



Riyadh Global  
**Digital Health  
Summit** —

11-12 August, 2020

# **Predicting Pandemics – Is the Technology Available Now?**

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# Predicting Pandemics – Is the Technology Available Now?

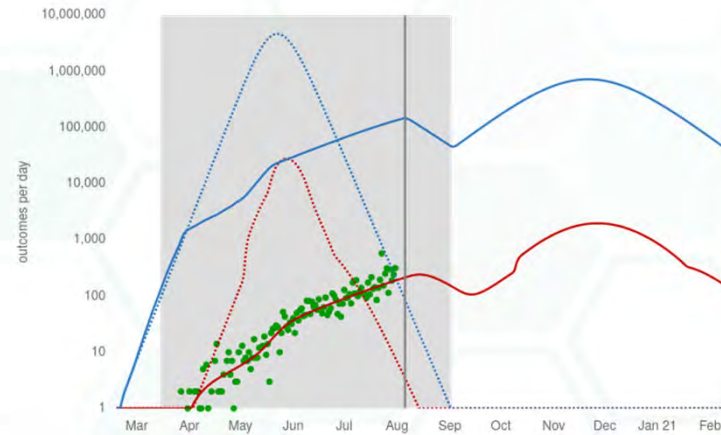
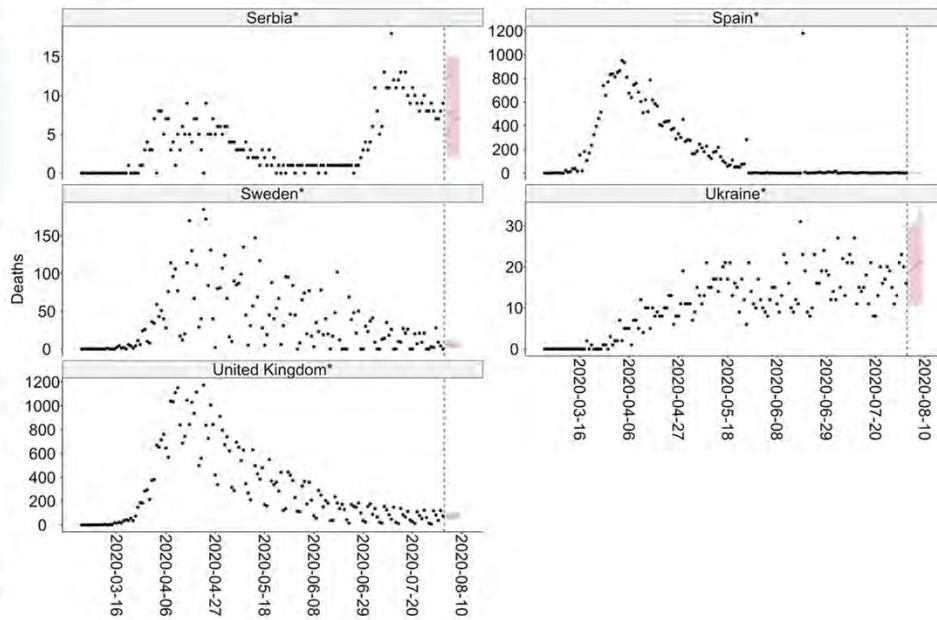
- The answer depends on what we mean by 'prediction'
  - What is being predicted?
  - Over what time horizon?
- Prediction at different stages of the global pandemic
  - Emergence –  
**Global pandemic was highly predictable by mid-February**
  - Over the first wave-  
**The epidemic is more unpredictable now than they were in February**
- *Life can only be understood backwards; but it must be lived forwards.*  
- Søren Kierkegaard



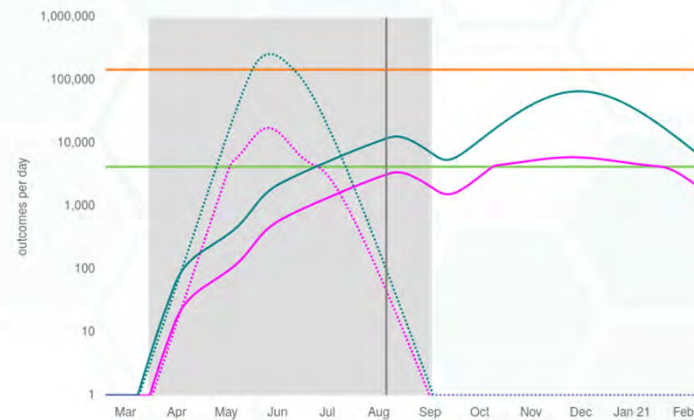
Imperial College  
London



# What is Possible and what are the Limits of PM?



<https://covid19sim.org/v2.20200731/>



Walker P, Whittaker C, Watson O et al. (2020).. <https://doi.org/10.25561/77735>




Cori A, Ferguson NM, Fraser C, Cauchemez S. 2013. *American journal of epidemiology*. 178(9):1505-12

<https://mrc-ide.github.io/covid19-short-term-forecasts/>

<https://viz.covid19forecasthub.org/>

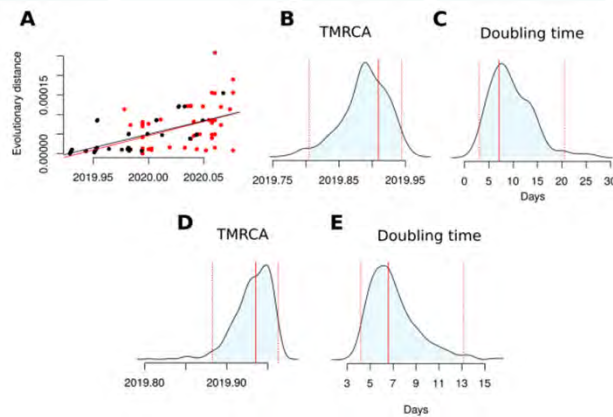
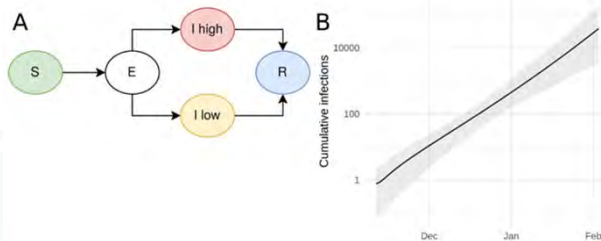
<https://www.cdc.gov/coronavirus/2019-ncov/covid-data/forecasting-us.html>

# Prediction at Different Stages

-  Predicting pandemic emergence
-  Predicting global dissemination patterns
-  Short-term predictions (health-care demand)

|   | Baseline <sup>1</sup>    | Smaller catchment <sup>1</sup> | Shorter detection window <sup>1</sup> | 6 exported cases         | 8 exported cases         |
|---|--------------------------|--------------------------------|---------------------------------------|--------------------------|--------------------------|
| Exported number of confirmed cases <sup>2</sup>   | 7                        | 7                              | 7                                     | 6                        | 8                        |
| Daily international passengers travelling out of Wuhan International Airport <sup>3</sup> | 3,301                    | 3,301                          | 3,301                                 | 3,301                    | 3,301                    |
| Effective catchment population of Wuhan International Airport                             | 19 million               | 11 million                     | 19 million                            | 19 million               | 19 million               |
| Detection window (days)   | 10 days                  | 10 days                        | 8 days                                | 10 days                  | 10 days                  |
| Estimated total number of cases (95% CI)  | 4,000<br>(1,700 – 7,800) | 2,300<br>(1,000 – 4,500)       | 5,000<br>(2,200 – 9,700)              | 3,400<br>(1,400 – 7,000) | 4,600<br>(2,100 – 8,600) |

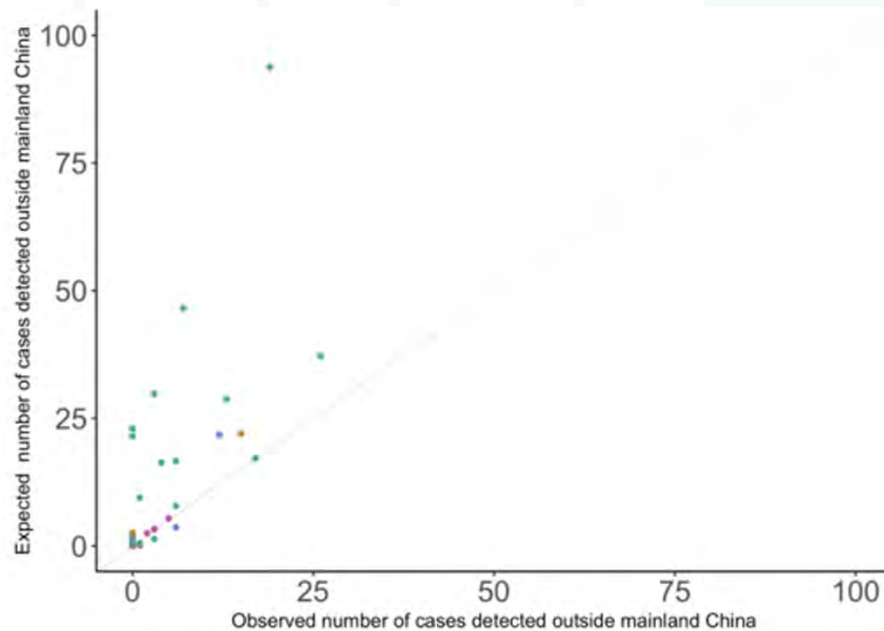
Imai N, Dorigatti I, Cori A, Riley S, Ferguson NM. **Estimating the potential total number of novel Coronavirus (2019-nCoV) cases in Wuhan City, China.** Preprint published by the Imperial College London. 2020.



E Volz, M Baguelin, S Bhatia et al. Phylogenetic analysis of SARS-CoV-2. Imperial College London; 15-02-2020. doi: <https://doi.org/10.25561/77169>.



# International Travel, Passenger Screening, and Probability of Epidemic, and a Little Back-of-the-envelope Math



S Bhatia, N Imai, G Cuomo-Dannenburg *et al.*  
**Estimating the number of undetected COVID-19 cases among travellers from mainland China.**

Wellcome Open Research; 15-06-2020, doi:  
<https://doi.org/10.12688/wellcomeopenres.15805.1>

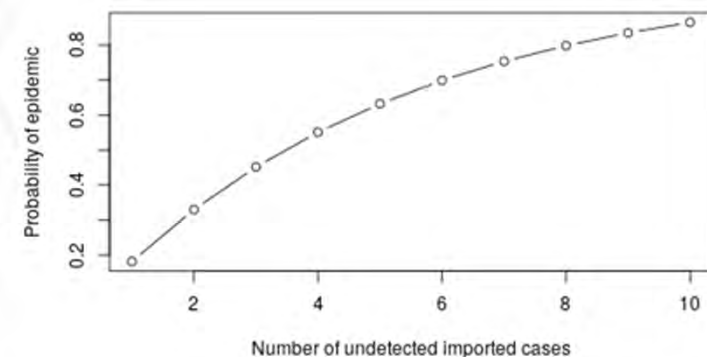
Probability of sparking an epidemic outside China depends on the reproduction number

$$p_1 = e^{R_0(p_1 - 1)}$$

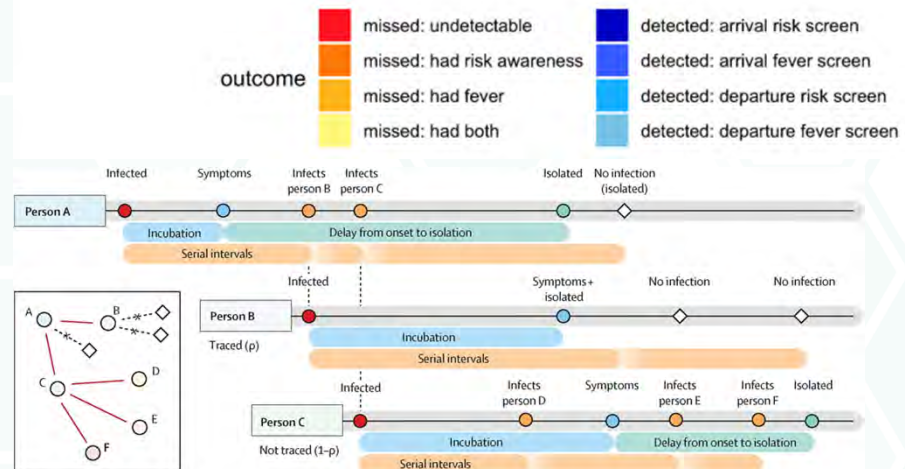
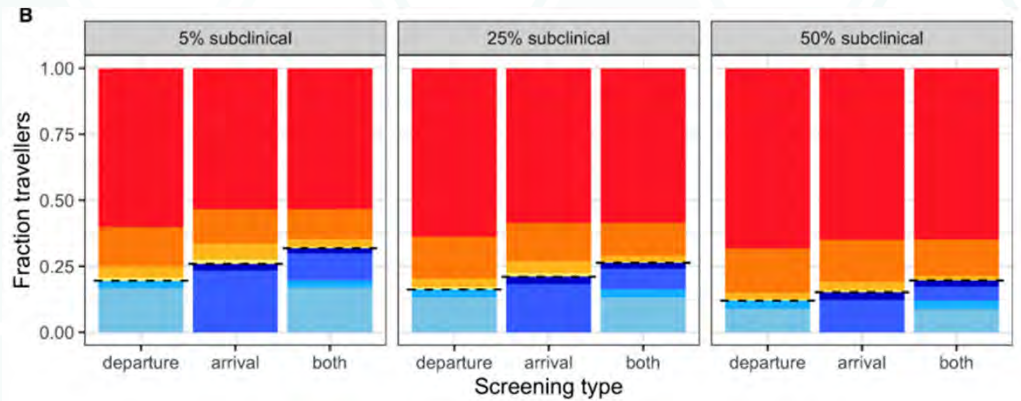
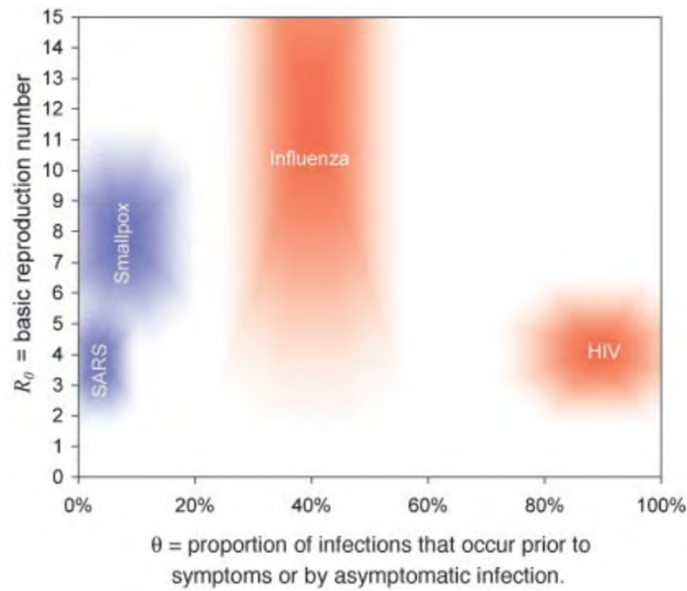
... and on the number of undetected imported infections

$$p_1 = p(\text{no epidemic} | 1 \text{ import})$$

$$p(\text{epidemic} | n \text{ imported infections}) = 1 - p(\text{no epidemic} | 1 \text{ import})^n$$



# Prospects for Containment with Numerous International Exports

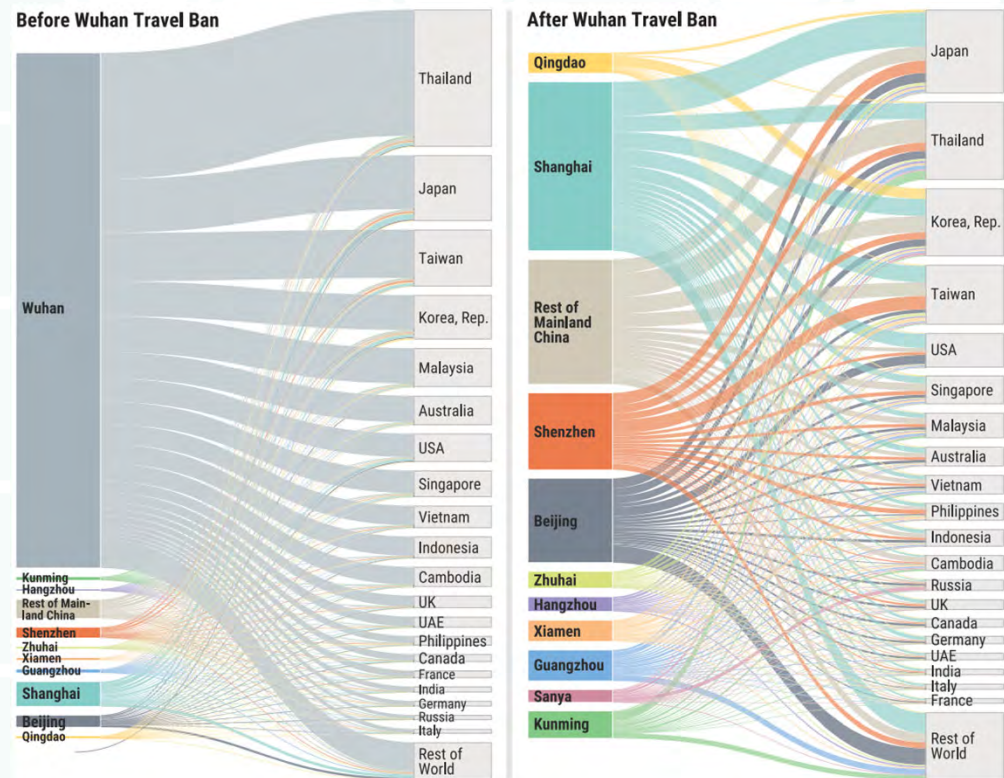
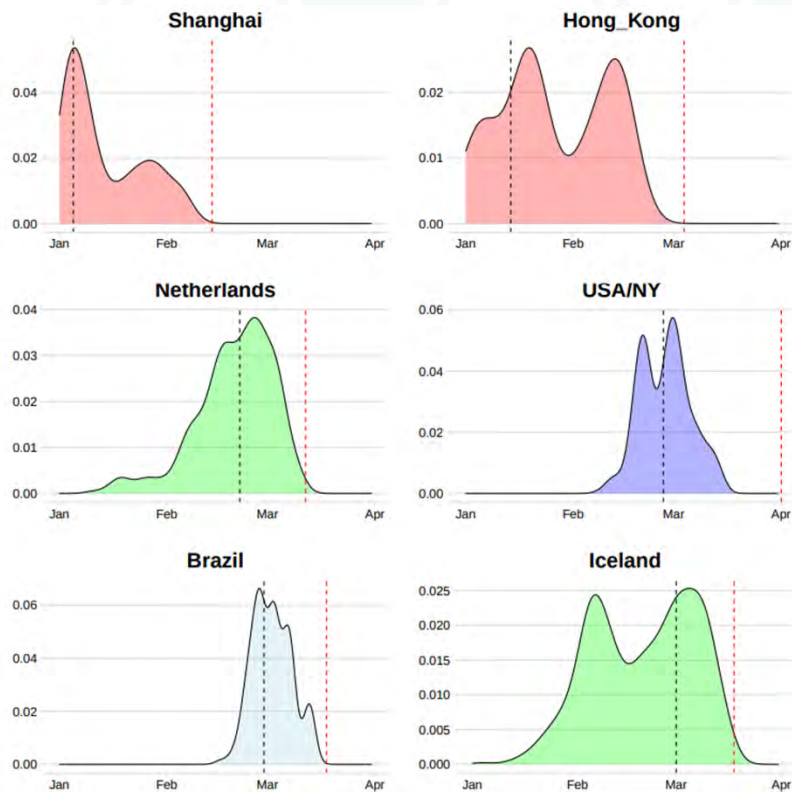


C Fraser, et al., PNAS, Apr 2004, 101 (16) 6146-6151;  
DOI:10.1073/pnas.0307506101

Gostic, Katelyn, et al. "Estimated effectiveness of symptom and risk screening to prevent the spread of COVID-19." *Elife* 9 (2020): e55570.

Hellewell J., et al., Russell TW, et al. *Lancet Glob Health*. 2020;8: e488–e496. doi:10.1016/S2214-109X(20)30074-7

# If a Pandemic Occurs, what is the likely Pattern of International Dissemination

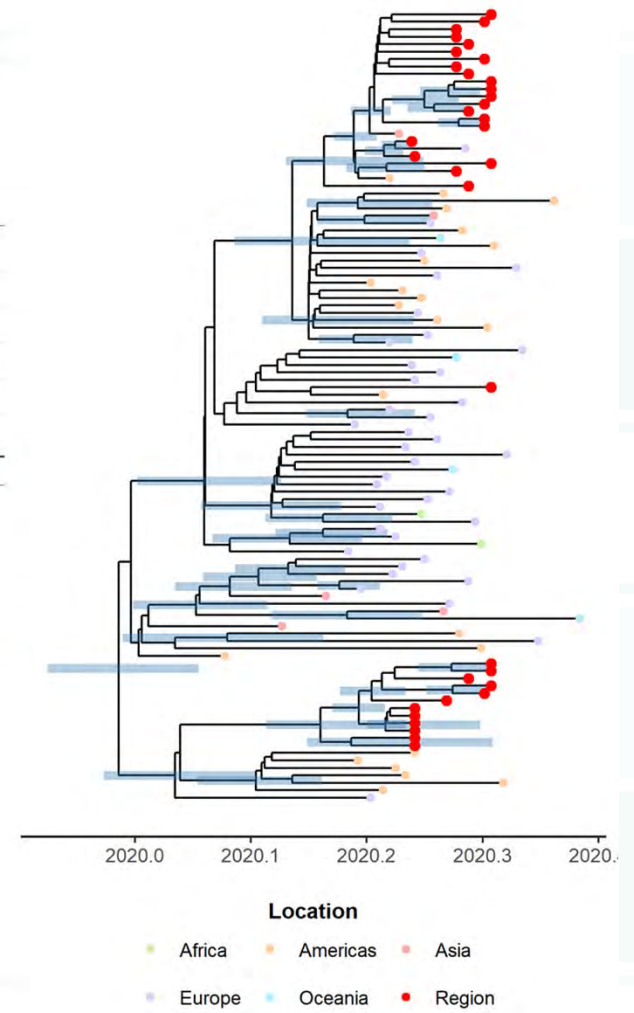
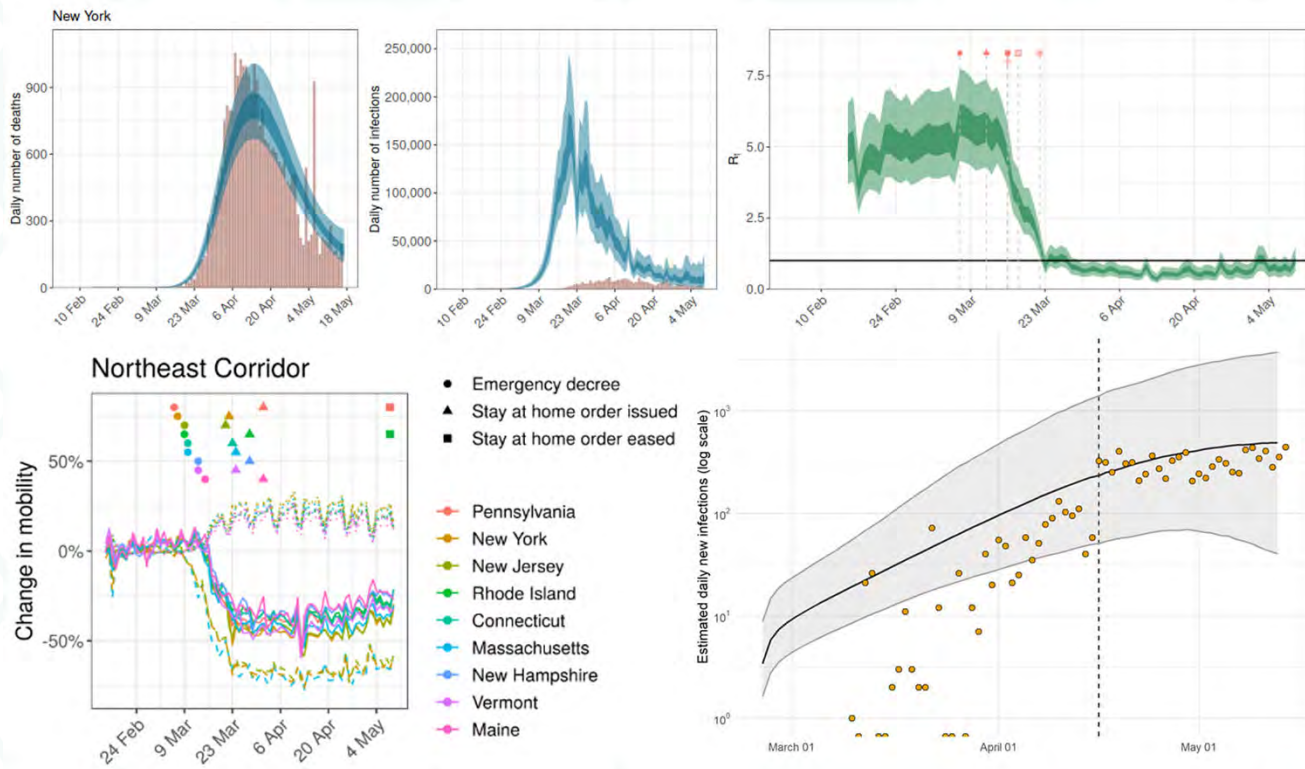


<http://sarscov2phylodynamics.org/2020/04/08/importations.html>

Chinazzi M, Davis JT, Ajelli M, Gioannini C, Litvinova M, Merler S, et al. Science. 2020;368: 395–400. doi:10.1126/science.aba9757



# March/April 2020, a Pandemic is Underway: Short-term Forecasting



Flaxman S, et al. Nature. 2020 <https://doi.org/10.1038/s41586-020-2405-7>,  
 HJT Unwin, et al. Imperial College London; 21-05-2020, doi: <https://doi.org/10.25561/79231>

<http://sarscov2phylodynamics.org>



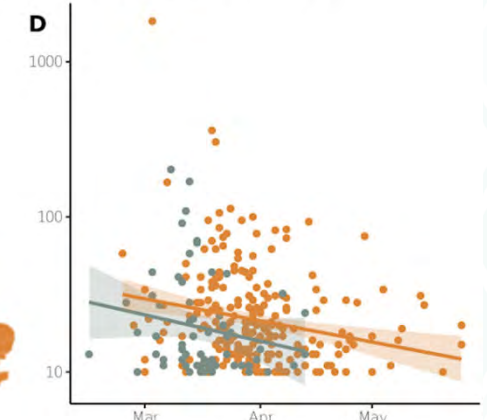
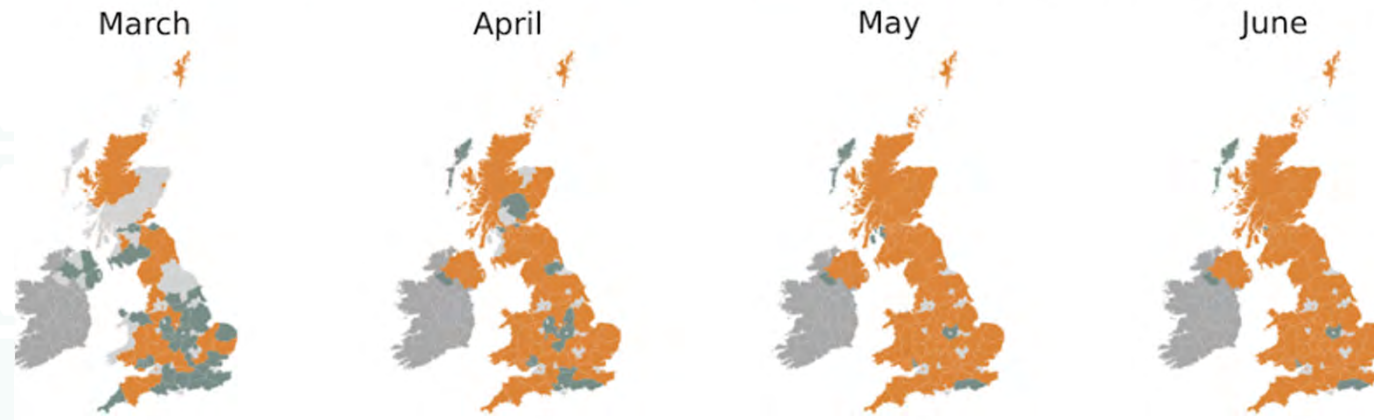
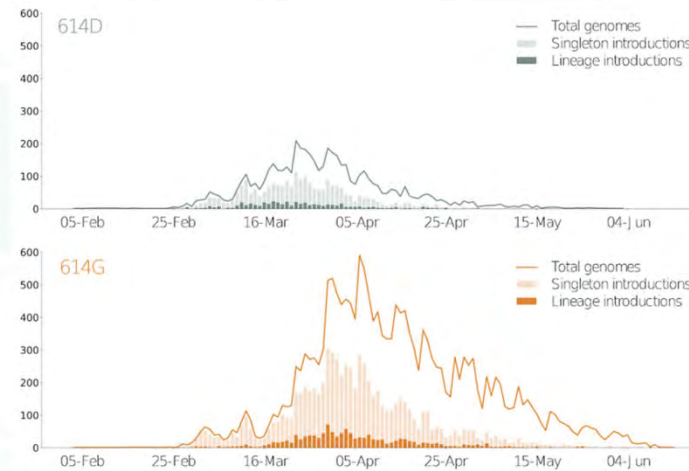
# Limits to Prediction: The Virus is a Moving Target

## Evaluating the effects of SARS-CoV-2 Spike mutation D614G on transmissibility and pathogenicity

EM Volz, et al. The COVID-19 Genomics UK Consortium

<https://www.medrxiv.org/content/10.1101/2020.07.31.20166082v1>

Mutation Spike D614G, arising in Feb/March increases transmission rate by 21% (95% CI: 6-56).



## Predictive Modelling is not a Monolithic Methodology or a New Research Area. But a Rapidly Expanding Field.

- Google Scholar: Over 30,000 academic publications with COVID-19 in the title. Less than 2% indicate that they contain PM in the title. Nevertheless, nearly every business, hospital, city, state, and national government has been provided with COVID-19 forecasts.
- PM encompass a wide variety of statistical and mathematical models applied to a diverse data to address different inference and prediction goals.

# THANK YOU



وزارة الحرس الوطني - الشؤون الصحية  
Ministry of National Guard - Health Affairs



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