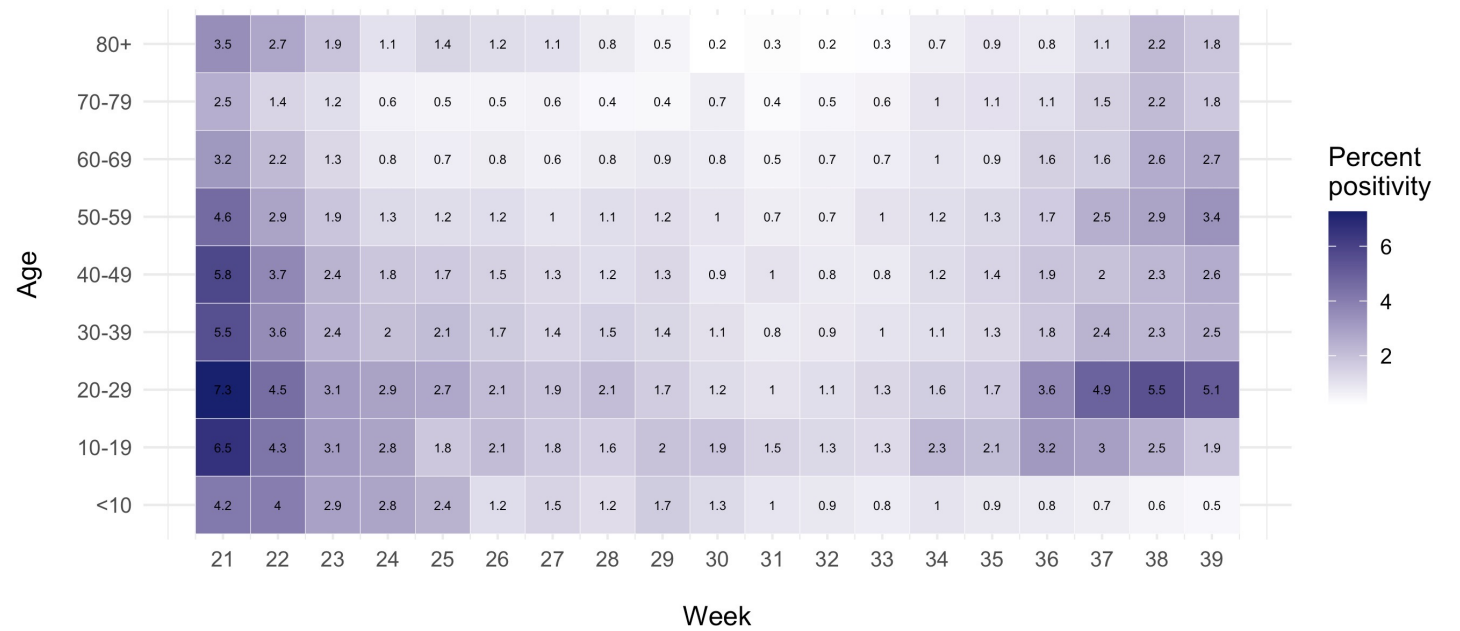


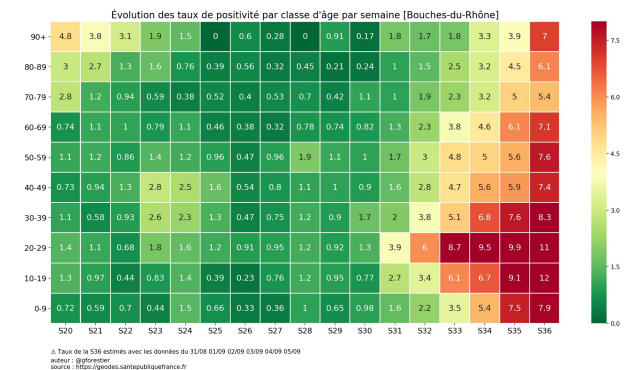
Figure courtesy of Drs. Peter Juni and Ashleigh Tuite.

Transmission vs. Virulence

Ontario



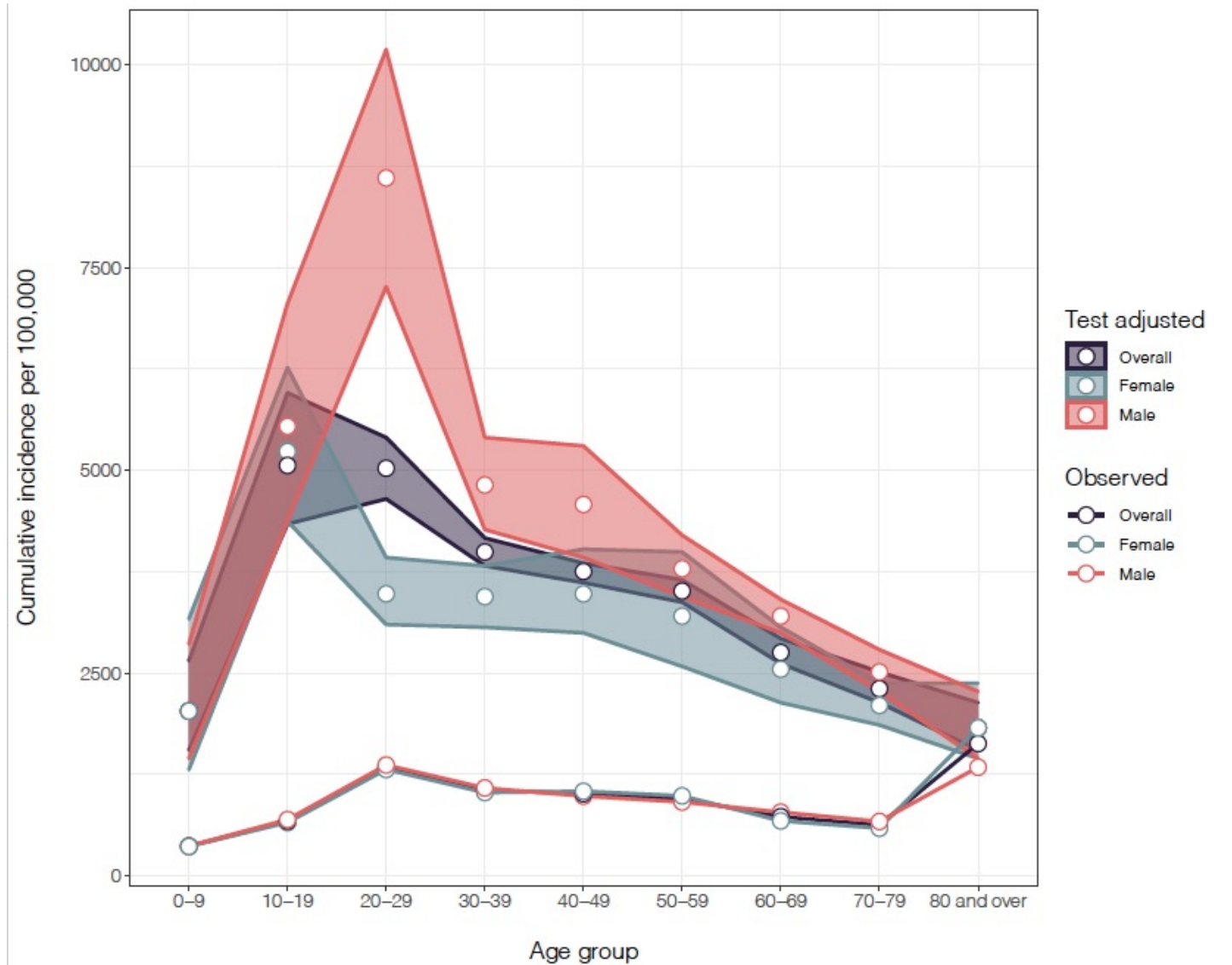
Spain



France

Adjustment for Under-testing

Fisman et al, Ann Intern Med, forthcoming



Virulence and Age

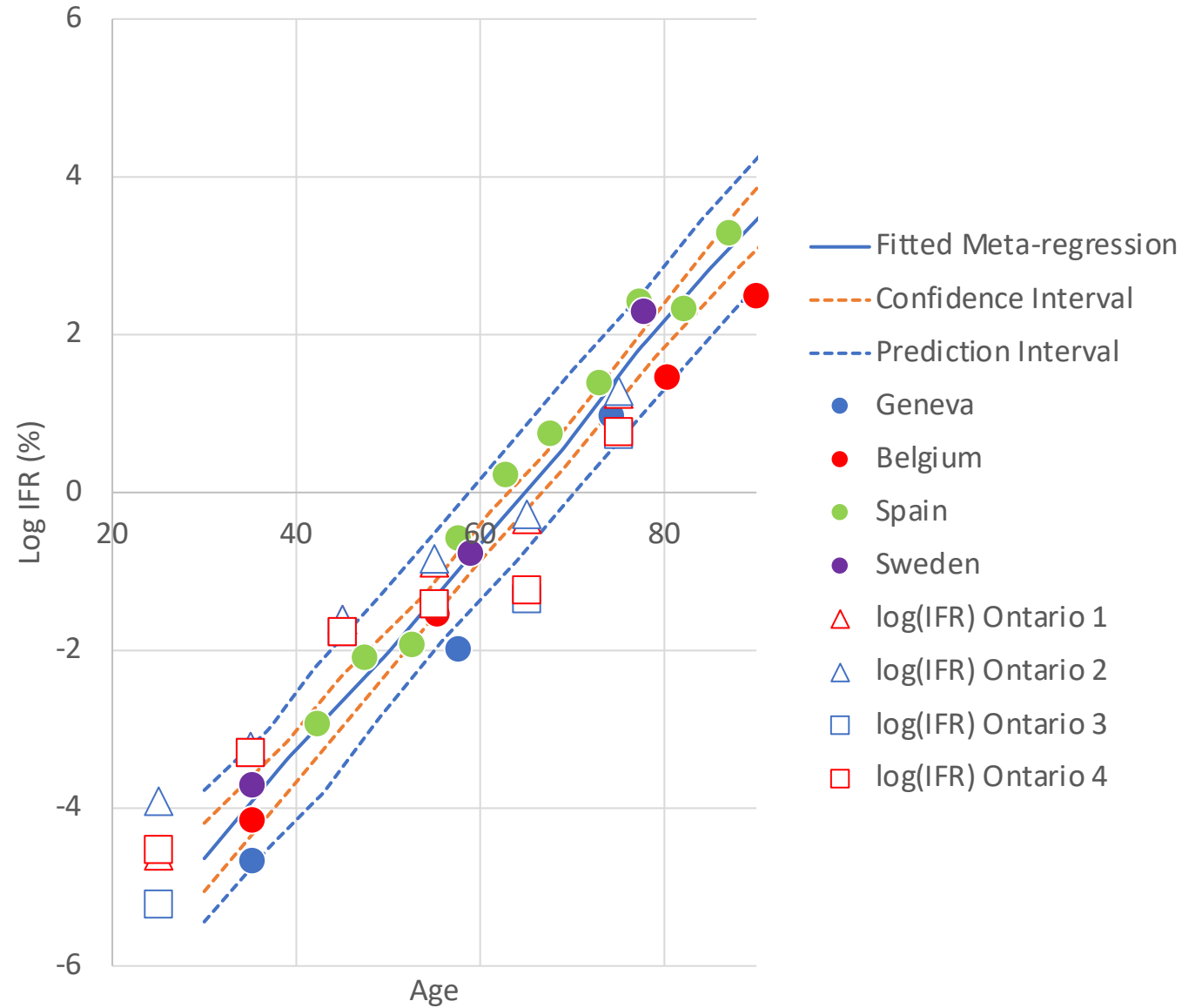
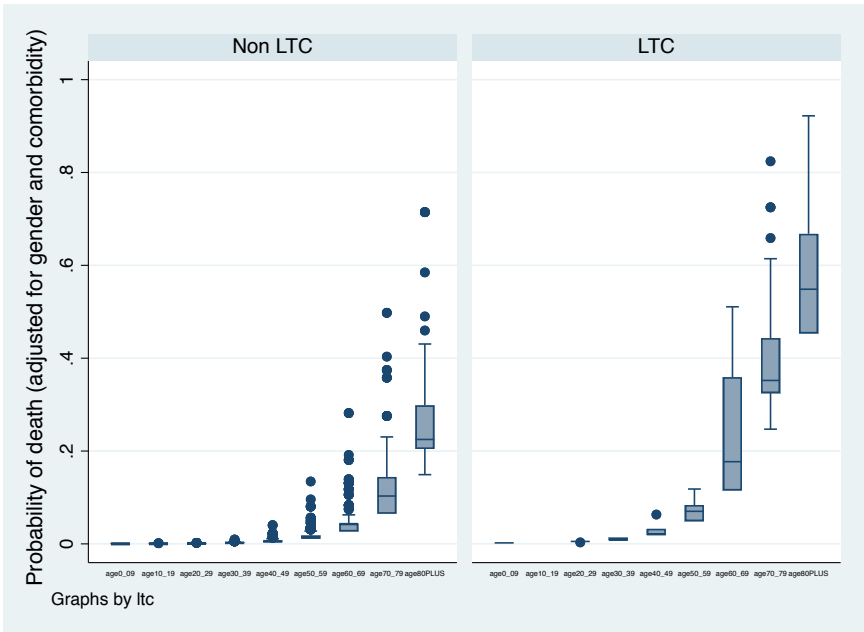
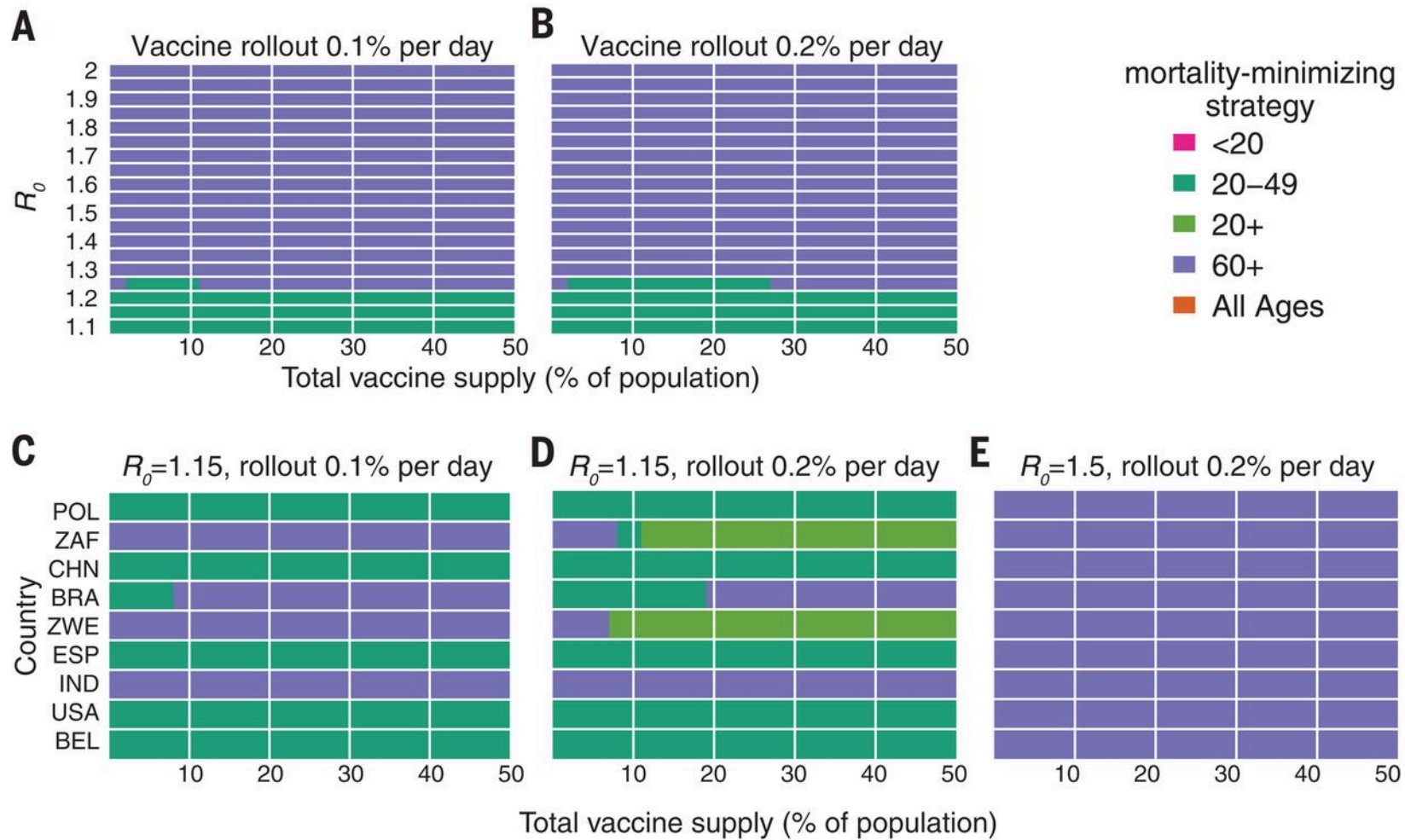


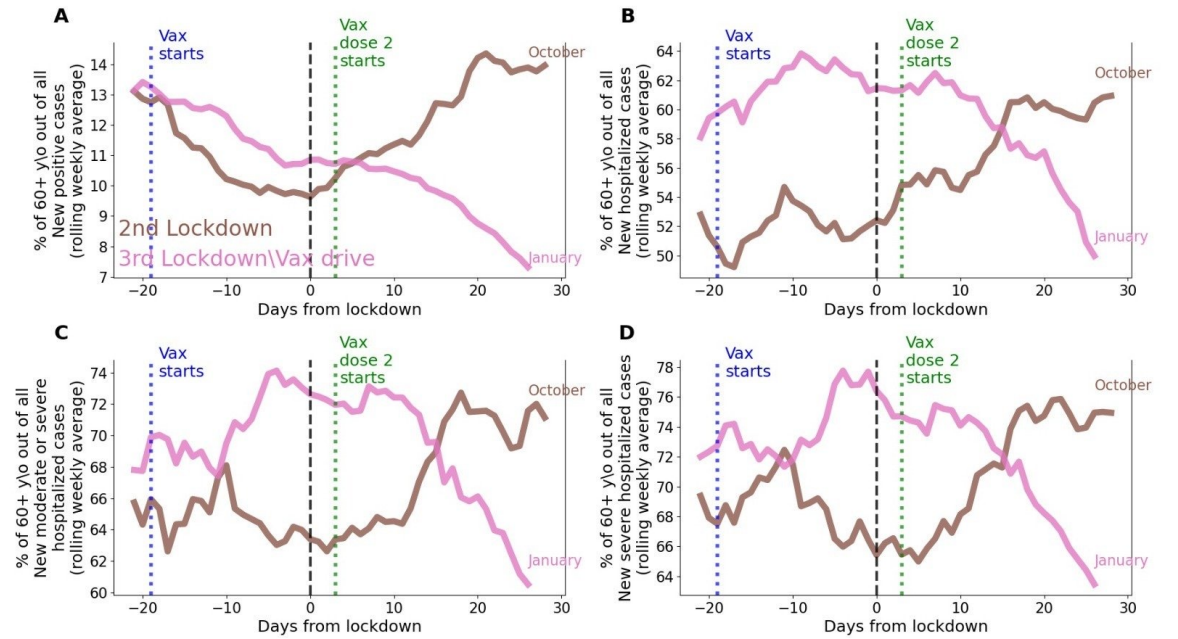
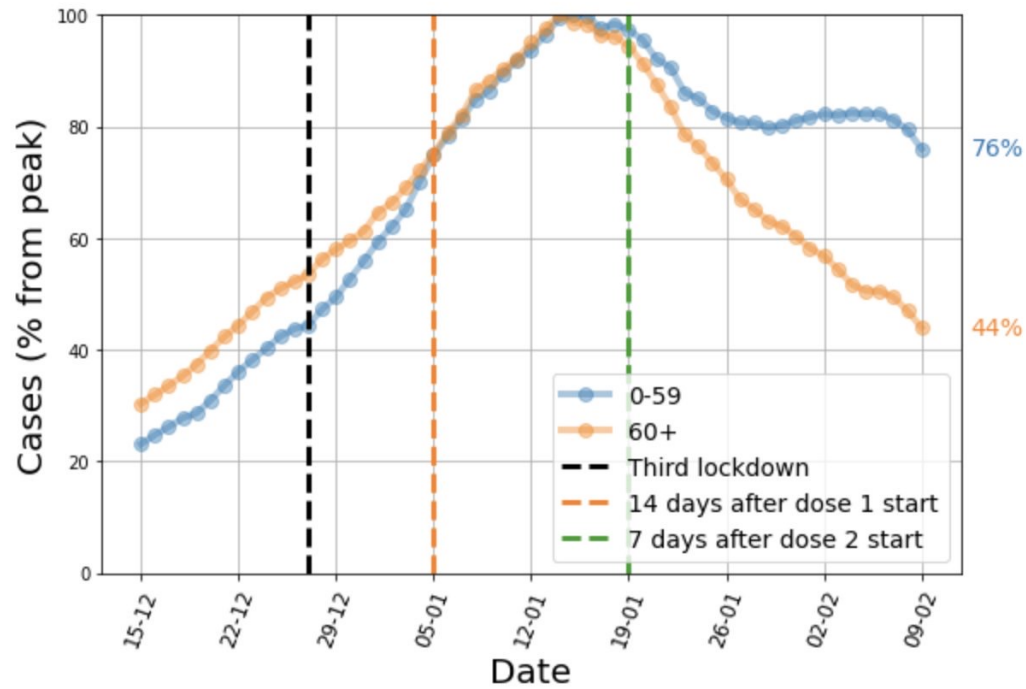
Fig. 2 Mortality-minimizing vaccine prioritization strategies across reproductive numbers R_0 and countries.



Kate M. Bubar et al. *Science* 2021;371:916-921

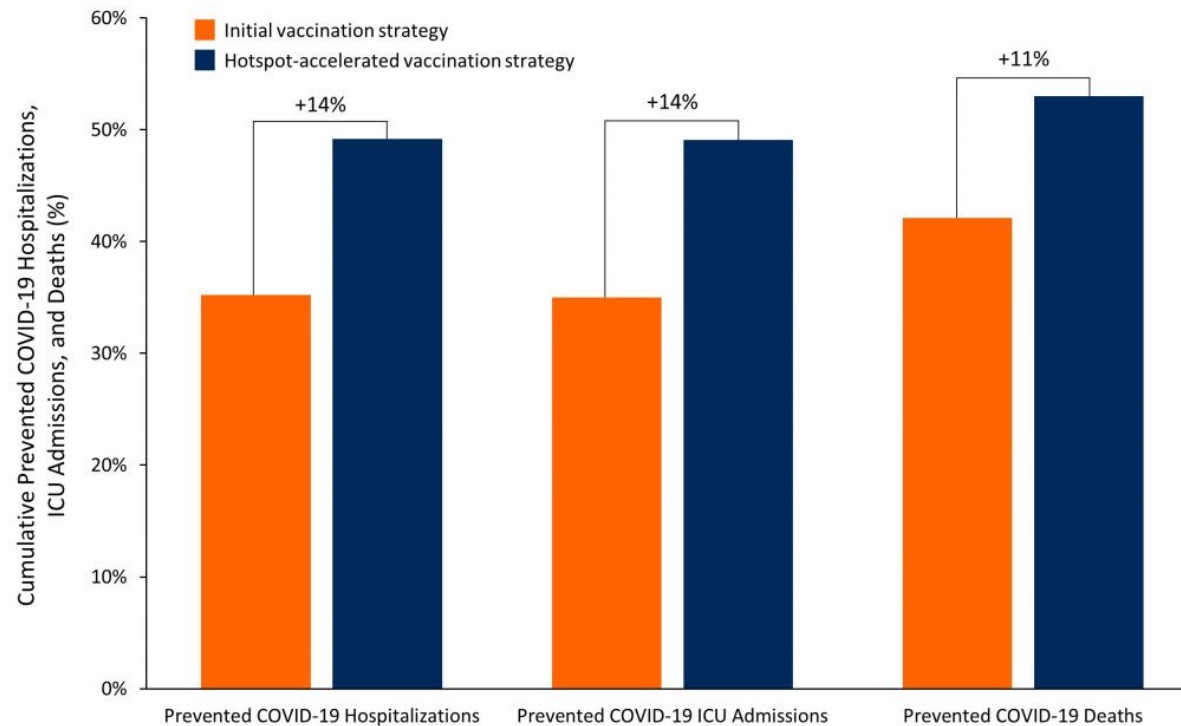
Israel

- [Source: Eran Segal (@segal_eran), now published at <https://www.nature.com/articles/s41591-021-01337-2>]



Geographic Variability in Risk

- Source: Mishra S et al., <https://covid19-sciencetable.ca/sciencebrief/a-vaccination-strategy-for-ontario-covid-19-hotspots-and-essential-workers/>



Intersection
Between COVID-
19 Risk and
Economic
Disadvantage:
Universal?

SHARE



RESEARCH ARTICLE

Socioeconomic status determines COVID-19 incidence and related mortality in Santiago, Chile

Gonzalo E. Mena^{1,†,*}, Pamela P. Martinez^{2,3,4,5,†,*}, Ayesha S. Mahmud^{2,6}, Pablo A. Marquet^{7,8,9,10,11}, Caroline O. ...

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Science 27 Apr 2021:
eabg5298
DOI: 10.1126/science.abg5298

Article

Figures & Data

Info & Metrics

eLetters

PDF

Abstract

The current COVID-19 pandemic has impacted cities particularly hard. Here, we provide an in-depth characterization of disease incidence and mortality, and their dependence on demographic and socioeconomic strata in Santiago, a highly segregated city and the capital of Chile. Our analyses show a strong association between socioeconomic status and both COVID-19 outcomes and public health capacity. People living in municipalities with low

math: 2%

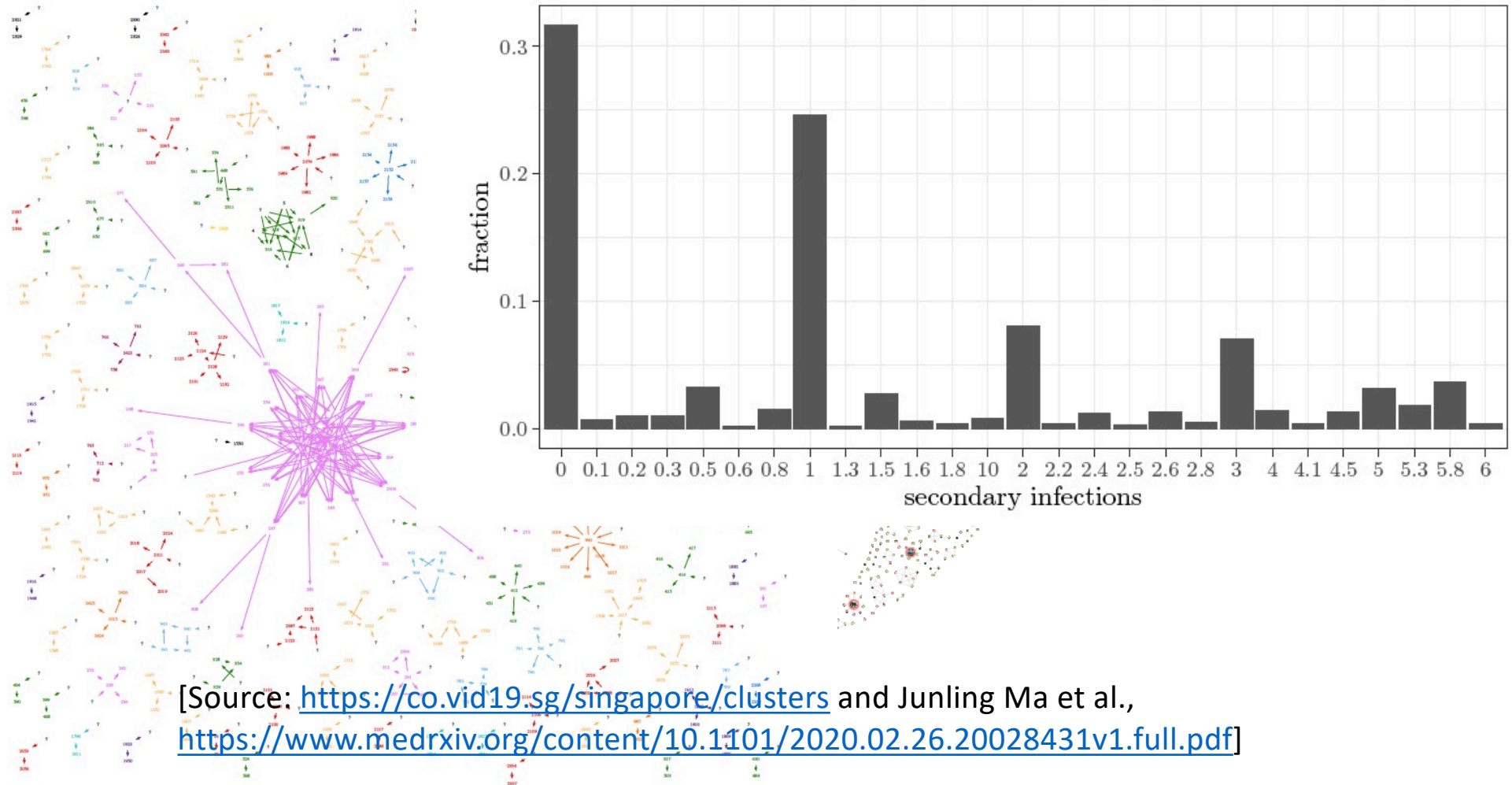
Schrödinger's Coronavirus

- Many paradoxes.
 - Virulent pathogen (IFR 1%) characterized by asymptomatic/pre-symptomatic spread.
 - Pareto-distributed R_0 : transmission with lots of dead ends, yet causes super-spreader events.
 - Pandemic pathogen that “skips” children (?), except when resurgences are driven by school opening.



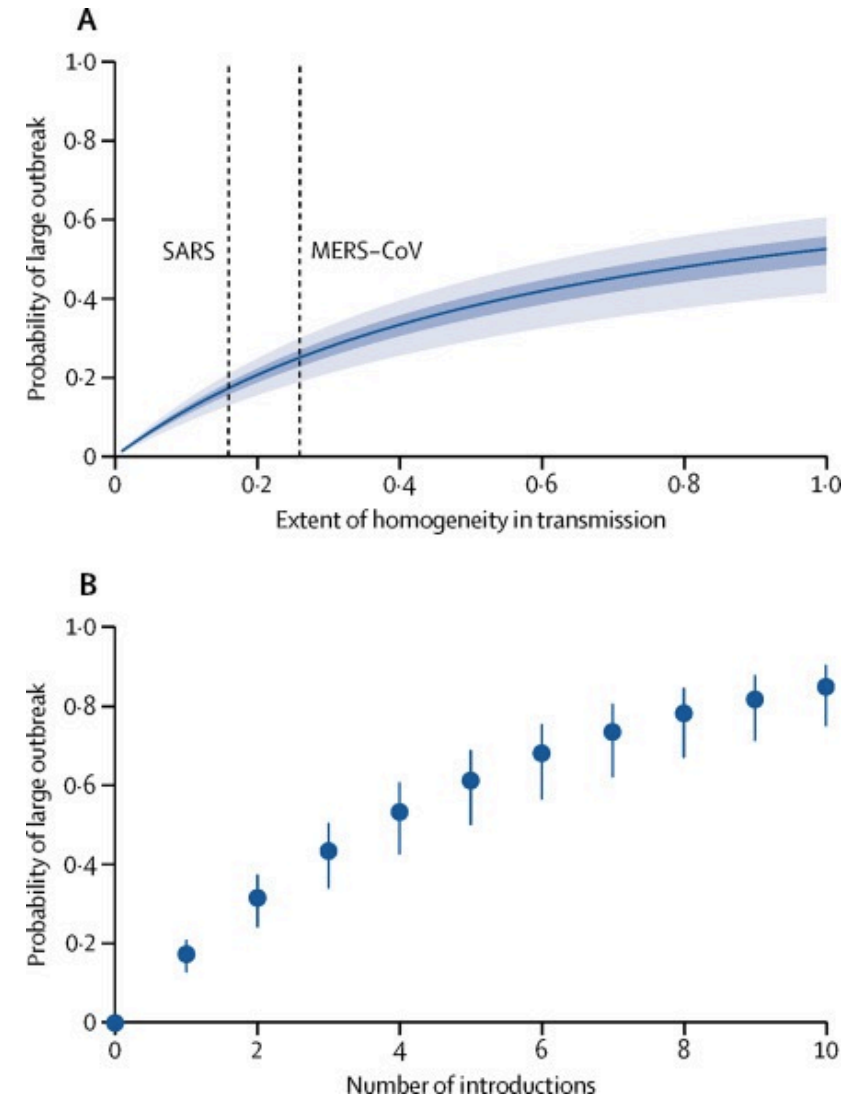
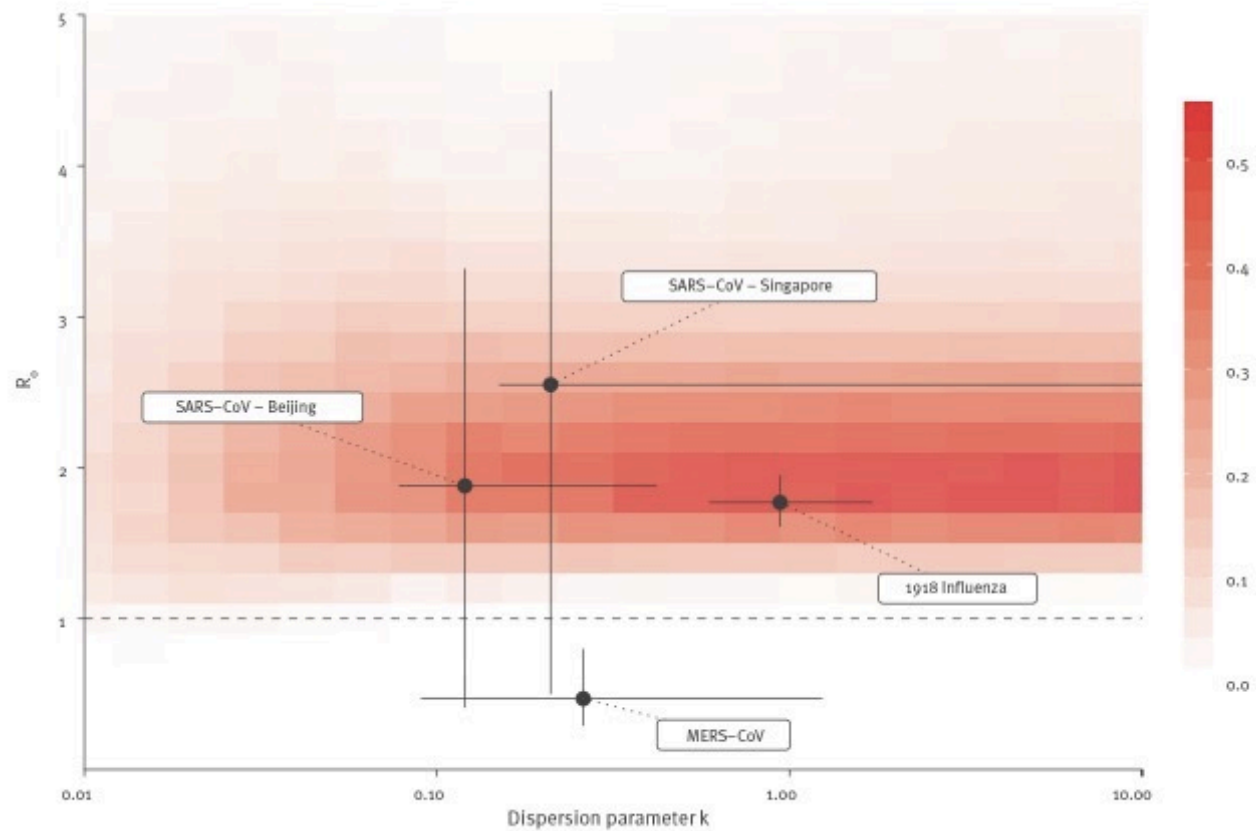
[Image: Christian Schim, Wikimedia commons. https://commons.wikimedia.org/wiki/File:Schrödingers_cat_film.svg]

Dead Ends and Super-spreaders

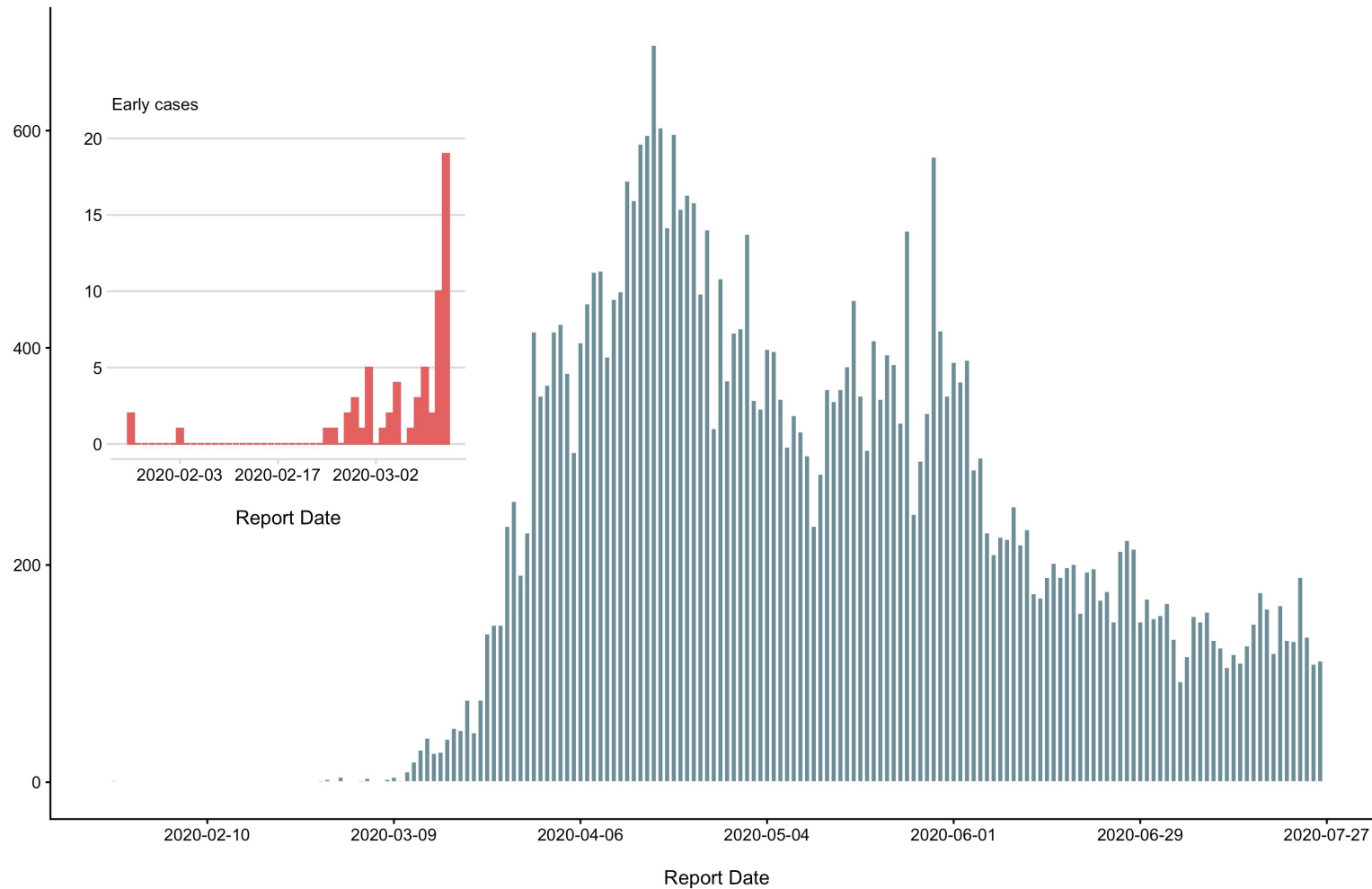


[Source: <https://co.vid19.sg/singapore/clusters> and Junling Ma et al., <https://www.medrxiv.org/content/10.1101/2020.02.26.20028431v1.full.pdf>]

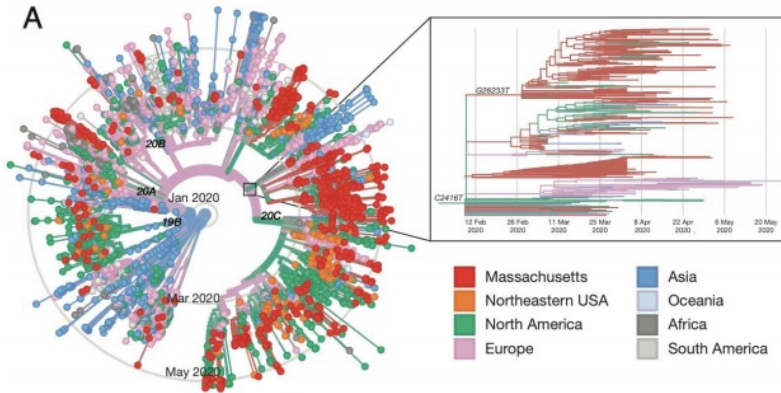
Overdispersion and Explosive Outbreaks



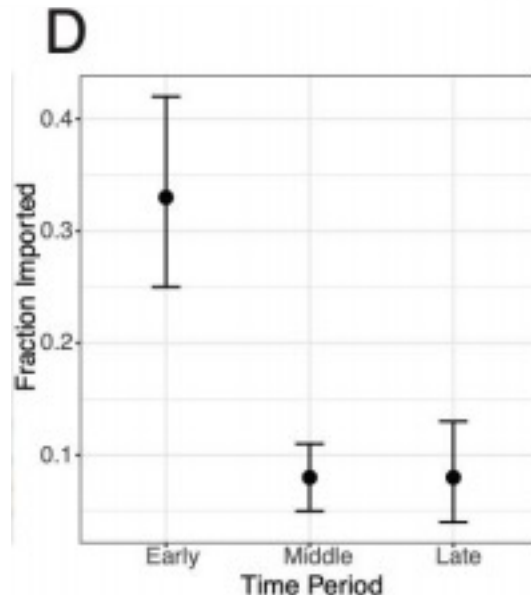
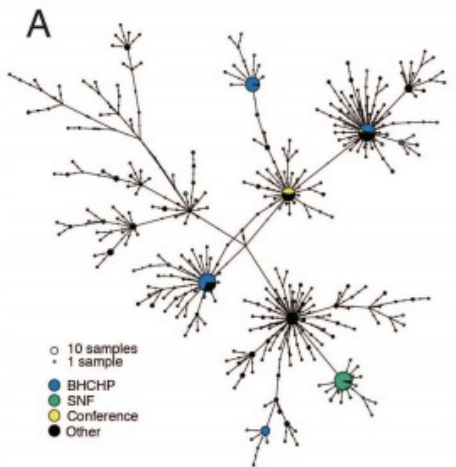
Sudden Explosion: Ontario, March/April 2020



The Primacy of SSE: Massachusetts

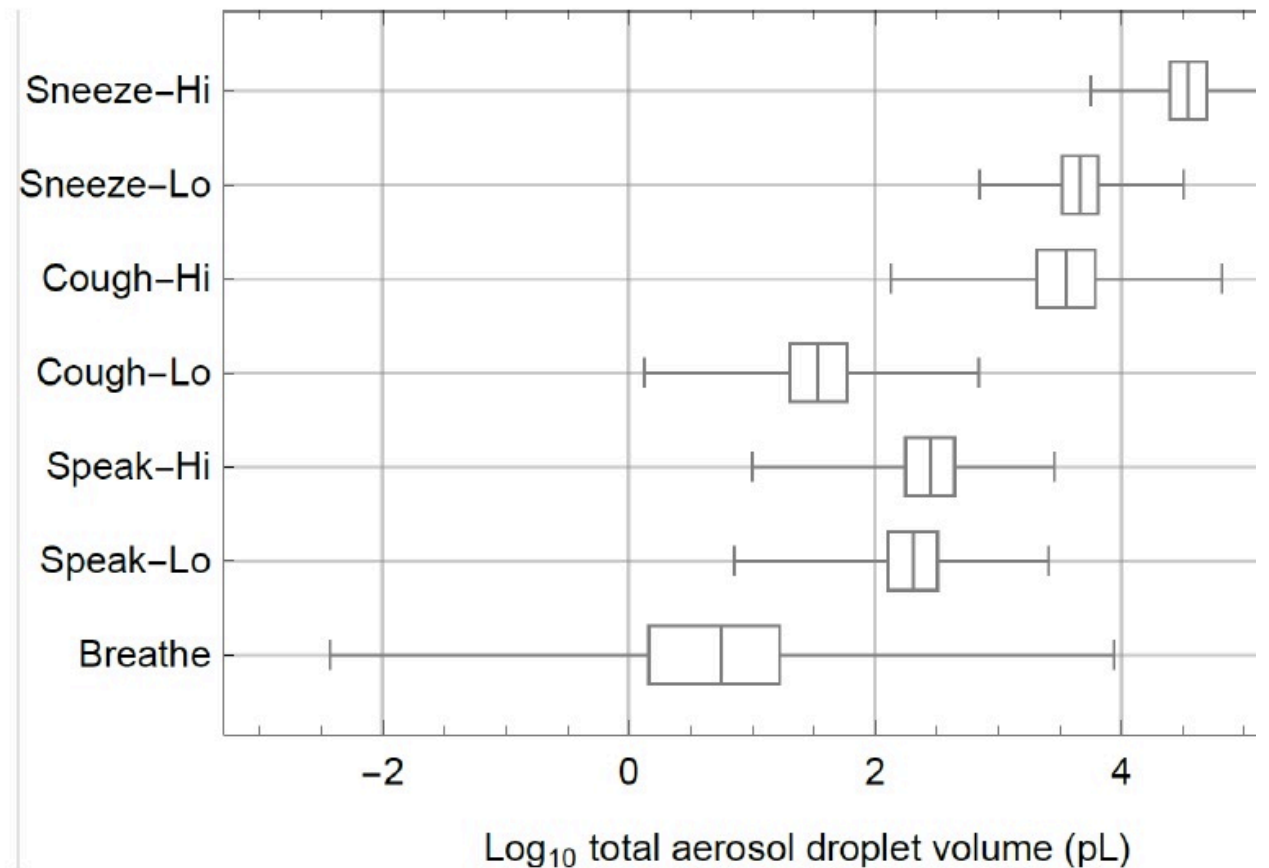


- Multiple introductions, dominant strains transmitted w/i state are downstream from uncontrolled SSE in SNF and homeless shelter.
- Strains of European and New York origin.
- Biogen conference superspreader event (N = 90) was controlled, SNF and homeless/public housing outbreaks were not.
- Early introductions from China and Italy had no secondary transmission.

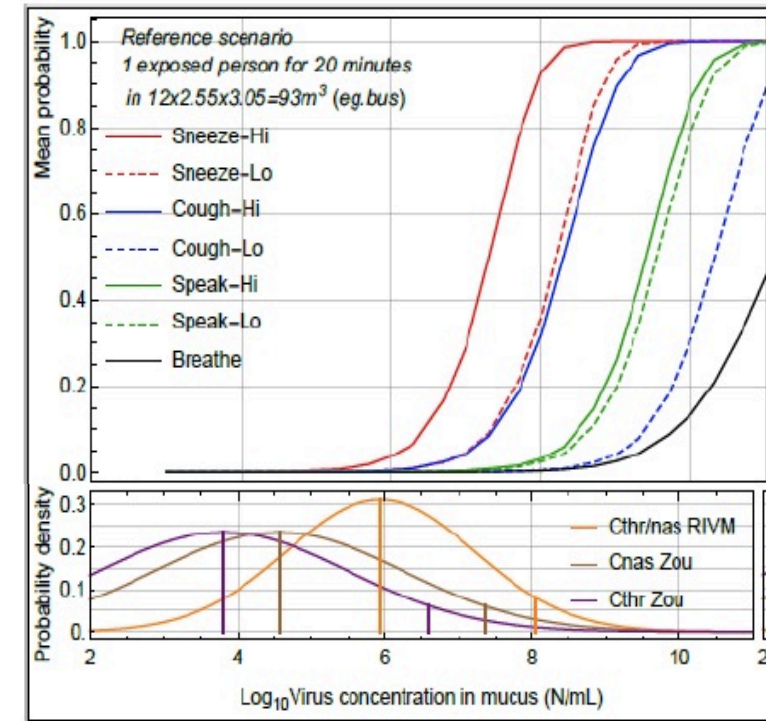
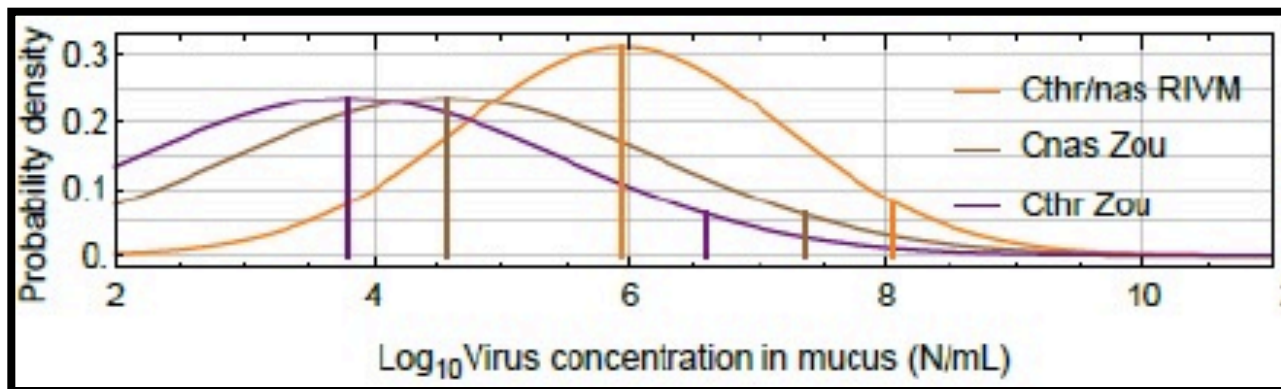
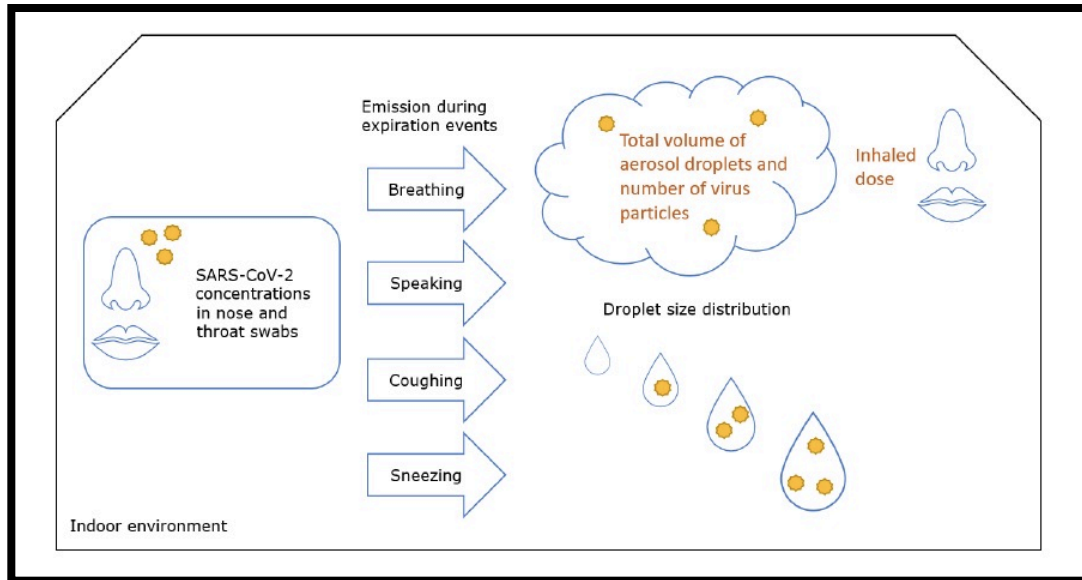


Can Rare, Conditional Aerosol Transmission Explain the 3 C's?

- Host [adult vs. child], disease stage, and activity [e.g., breathing vs. singing] may explain spectrum of aerosolized virus.
 - Exponential increase in aerosol generation from breathing → sneezing.
- Settings [crowding, duration, poor ventilation] determine probability of effective exposure.

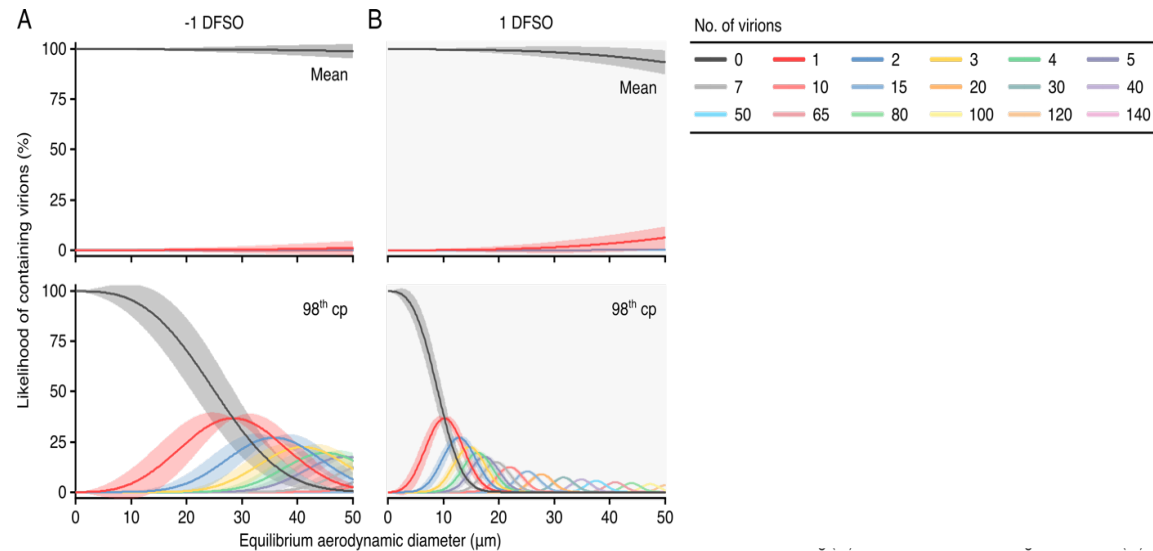
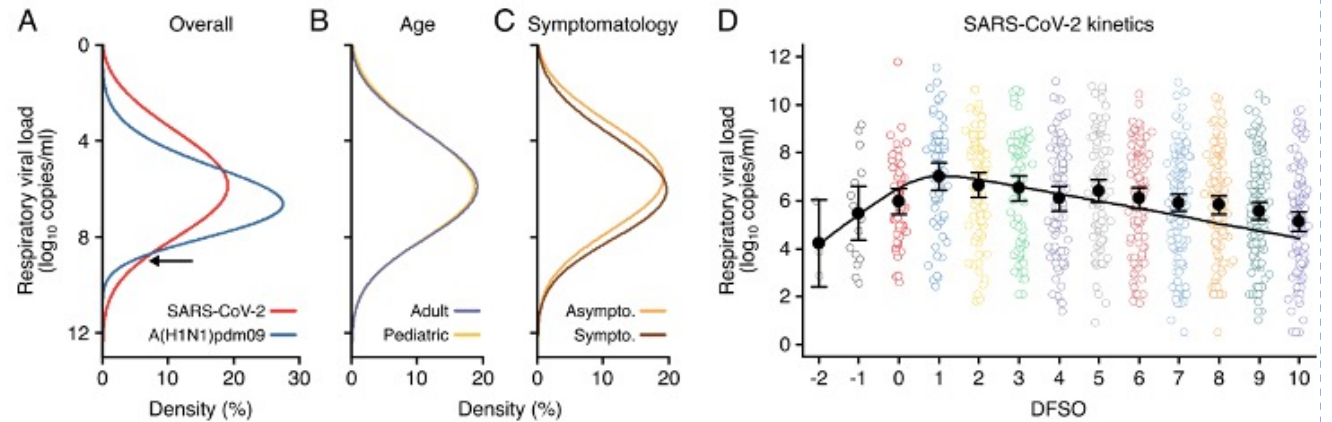


Quantitative Risk Analysis



Model based on varying levels of aerosolization, spectra of viral load in mucus, different sized spaces and durations of exposure. Ventilation not considered.

Heterogeneity in Respiratory Viral Load Further Explains Overdistributed R_0 .



- Respiratory Tract Viral Load Varies by Person and Time [Chen P et al., <https://www.medrxiv.org/content/10.1101/2020.10.13.20212233v2>]

Importance for Policy

- The R_0 we observe for SARS-CoV-2 represents a weighted average of cases with $R_0 < 1$ (majority) and $R_0 \gg \gg \gg 1$ (minority).
- Focus efforts on infective minority:
 - Ventilation and de-densification.
 - Bidirectional protection from masks.
 - Appropriate respirators for those at greatest risk.
- An epidemic is transformed into a controllable and preventable disease.

What Works?

- [Source: Haug et al., <https://www.nature.com/articles/s41562-020-01009-0>]

Fig. 1: Change in R_t (ΔR_t) for 46 NPIs at L2, as quantified by CC analysis, LASSO and TF regression.

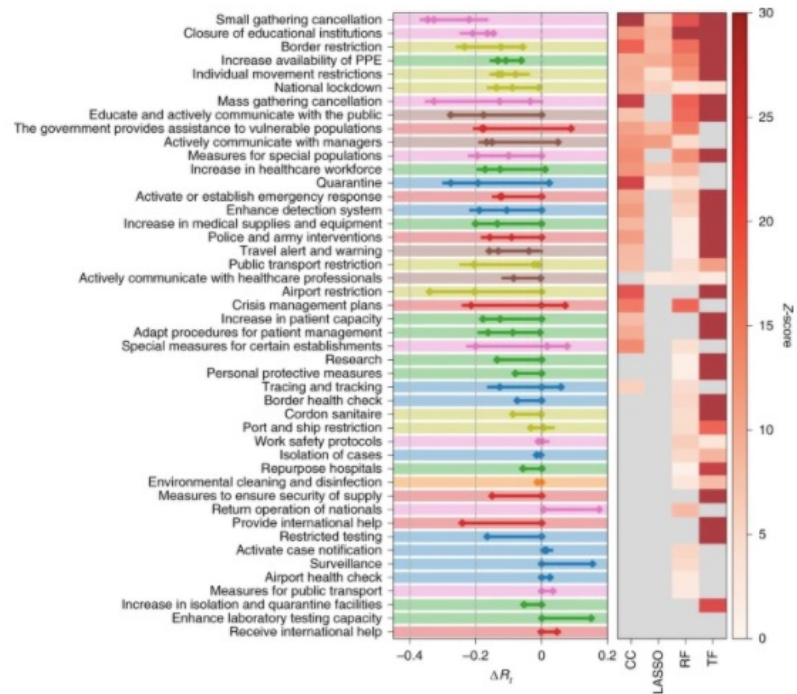
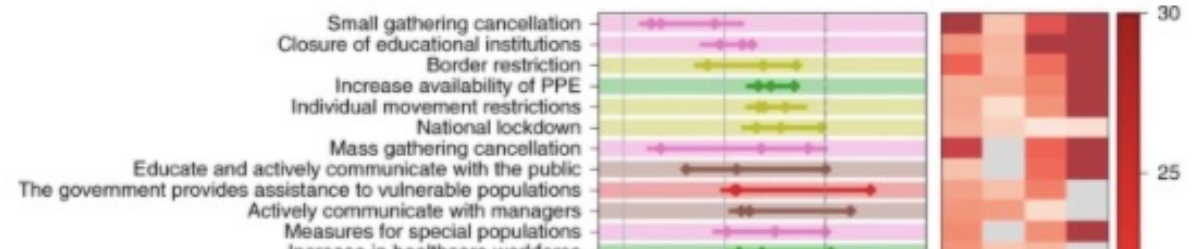


Fig. 1: Change in R_t (ΔR_t) for 46 NPIs at L2, as quantified by CC analysis, LASSO and TF regression.



Overcoming the 4 C's.

Type and level of group activity	Low occupancy			High occupancy		
	Outdoors and well ventilated	Indoors and well ventilated	Poorly ventilated	Outdoors and well ventilated	Indoors and well ventilated	Poorly ventilated
Wearing face coverings, contact for short time						
Silent	Low	Low	Low	Low	Low	Medium
Speaking	Low	Low	Low	Low	Low	Medium
Shouting, singing	Low	Low	Medium	Medium	Medium	High
Wearing face coverings, contact for prolonged time						
Silent	Low	Low	Medium	Low	Medium	High
Speaking	Low	Medium*	Medium	Medium*	Medium	High
Shouting, singing	Low	Medium	High	Medium	High	High
No face coverings, contact for short time						
Silent	Low	Low	Medium	Medium	Medium	High
Speaking	Low	Medium	Medium	Medium	High	High
Shouting, singing	Medium	Medium	High	High	High	High
No face coverings, contact for prolonged time						
Silent	Low	Medium	High	Medium	High	High
Speaking	Medium	Medium	High	High	High	High
Shouting, singing	Medium	High	High	High	High	High

Risk of transmission
 Low ■ Medium ■ High ■

* Borderline case that is highly dependent on quantitative definitions of distancing, number of individuals, and time of exposure

Source:

<https://www.bmj.com/content/370/bmj.m3223>

En Español
Tambien (Y
Otros
Idiomas)

Riesgo de transmisión de COVID-19 en distintas situaciones

■ Bajo
 ■ Medio
 ■ Alto

😷 Con mascarilla...

...durante poco tiempo

	Baja ocupación			Alta ocupación		
	Al aire libre	Interior bien ventilado	Interior mal ventilado	Al aire libre	Interior bien ventilado	Interior mal ventilado
😬 En silencio	Bajo	Bajo	Bajo	Bajo	Bajo	Medio
😬 Hablar	Bajo	Bajo	Bajo	Bajo	Bajo	Medio
😬 Gritar/cantar	Bajo	Bajo	Medio	Medio	Medio	Alto

...durante mucho tiempo

	Baja ocupación			Alta ocupación		
	Al aire libre	Interior bien ventilado	Interior mal ventilado	Al aire libre	Interior bien ventilado	Interior mal ventilado
😬 En silencio	Bajo	Bajo	Medio	Bajo	Medio	Alto
😬 Hablar	Bajo	Bajo	Medio	Medio	Medio	Alto
😬 Gritar/cantar	Bajo	Medio	Alto	Medio	Alto	Alto

😬 Sin mascarilla...

...durante poco tiempo

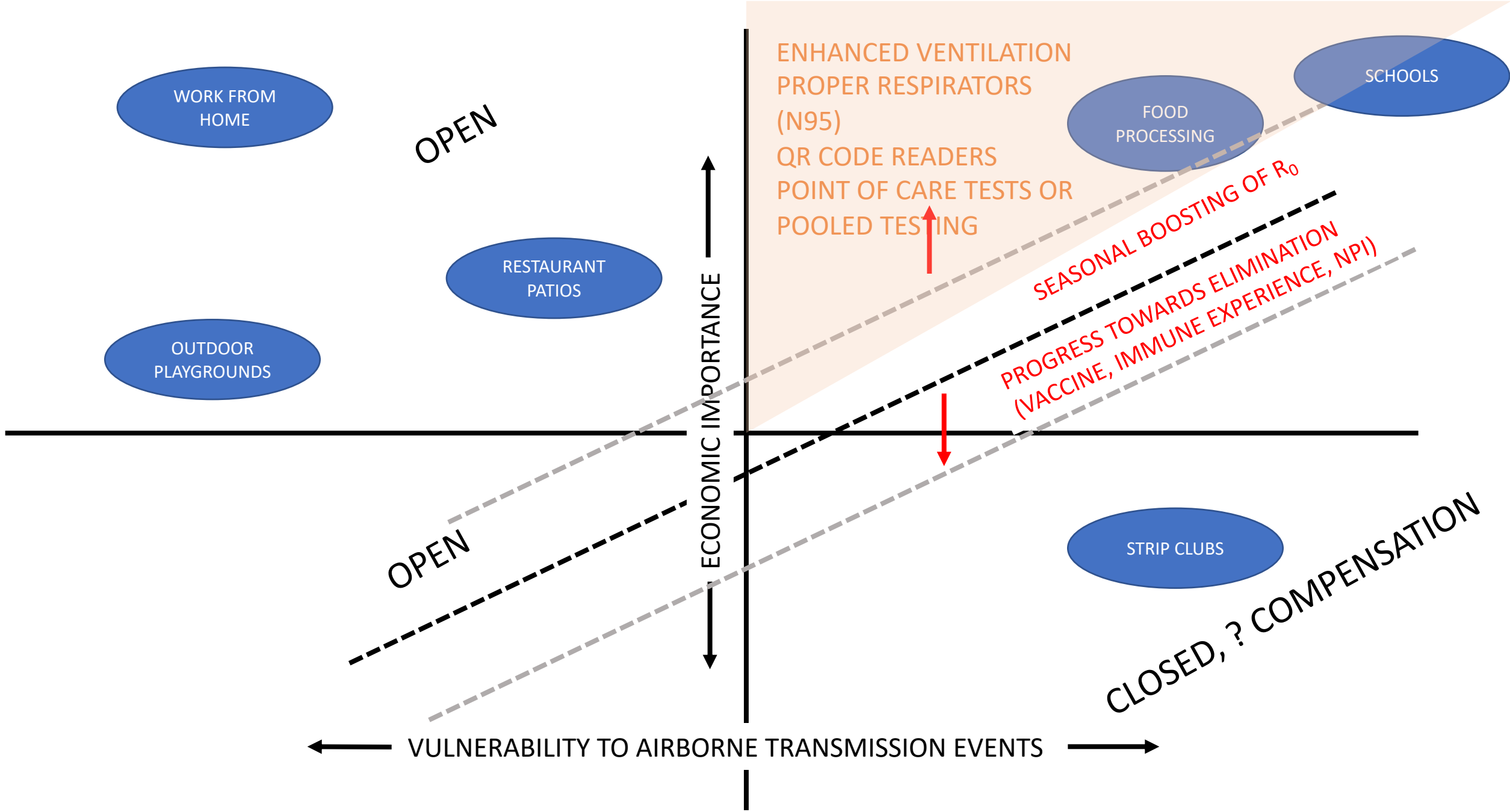
	Baja ocupación			Alta ocupación		
	Al aire libre	Interior bien ventilado	Interior mal ventilado	Al aire libre	Interior bien ventilado	Interior mal ventilado
😬 En silencio	Bajo	Bajo	Medio	Medio	Medio	Alto
😬 Hablar	Bajo	Medio	Medio	Alto	Alto	Alto
😬 Gritar/cantar	Medio	Medio	Alto	Alto	Alto	Alto

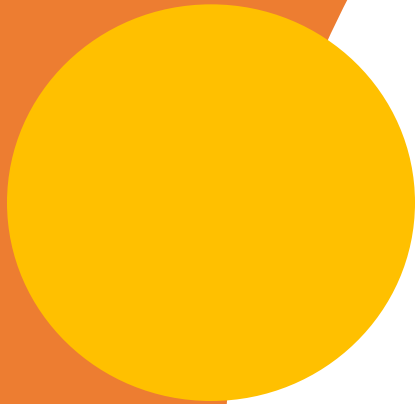
...durante mucho tiempo

	Baja ocupación			Alta ocupación		
	Al aire libre	Interior bien ventilado	Interior mal ventilado	Al aire libre	Interior bien ventilado	Interior mal ventilado
😬 En silencio	Bajo	Medio	Alto	Medio	Alto	Alto
😬 Hablar	Medio	Medio	Alto	Alto	Alto	Alto
😬 Gritar/cantar	Medio	Alto	Alto	Alto	Alto	Alto

Fuente: Jones N. et al. BMJ 2020; 370; m3223

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