An informal look at the *Wuhan Plague*

plague, *n.*

Text size: A A

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Quotations: Show all | Hide all Keywords: On | Off

Pronunciation: Brit. /pleɪg/, U.S. /pleɪg/

Forms: ME **plaage**, ME **plaghe**, ME **ploge**, ME–16 **plage**, 15 **plag**, 15 **plaigue**, 15 ... (Show More)

Frequency (in current use):

Origin: Probably of multiple origins. A borrowing from Latin. Probably also partly a borrowing from French. **Etymons:** Latin *plāga*; French *plage*, *plague*.

Etymology: < classical Latin *plāga*... (Show More)

b. Any infectious disease which spreads rapidly and has a high mortality rate; an epidemic of such a disease.

Thesaurus »
Categories »

In early use difficult to distinguish from sense 3c.

*a*1475 *Bk. Quinte Essence* (1889) 24 Þese plagis of pestilence þat ben vncurable.

*a*1500 (▸1465) *Vision E. Leversedge* in *Notes & Queries Somerset & Dorset* (1905) **9** 23 (*MED*) I..by the hand and vysytacyon of almyghty God was smyton with the plage of pestylence.

1552 *Bk. Common Prayer* (STC 16279) Letanye sig. □□.viiᵛ In the tyme of any common plague or Sickenes.

1569 E. Fenton tr. P. Boaistuau *Certaine Secrete Wonders Nature* f. 65 This corruption [*sc.* poisoning the wells] engendred such contagious diseases..that there died wel nigh the thirde person..: for this plague passing sodainly from citie to citie, by the contagiousnesse therof destroyed and smoothered al things bearing life.

1598 G. Chapman tr. Homer *Seauen Bks. Iliades* i. 3 Atrides, some new error now, procures this plague I feare, To driue vs hence, if with our liues we may th'impulsions beare Of this our double pestilence, th'infection and our warre.

1601 J. Sanderson *Travels* (1931) 49 I doe beleeve also that... The plague comming into some of their orchards of date trees, that one infects another, and many doe dye of the plague.

1668 Duchess of Newcastle *Grounds Nat. Philos.* (ed. 2) x. ii. 132 The truth is, the Spotted Plague is a Gangrene, but is somewhat different from other sorts of Gangren's; for this begins amongst the Vital Parts, and, by an Infection, spreads to the Extream Parts.; and not only so, but to Forrein Parts; which makes not only a general Infection amongst all the several Parts of the Body, but the Infection spreads it self to other Bodies.

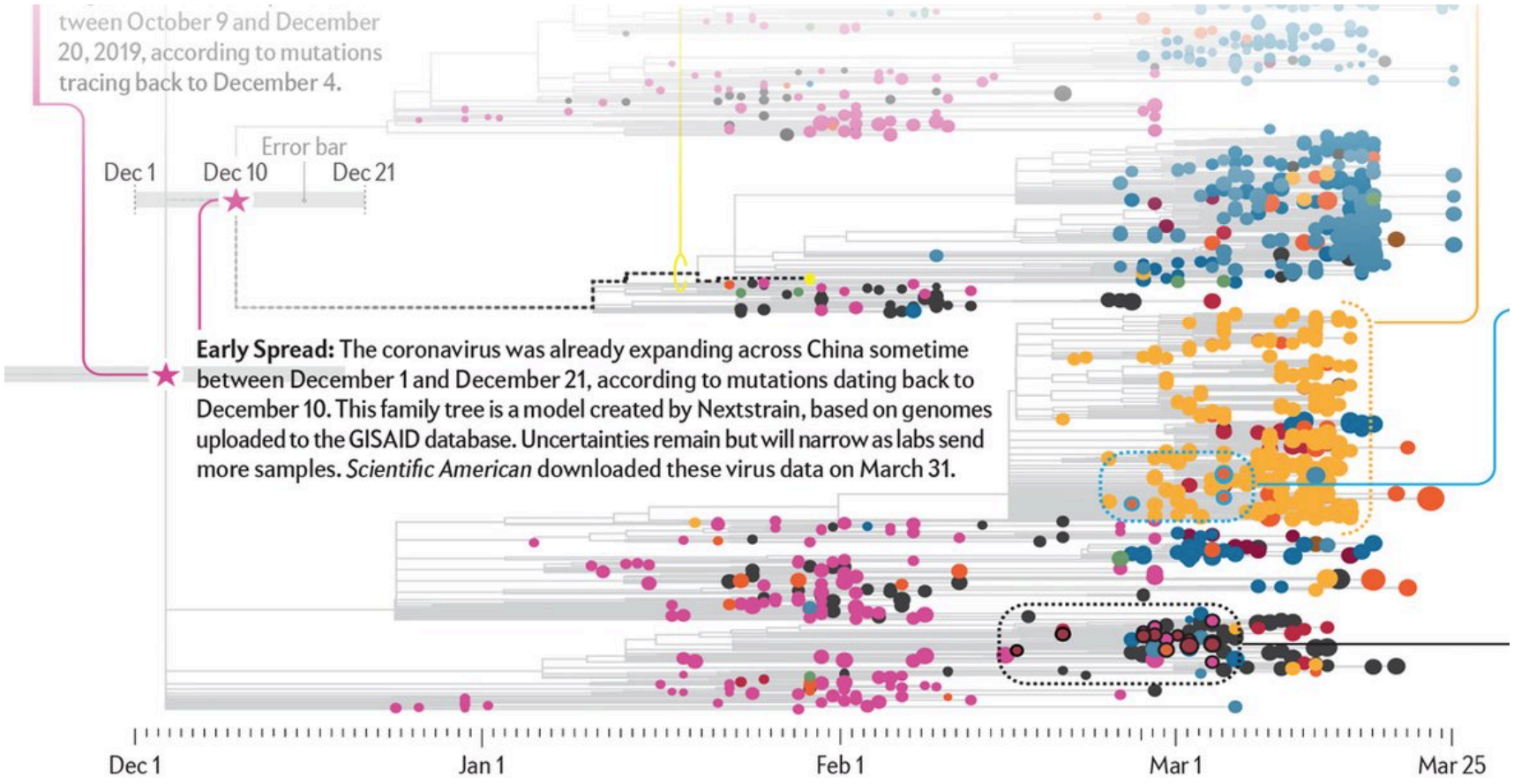
1683 W. Salmon *Doron Medicum* i. i. 3/2 Betonica,..is a Woundherb... The Essence is good against the Falling-sickness, Palsie,..Poyson, Plague,..Frensie, Madness.

1697 J. Dryden tr. Virgil *Georgics* iii, in tr. Virgil *Wks.* 117 From the vicious Air, and sickly Skies, A Plague did on the dumb Creation rise.

1738 J. Wesley *Coll. Psalms & Hymns* (new ed.) xci. v Nor to thy healthful Dwelling shall Any infectious Plague draw nigh.

1807 *Med. & Physical Jrnl.* **17** 338 Instructions how to communicate and to treat this plague [*sc.* small-pox].

Origin



Credit: Martin Krzywinski; Source: Nextstrain (enabled by data from GISAID) https://nextstrain.org/ncov

Geographical origin is *scientifically* relevant

- Understanding the conditions for its emergence and mitigating future outbreak pathways
- The initial condition for spatial spreading
- Politics (above my pay grade but clearly relevant)

But controversial

MENU nature Subscribe Search My

EDITORIAL · 07 APRIL 2020

Stop the coronavirus stigma now

The pandemic is fuelling deplorable racism and discrimination, especially against Asian people. Education and research will also pay the price.

Chinatown in San Francisco, California, during coronavirus: China sends some 400,000 students to the United States. How many will return once lockdowns are lifted? Credit: Jeff Chiu/AP/Shutterstock

When the World Health Organization (WHO) announced in February that the disease caused by the new coronavirus would be called COVID-19, the name was quickly adopted by organizations involved in communicating public-health information. As well as naming the illness, the WHO was implicitly sending a reminder to those who had erroneously been associating the virus with Wuhan and with China in their news coverage—

PDF version

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Calling all coronavirus researchers: keep sharing, stay open

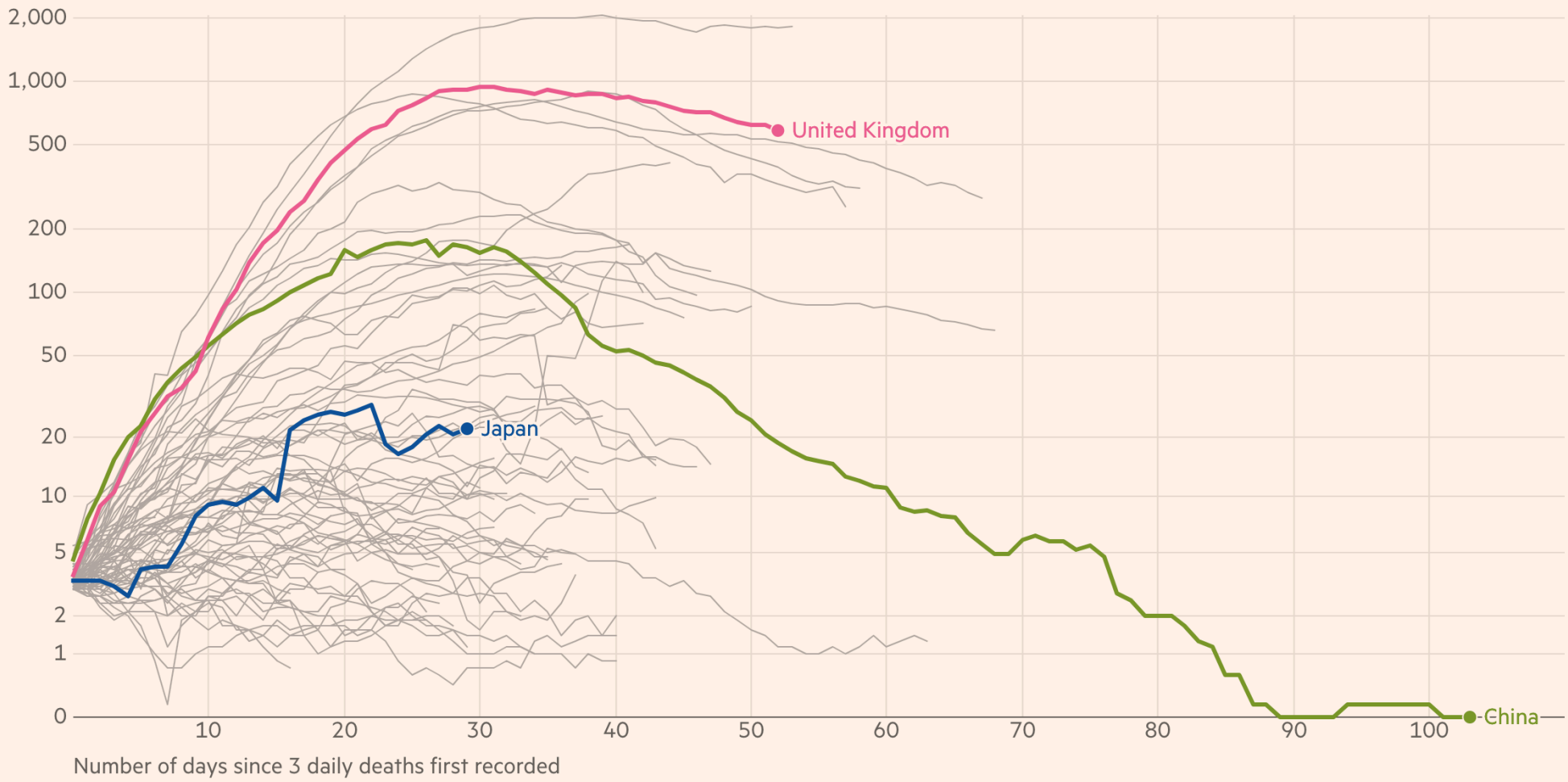
SUBJECTS

Diseases Infection

public-health information. As well as naming the illness, the WHO was implicitly sending a reminder to those who had erroneously been associating the virus with Wuhan and with China in their news coverage—including *Nature*. That we did so was an error on our part, for which we take responsibility and apologize.

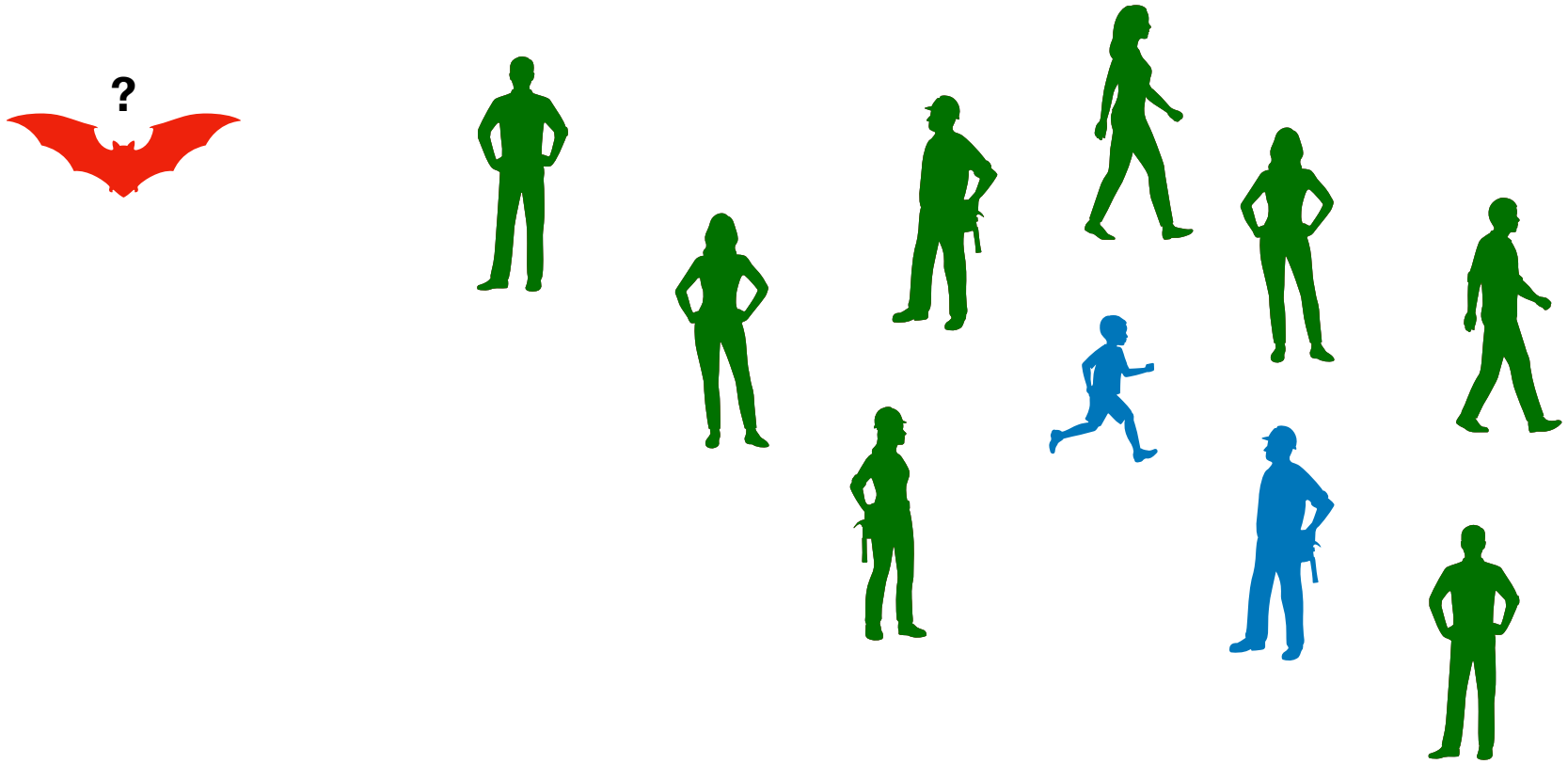
New deaths attributed to Covid-19 in Japan and United Kingdom

Seven-day rolling average of new deaths, by number of days since 3 average deaths first recorded



Source: FT analysis of data from European Centre for Disease Prevention and Control. Data updated May 6 2020, 6.37pm BST

Susceptible Infected Recovered models in Epidemiology



Variants of SIR

- mean field (well mixed)
  - single representative agent
  - different agent classes (“young”, “old” etc)
- contact networks
  - infection dynamics on a graph
- + Exposed(s), Dead (etc) = SE^nIRD in general

SIR model

$$
\begin{aligned}
\dot{S}_j &= -S_j \sum_k \kappa_{jk} I_k / N\tau \\
\dot{I}_j &= S_j \sum_k \kappa_{jk} I_k / N\tau - I_j/\tau \\
\dot{R}_j &= I_j[1 - \omega_j(\vec{I})]/\tau \\
\dot{D}_j &= I_j \omega(\vec{I})/\tau
\end{aligned}
$$

Symmetric pairwise infectivity $\kappa_{jk} = \left(\frac{\kappa_j^\alpha + \kappa_k^\alpha}{2} \right)^{1/\alpha}$

rescaled SIR

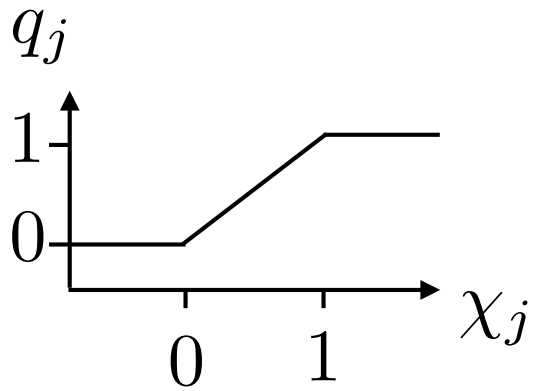
$$
\begin{aligned}
\dot{s}_j &= -s_j \sum_k \kappa_{jk} i_k \\
\dot{i}_j &= s_j \sum_k \kappa_{jk} i_k - i_j \\
\dot{r}_j &= i_j [1 - \omega_j(\vec{i})] \\
\dot{d}_j &= i_j \omega_j(\vec{i})
\end{aligned}
$$

Health risks

Beds per infected agent in category *j*
under triage (small index prioritised)

$$\chi_j = \frac{h - \sum_{k<j} p_k i_k}{p_j i_j}$$

Probability of an infected *j getting a bed*



Probability of death for an infected j

$$\omega_j(\vec{i}) = p_j(\tilde{\omega}_j q_j + (1 - q_j))$$

rescaled SIR

(single representative agent)

$$
\begin{aligned}
\dot{s} &= -s\kappa i \\
\dot{i} &= (s\kappa - 1)i \\
\dot{r} &= i[1 - \omega(i)] \\
\dot{d} &= i\omega(i)
\end{aligned}
$$

Health risks

(single representative agent)

- Keep it simple!
- proportion *p* (a few %) of those infected will need intensive health intervention, *those who receive it* are assumed to survive with probability ~50%, otherwise they die.
- only a fraction *h* of the population can be accommodated in intensive treatment: UK is about 7 per 100,000 (many are usually occupied!)
- In multi-agent variants of these models triage might be assumed to consign vulnerable groups to the end of the queue

Assumptions

- Mean field
- Single representative agent (no game theoretic arbitrage)
- No hidden immunity

Parameterisation

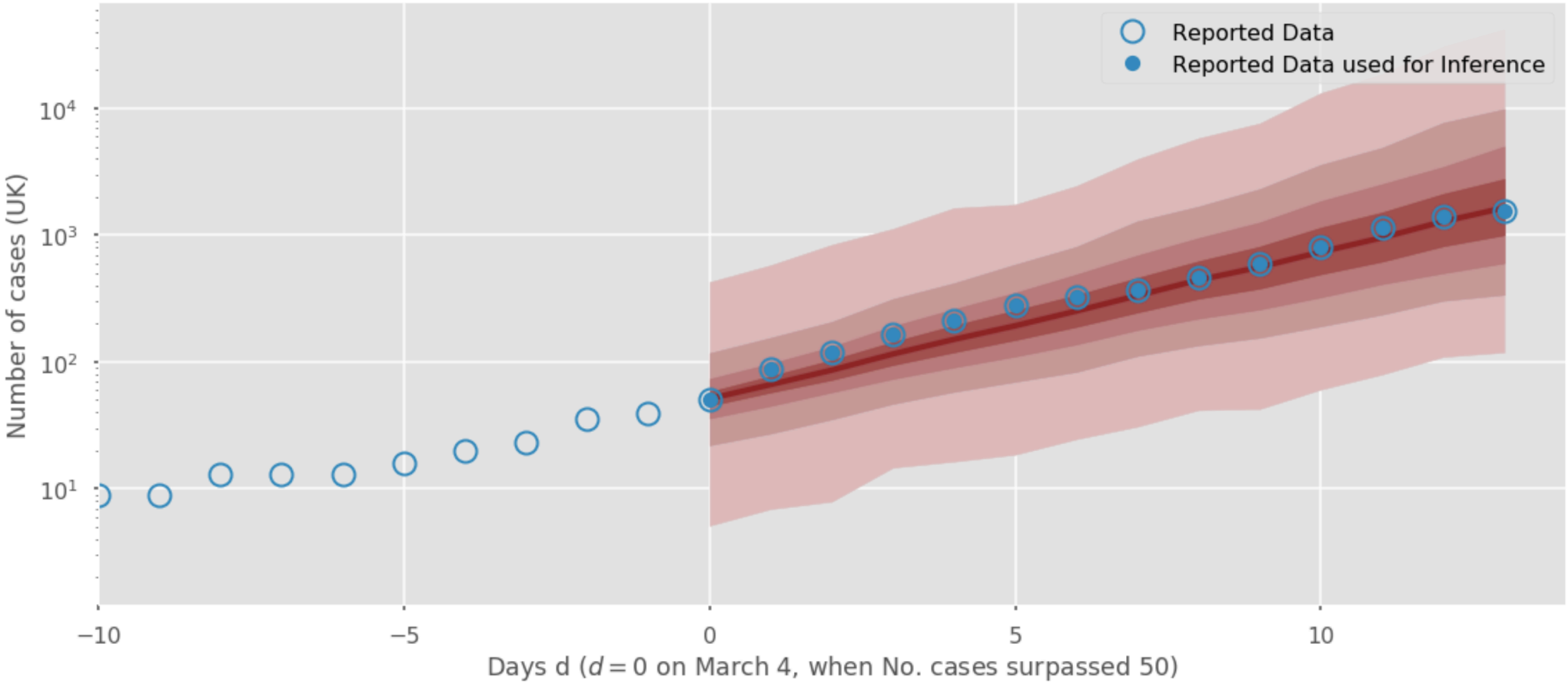
(i) use others' fits!

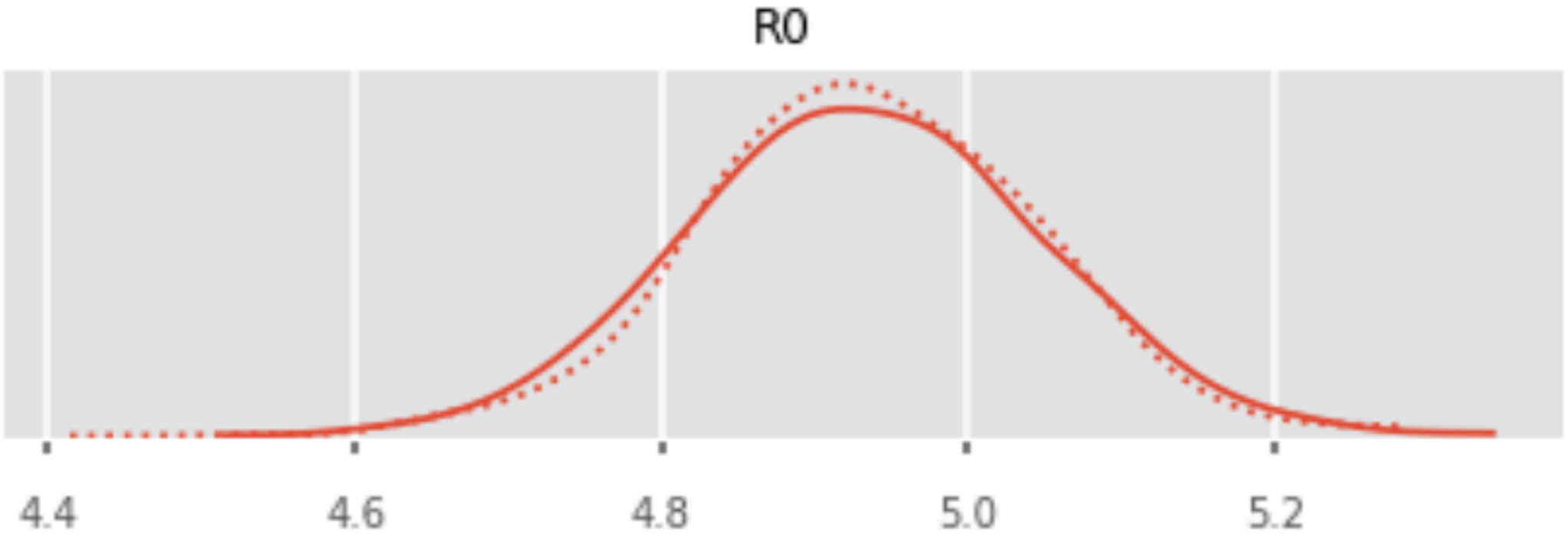
$$\tau \sim 5 - 7 \, \text{days}$$

$$R_0 = \kappa \sim 3 - 5 \quad \text{UK}$$

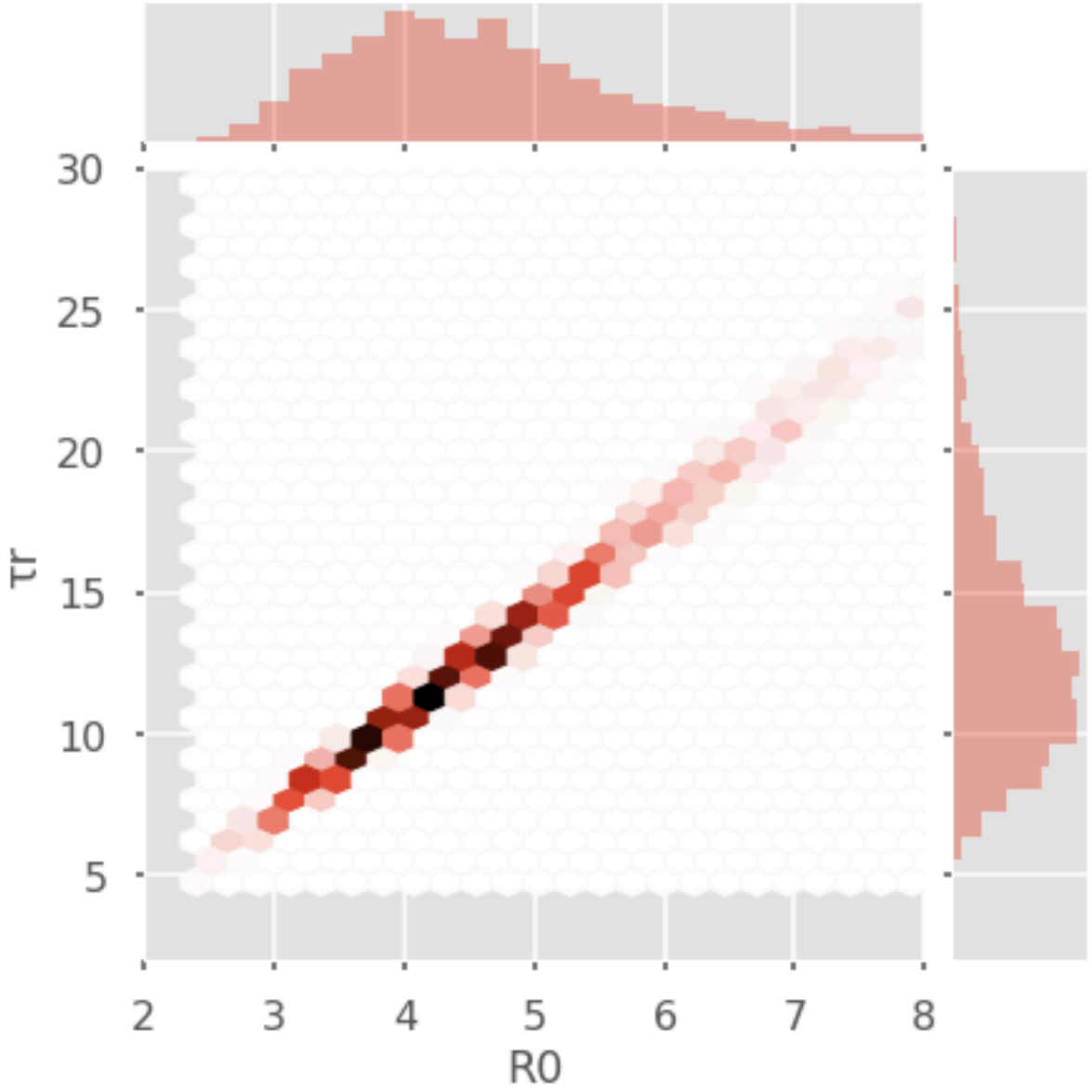
$$R_0 = \kappa \sim 1 - 2 \quad \text{Japan}$$

(ii) use a Bayesian approach (John Molina)

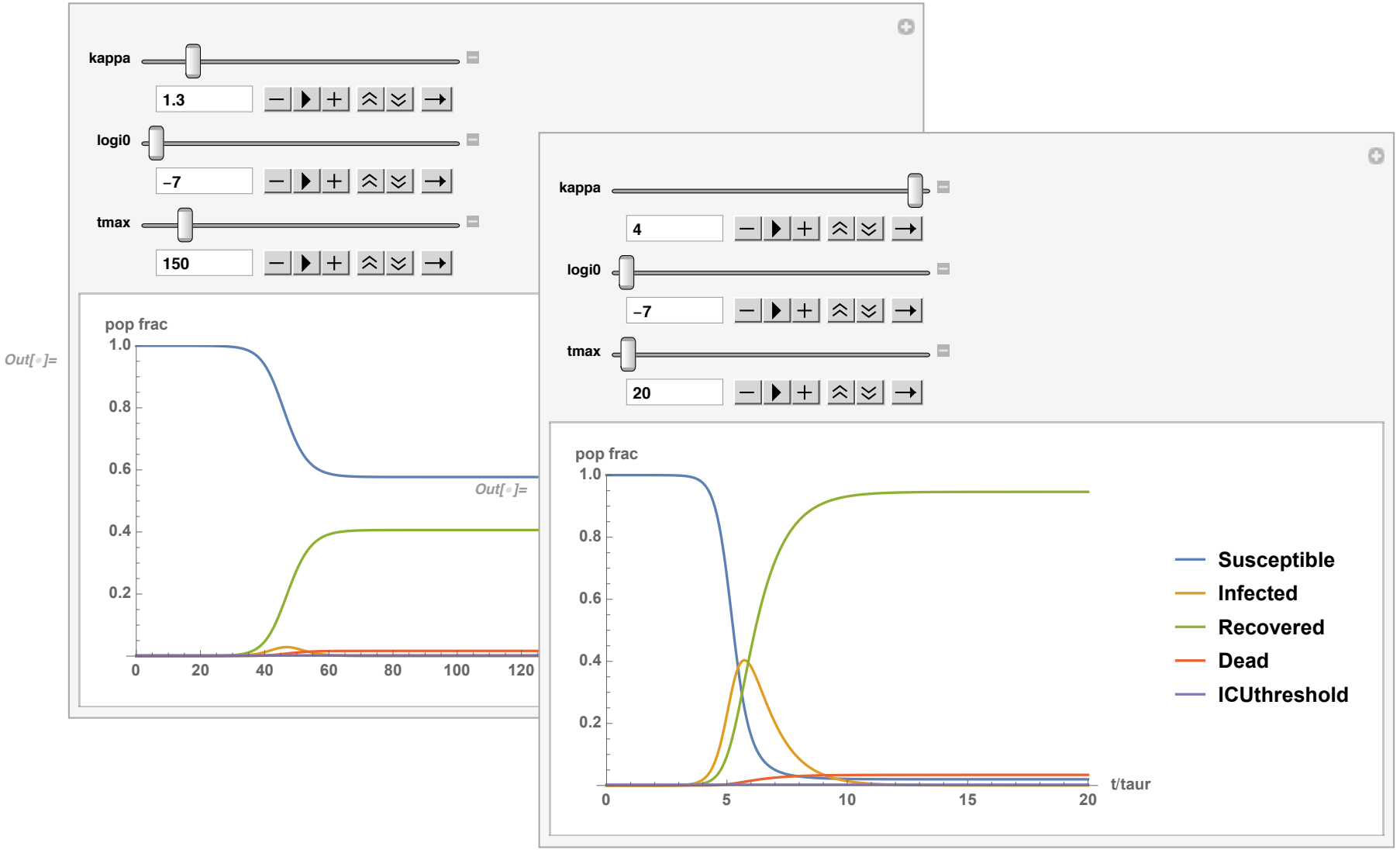

Reported Data
Reported Data used for Inference
Number of cases (UK)
10^4
10^3
10^2
10^1
−10
−5
0
5
10
Days d ($d = 0$ on March 4, when No. cases surpassed 50)


R0
4.4
4.6
4.8
5.0
5.2

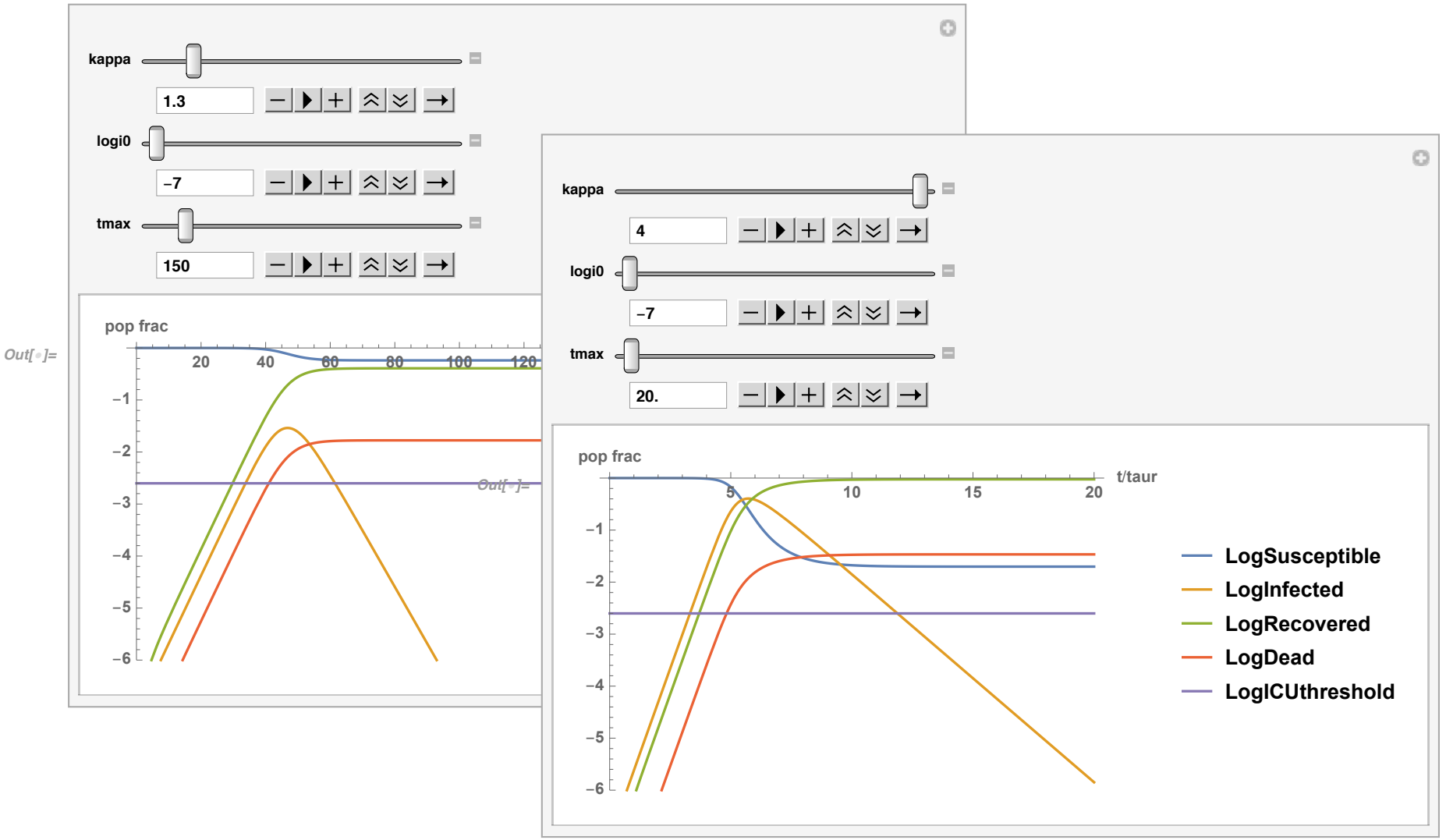
Posterior distributions



SIR dynamics (linear scale)



SIR dynamics (log_{10} scale)



Some important numbers (i)

If… we *somehow* engineer infectivity κ so that infected cases stick to a nominal healthcare threshold

$$i = h/p \sim \frac{10 \times 10^{-5}}{4\%} \sim 2.5 \times 10^{-3}$$

Then… we get the epidemic over as quickly as possible while not over-stressing the NHS.

This equates to a time

$$t \sim \tau s/i \sim \tau p/h \sim 2000\,\mathrm{days}$$

obviously h is important!

Some important numbers (ii)

$$
\begin{aligned}
\dot{s} &= -s\kappa i \\
\dot{i} &= (s\kappa - 1)i \\
\dot{r} &= i[1 - \omega(i)] \\
\dot{d} &= i\omega(i)
\end{aligned}
$$

when this is all over “herd immunity” can, at best, protect an uninfected fraction $s = 1/\kappa$

$$s_\infty = 1/\kappa$$

- This is small. Most people will become infected*
  - We would probably agree that this small fraction should be the vulnerable
    - …that requires the rest of us to catch it!

*unless

(i) substantial & permanent behavioural changes: $\kappa \approx 4 \rightarrow \kappa \approx 1$
(ii) effective contact tracing *a la* S Korea: ~~SIR~~
(iii) lockdown to $\kappa \lesssim 1$ until a vaccine
(iv) hidden immunity

Vaccine timeline

We are talking at least a year before a vaccine will be available.

Mike Ryan, executive director of the WHO's health emergencies program

It will take at least a year to a year in a half to have a vaccine we can use

Anthony Fauci, director of the US National Institute of Allergy and Infectious Diseases (NIAID)

No absolute assumption can be made that a vaccine will appear at all

Dr David Nabarro, Professor at Imperial College London & special envoy to the WHO on Covid-19

Economic "Discount" times on epidemic cost ~ year(+)

Utility theory for decision making

Individual-level utility

$$U = \int_t^{\infty} f^{t-t'} \left(-\alpha(\dot{d}(t')) + \beta(\dot{s}(t')) - \gamma(\kappa, \kappa^\star) - \varepsilon(\kappa) \right) dt'$$

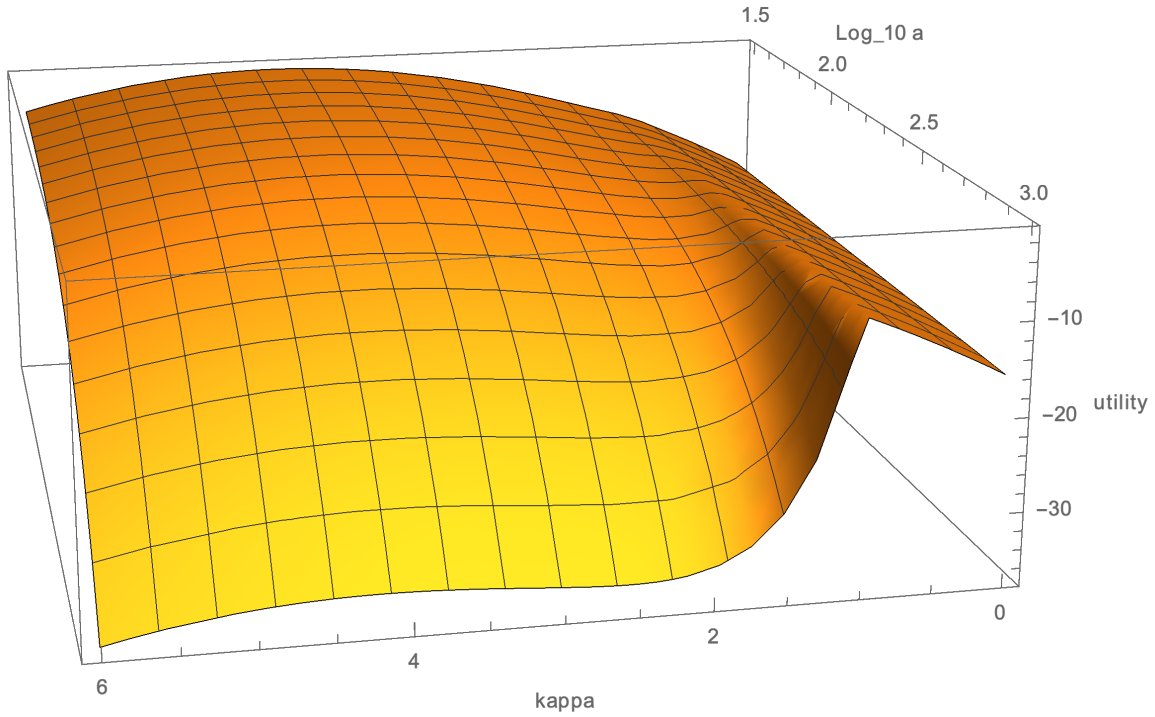
$$U = \int_t^{\infty} f^{t-t'} \left(-a\dot{d}(t') + b\dot{s}(t') - (\kappa - \kappa^\star)^2 - \epsilon\,\kappa \right) dt'$$

$$U = \int_t^{\infty} f^{t-t'} \left(-a\dot{d}(t') - (\kappa - \kappa^\star)^2 \right) dt'$$

$$U = \int_t^{T} \left(-a\dot{d}(t') - (\kappa - \kappa^\star)^2 \right) dt'$$

Utility surface (constant κ)

$$U = \int_t^T \left(-a\dot{d}(t') - (\kappa - \kappa^\star)^2 \right) dt'$$



Utility at constant κ

$$U = \int_t^T \left(-a\dot{d}(t') - (\kappa - \kappa^\star)^2 \right) dt'$$

$$U \sim -ad(T) - (\kappa - \kappa^\star)^2 T$$

Costs per person: death ~ £10^5 *difference* in death rate fast/slow ~few%

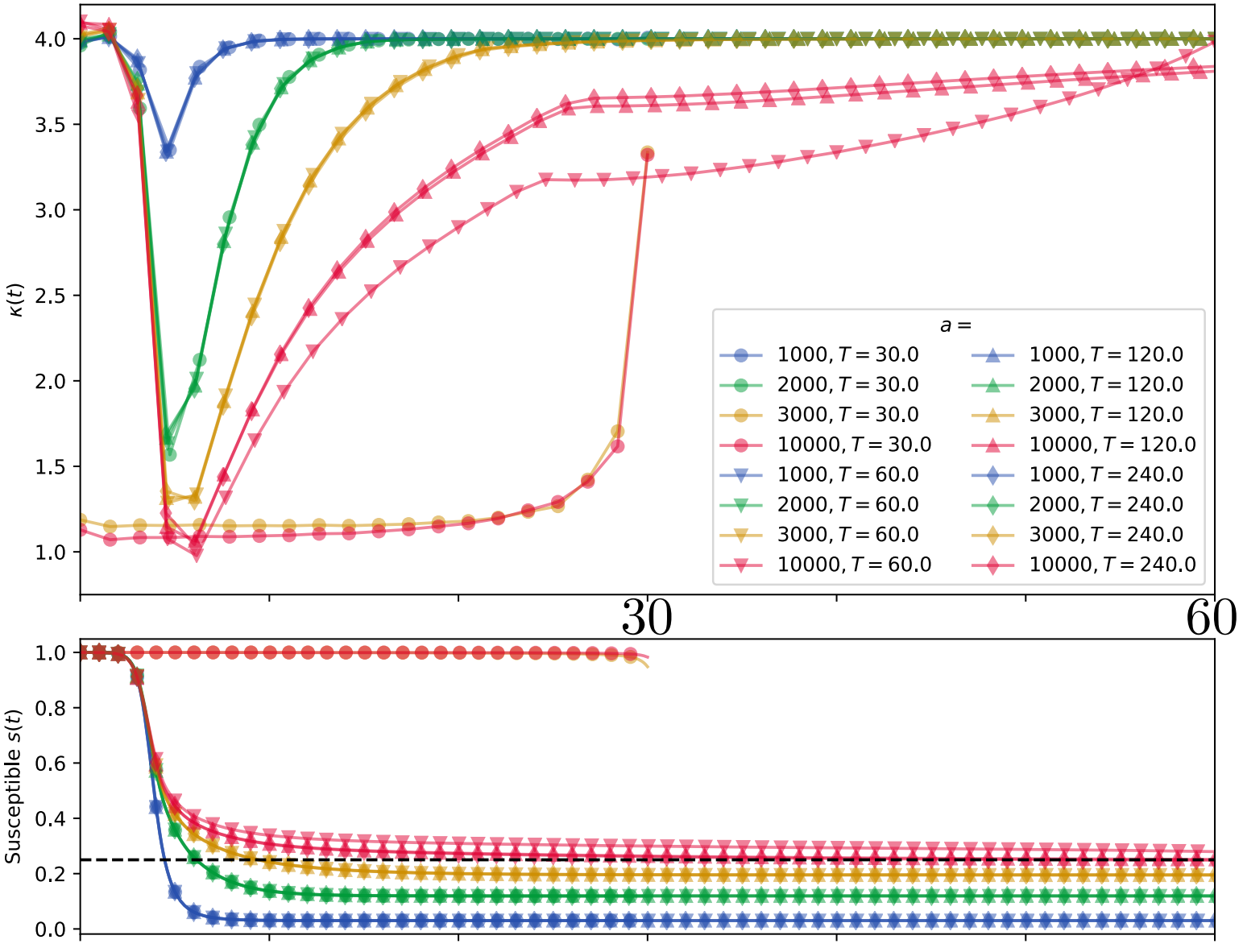
loss of freedom/salary ~ £10^4 per year

Challenging to parameterise a utility under which an "rational economic agent" would chose the $\kappa \approx 1$ branch

Utility a functional of $\kappa(t)$

$$U = \int_t^T \left(-a\dot{d}(t') - (\kappa - \kappa^\star)^2\right) dt'$$

(Simon Schnyder)



Utility with government field

$$U = \int_t^{\infty} f^{t-t'} \left(-a\dot{d}(t') + b\dot{s}(t') - (\kappa - \kappa^{\star})^2 - \varepsilon(\kappa) \right) dt'$$

Its likely that <u>this</u> is controlling behaviour

Role of media somewhat ambiguous in classical economic theory

How is the Government choosing this field?

Government-level “utility”

$$U_{\mathrm{gov}} = \int_t^{\infty} f_g^{t-t'} \left(-\alpha_g(\dot{d}(t')) - \beta_g(i(t')) - \gamma_g(\kappa, \kappa^\star) - \varepsilon_g(\kappa) \right) dt'$$

Some $\kappa(t)$, also an extremum of *U* at the individual level, extremises this!

α_g ?

γ_g ~10’s % of GDP

β_g The government apparently cares very much about NHS load

…politics dominant

Role of media unambiguous in classical political theory!

Summary

- Important we can talk about science unhindered by Orwellian “newspeak”
- Personal decision-making is highly sensitive to intervention
- What “utility” is, or should, the government be seeking to maximise?
- How does uncertainty enter? Is there a thermodynamic analogy?
- Ironically, might it even be that alternative political/media environments are better able to make rational decisions under these circumstances?

Acknowledgements

- Simon Schnyder Fellow, Fukui Institute, Kyoto
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- Ryoichi Yamamoto, Dept Engineering, Kyoto University

Crisis

danger(ous)

opportunity

Exclusive: Government scientist Neil Ferguson resigns after breaking lockdown rules to meet his married lover

Prof Ferguson allowed the woman to visit him at home during the lockdown while lecturing the public on the need for strict social distancing

By Anna Mikhailova, DEPUTY POLITICAL EDITOR; Christopher Hope, CHIEF POLITICAL CORRESPONDENT; Michael Gillard *and* Louisa Wells

5 May 2020 • 7:17pm

Neil Ferguson and Antonia Staats

The scientist whose advice prompted Boris Johnson to lock down Britain resigned from his Government advisory position on Tuesday night as The Telegraph can reveal he broke social distancing rules to meet his married lover.