Mathematical Epidemiology for KoroNERV-20
- notes at Jun 22th regular meeting

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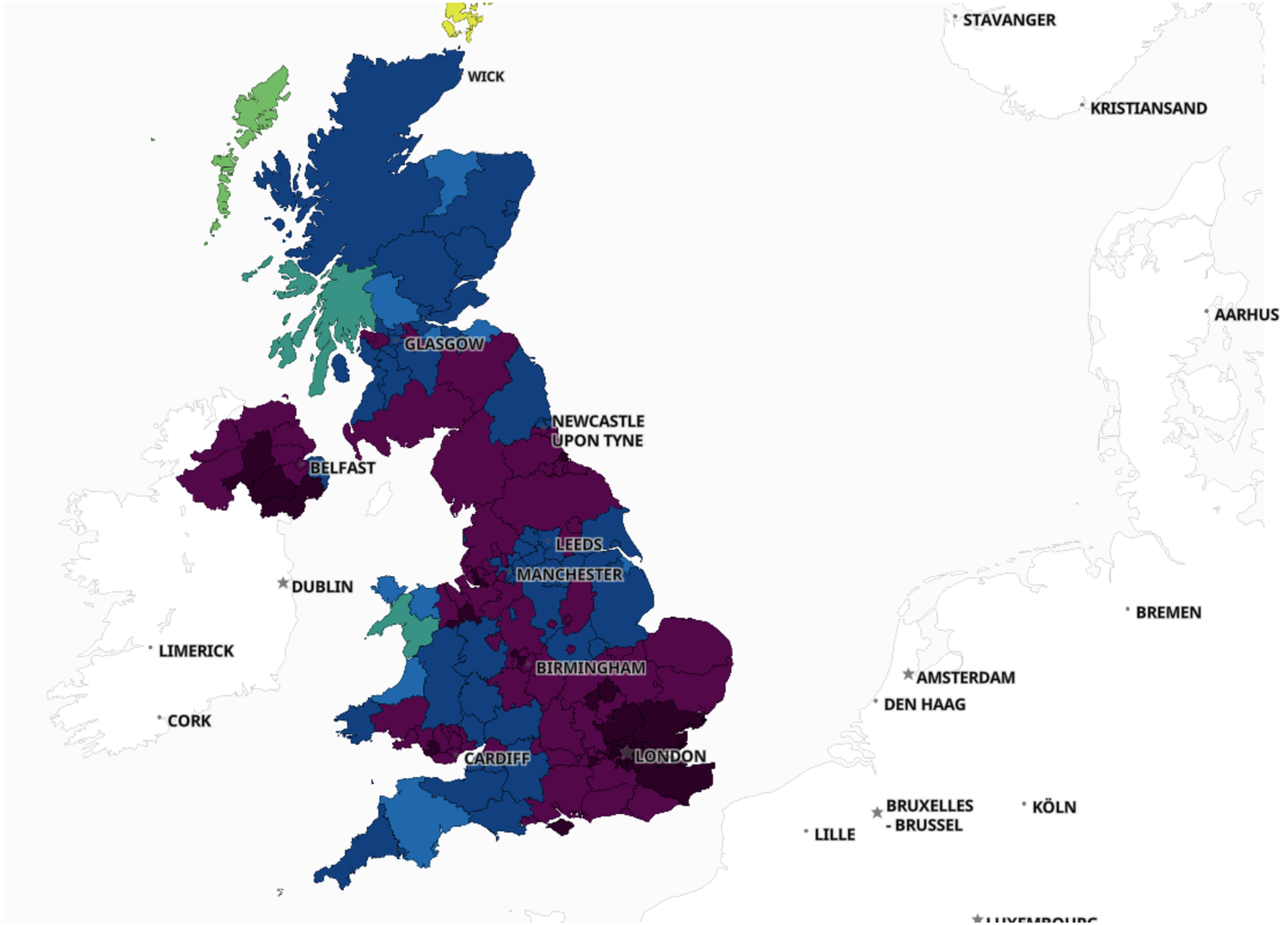
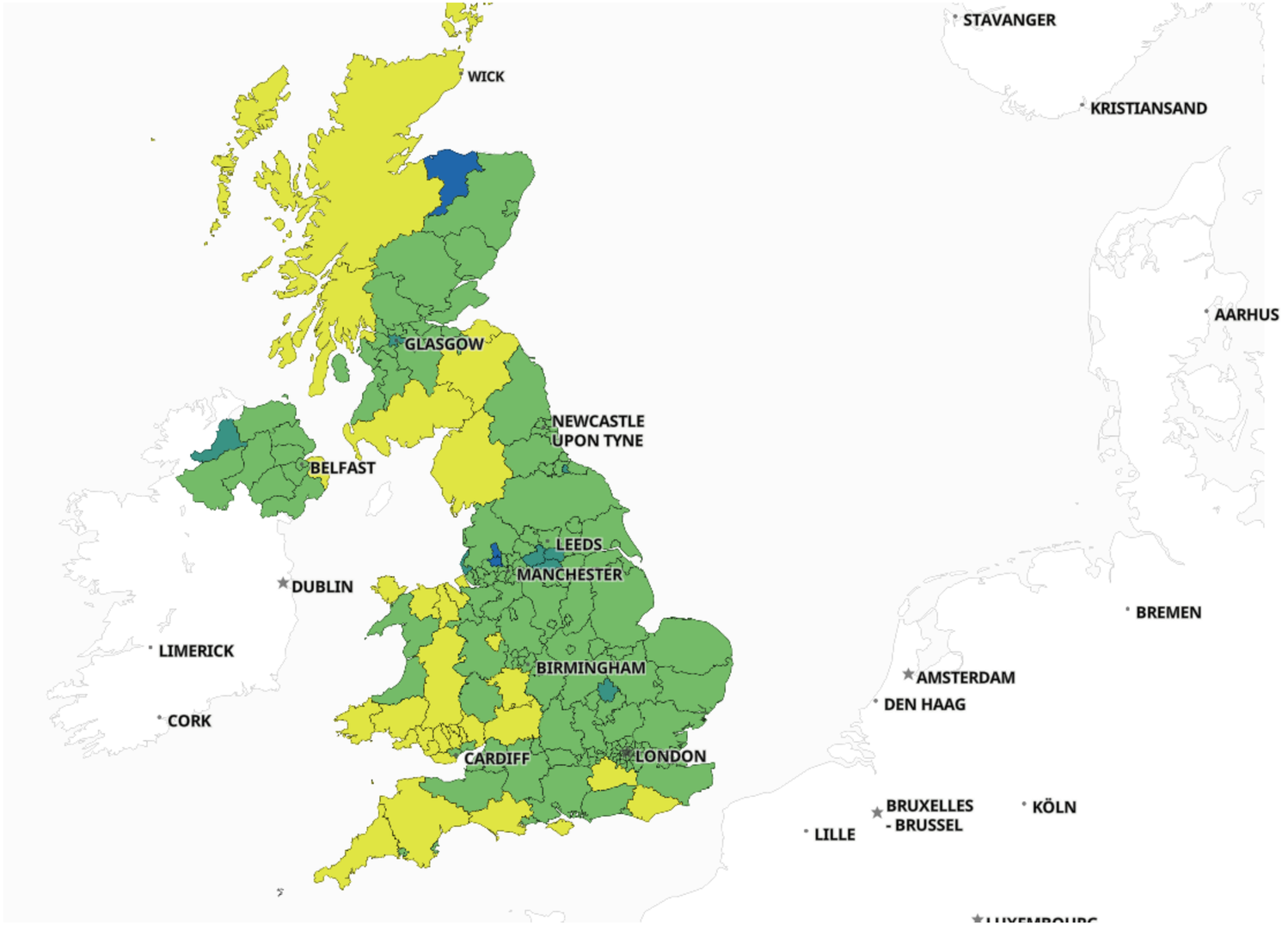
Still Remember

- We model it as a **machine**
  - it has its code
  - it consumes energy (of us)
  - it is still going on
- If we do rely on a model, we shall respect all it can tell us fully

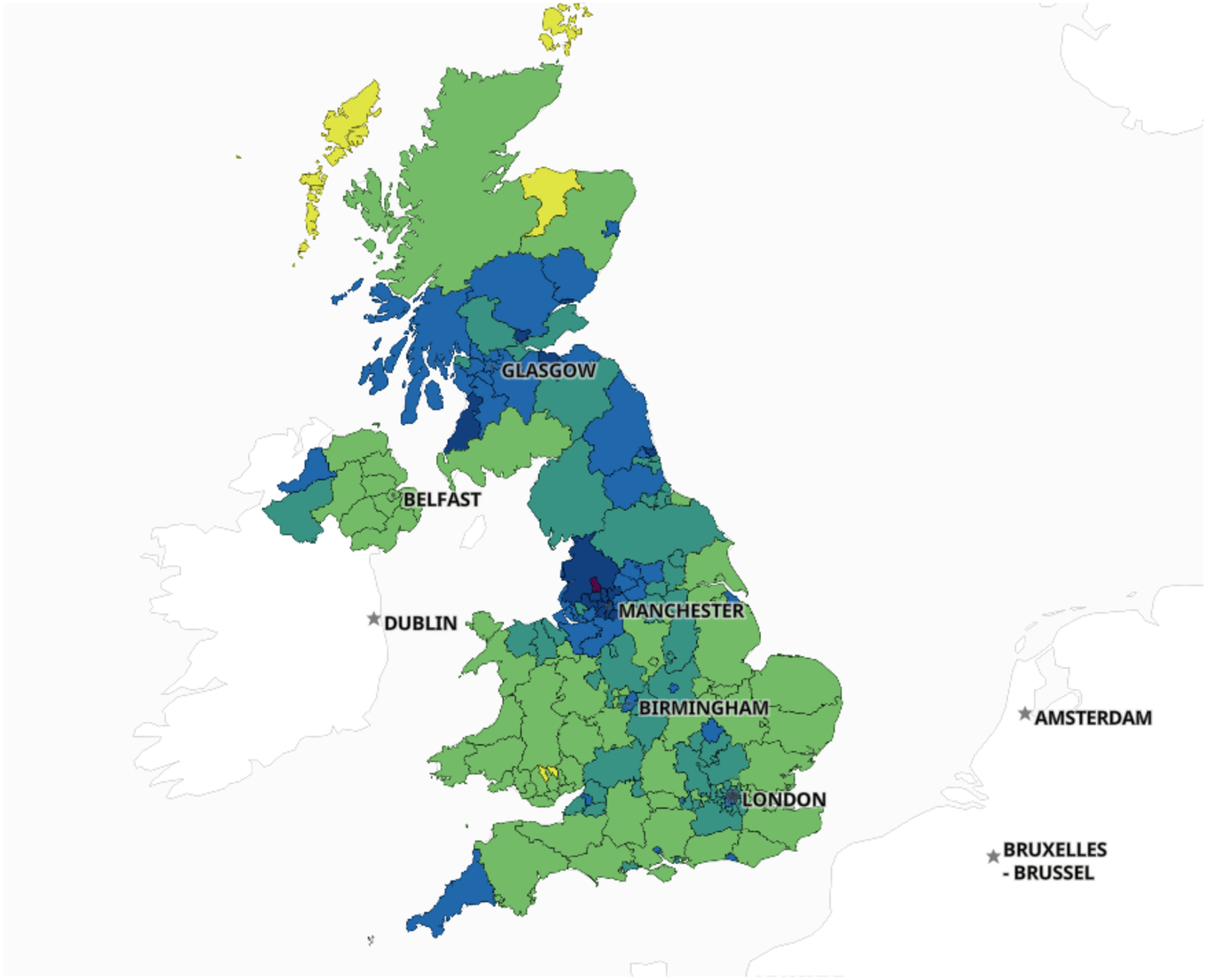
UK Incidence per 100 k, 7-day interval
Jan 3rd 2021



UK Incidence per 100 k, 7-day interval
May 9th 2021



UK Incidence per 100 k, 7-day interval
June 15th 2021



Last updated on Monday 21 June 2021 at 4:00pm

Daily update
Testing
Cases
Healthcare
Vaccinations
Deaths

Interactive map
About the data
Download data
What's new
Developer's guide

UK summary

The official UK government website for data and insights on coronavirus (COVID-19).

See the simple summary for the UK.

Vaccinations

People vaccinated

Up to and including 20 June 2021

Daily — 1st dose
163,750

Daily — 2nd dose
109,408

Total — 1st dose
43,127,763

Total — 2nd dose
31,449,915

All vaccination data

Percentage of adult population

81.9%
1st dose

59.7%
2nd dose

Cases

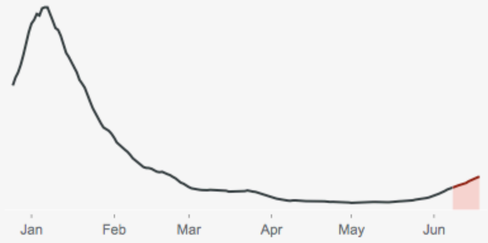
People tested positive

Latest data provided on 21 June 2021

Daily
10,633

Last 7 days
68,449 ↑16,373 (31.4%)

▶ Rate per 100,000 people: 89.3



All cases data

Deaths

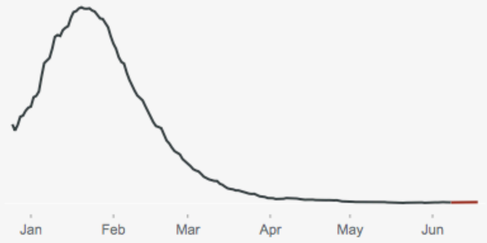
Deaths within 28 days of positive test

Latest data provided on 21 June 2021

Daily
5

Last 7 days
74 ↑8 (12.1%)

▶ Rate per 100,000 people: 0.1



All deaths data

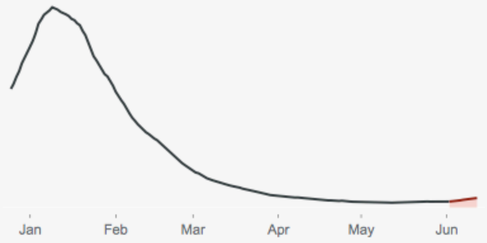
Healthcare

Patients admitted

Latest data provided on 15 June 2021

Daily
226

Last 7 days
1,413 ↑401 (39.6%)



All healthcare data

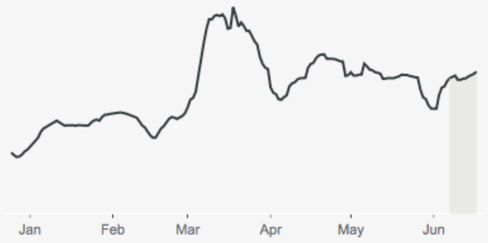
Testing

Virus tests conducted

Latest data provided on 20 June 2021

Daily
1,149,112

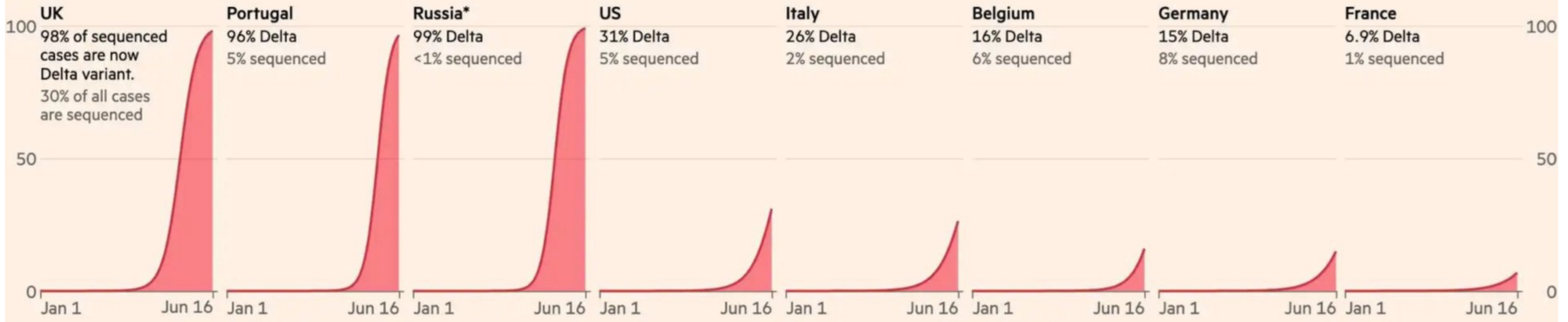
Last 7 days
6,375,758 ↑366,285 (6.1%)



All testing data

The Delta variant may be taking hold in parts of Europe and North America

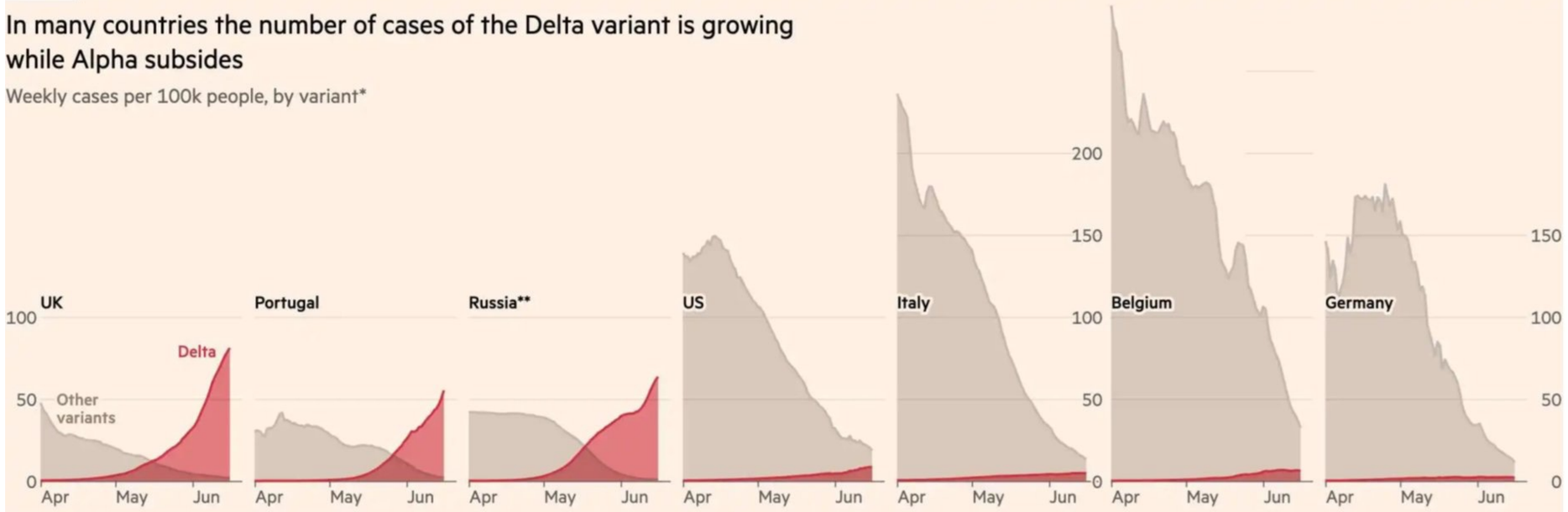
Modelled estimates of the Delta variant's share of all sequenced cases (%)



*More than 90% of Russia's sequenced cases of Delta are from Saint Petersburg
Source: FT prevalence estimates based on data from GISAID, Sciensano, Belgian National Reference Laboratory. Method from Tom Wenseleers / @TWenseleers

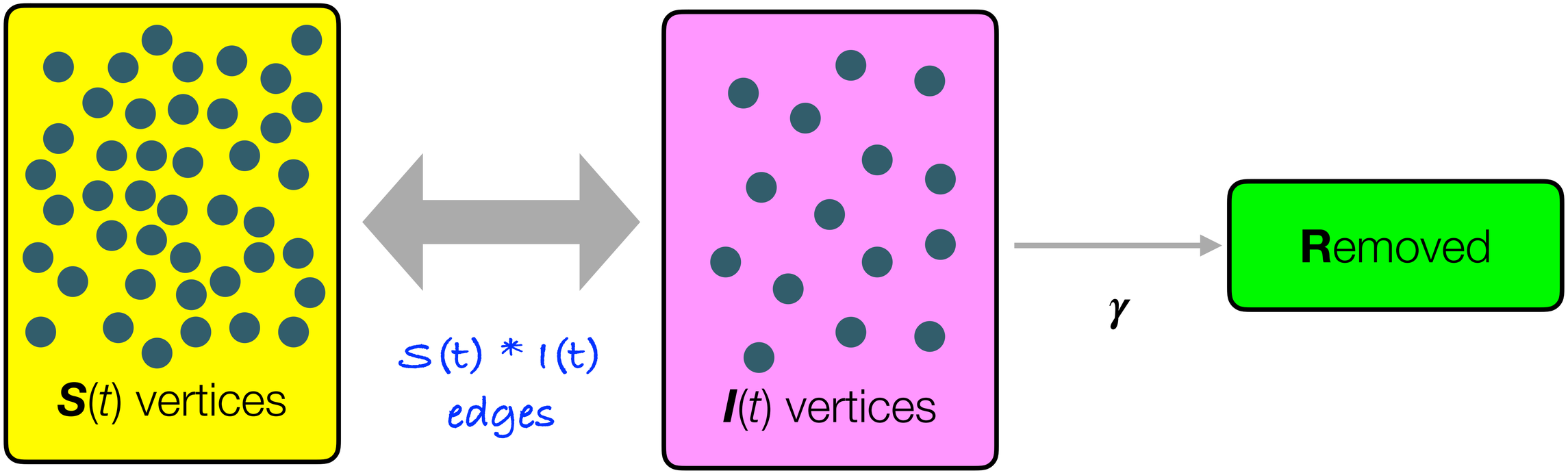
In many countries the number of cases of the Delta variant is growing while Alpha subsides

Weekly cases per 100k people, by variant*



*Modelled prevalence of Delta variant applied to total cases
**More than 90% of Russia's sequenced cases of Delta are from Saint Petersburg
Source: FT analysis of data from GISAID, Sciensano, Belgian National Reference Laboratory and Johns Hopkins CSSE

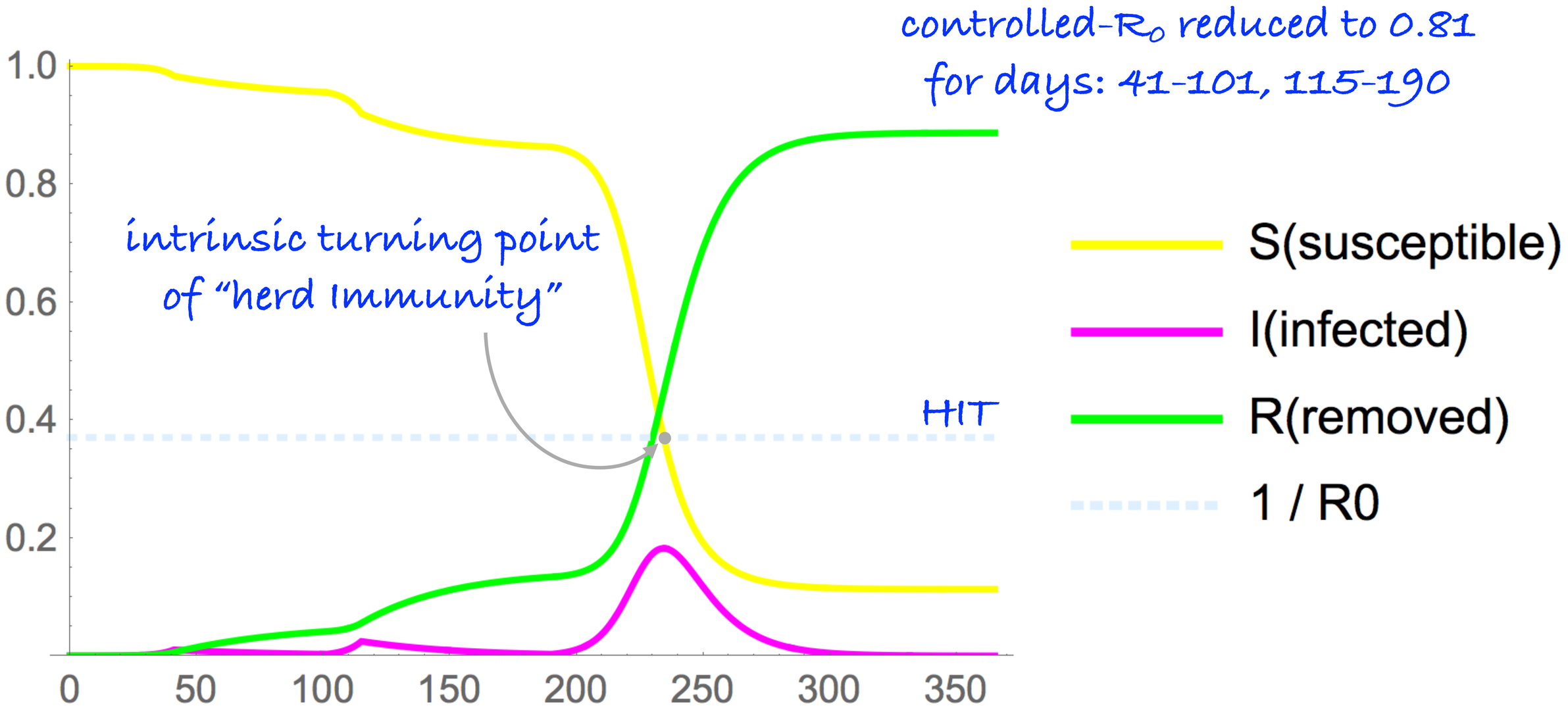
SIR Compartmental Epidemic Model
- zooming on the mass action mechanism



$$\frac{dS(t)}{dt} = -\frac{\gamma \cdot \mathcal{R}_0 \cdot season(t) \cdot control(t)}{N} I(t)S(t)$$

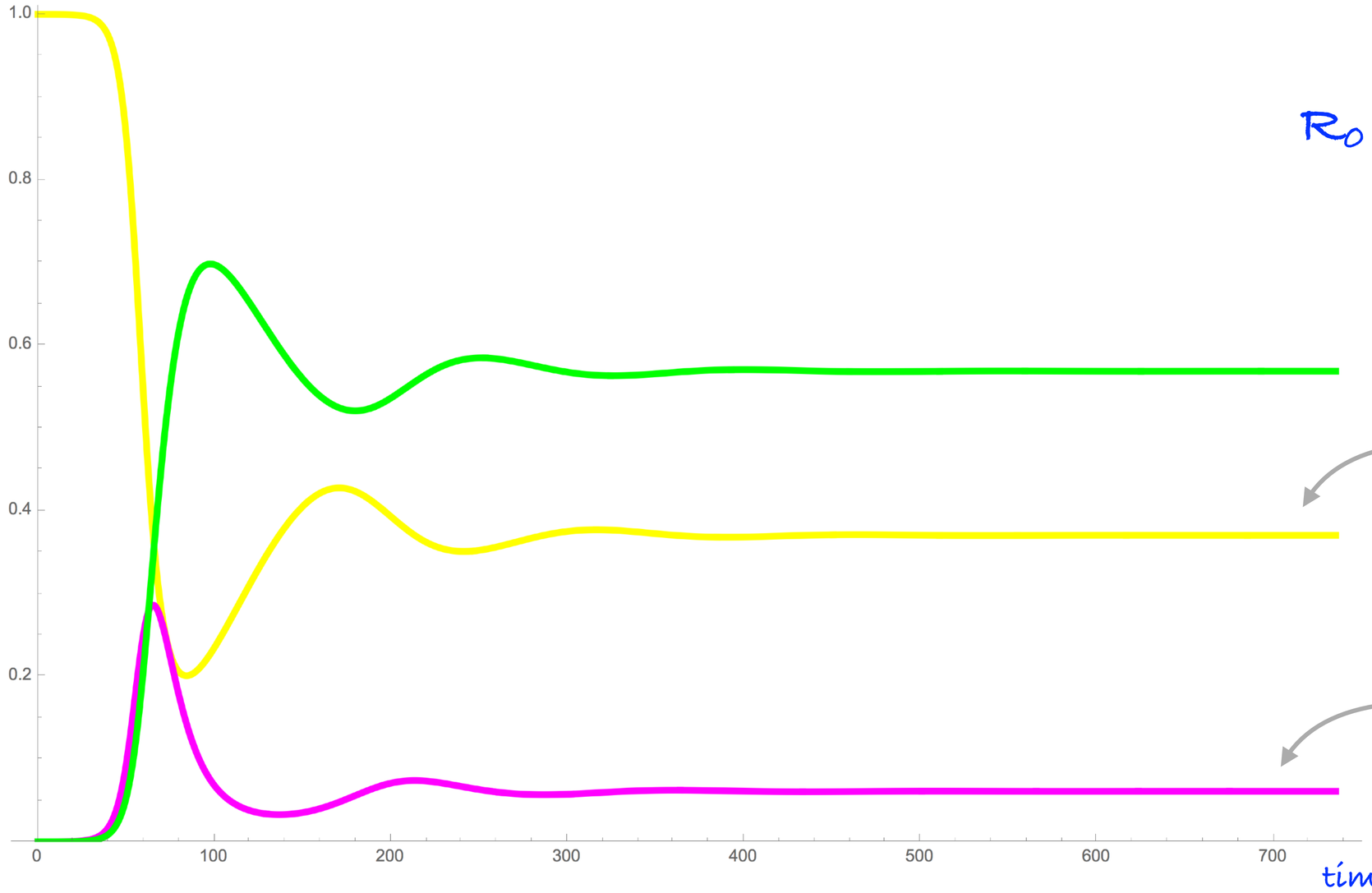
$$\frac{dI(t)}{dt} = \gamma I(t)\left(\frac{\mathcal{R}_0 \cdot season(t) \cdot control(t)}{N} S(t) - 1\right)$$

Herd Immunity Threshold Revisited



- we set λ very high (with respect to a pure demography) here to illustrate endemic equilibrium in general
- on the other hand, in reality, demography is not the only reason for endemic states anyway

Endemic Equilibrium is Asymptotically Stable for $\boldsymbol{R}_0 > 1$



$R_0 = \beta / (\lambda + \gamma) \cong 2.7$

$s^* = 1/R_0 \cong 0.37$

$i^* \cong 0.06$

Basic Vaccination Equation Revisited for HIT

$$threshold(\mathcal{R}_0, \varepsilon) = \frac{1}{\varepsilon}\left(1 - \frac{1}{\mathcal{R}_0}\right)$$

ε	R_0				
	2.7	3.5	4.5	5.5	6.45
92 %	68 %	78 %	85 %	89 %	92 %
86 %	73 %	83 %	90 %	95 %	98 %
80 %	79 %	89 %	97 %	—	—
63 %	100 %	—	—	—	—

- Assumptions:
  - vaccine distributed ***uniformly among yet-susceptible*** people
  - vaccine efficacy ***ε - for spreading***
  - immunity does not vanish in near time (circa one year, at least)
- Recovered people fraction bearing natural immunity then sums up with the vaccinated fraction
  - not shown here for clarity
  - be careful with overlaps

Vaccination - not ***sooo*** basic equations (ODE stability - SIS model)

$$\mathcal{R}(\psi) = \frac{\beta(\mu + (1-\varepsilon)\psi)}{(\mu+\gamma)(\mu+\psi)}$$

$$\mathcal{R}(\psi = 0) = \mathcal{R}_0 = \frac{\beta}{\mu+\gamma}$$

$$\mathcal{R}(\psi \to \infty) \to (1-\varepsilon)\mathcal{R}_0$$

$$\mathcal{R}(\psi^*) = 1 \Rightarrow \psi^* = \frac{(\mathcal{R}_0 - 1)\mu}{1-(1-\varepsilon)\mathcal{R}_0}$$

note $\psi^* \to \infty$ for $(1-\varepsilon)\mathcal{R}_0 \to 1$

- efficacy & speed (!)
- uniformity (!)
- after all, vaccination dynamics is
  - complicated enough for the backward bifurcation to occur
  - coexistence mechanism for multiple pathogen variants

And then, for the sake of completeness

$$p_\varepsilon = \frac{\psi^*}{\mu + \psi^*} = \frac{1}{\varepsilon}\left(1 - \frac{1}{\mathcal{R}_0}\right)$$

- Despite being the same numerically, the vaccinated fraction threshold is now given as a result of the vaccination dynamics, instead of being just a prime goal.
- This is a better starting position for investigation of the epidemic/ endemic dynamics.

Attachments - presented and discussed together with this note

- 18_June_2021_Risk_assessment_for_SARS-CoV-2_variant_DELTA.pdf

Revision History

- 2021/06/22: release version 1