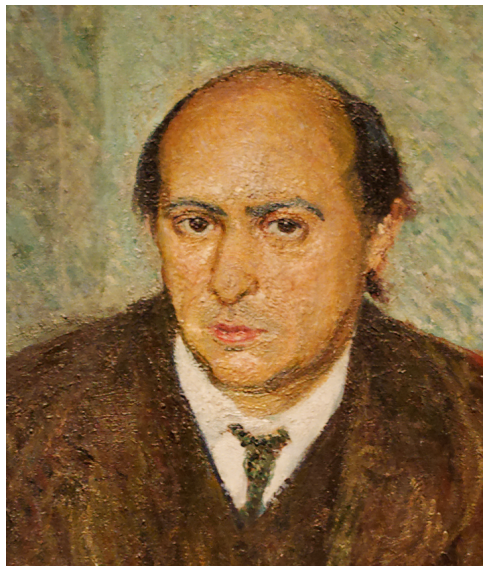
Some statistical aspects of the Covid-19 response

Simon Wood, Ernst Wit, Paul McKeigue, Danshu Hu, Beth Flood, Lauren Corcoran and **Thea Abou Jawad**

University of Edinburgh, U.K.
Svizzera italiana, Lugano, Switzerland.



10th April 2020 — 5 years on

10th April is the fifth anniversary of the day Covid deaths, ICU occupancy and mechanical ventilator use had all **peaked**.

This was not exactly what the policymakers expected:

> *182. E.g This photo shows a hard copy of the actual graph shown to the PM on 24/3* . . . given we'd ditched Plan A *(***peak** *around* **15-20 April** . . . *)*

— Dominic Cummings' STATEMENT OF EVIDENCE TO COVID INQUIRY 11/10/23

In this context, a week is a long time

– but the discrepancy goes unremarked.

This is not the only place where the data did not agree with Covid models, policy or narrative.

"Entertaining, illuminating and — when you recognize yourself in the stories it tells — mortifying." — *Wall Street Journal*

MISTAKES WERE MADE (but not by *me*)

WHY WE JUSTIFY FOOLISH BELIEFS, BAD DECISIONS, AND HURTFUL ACTS

UPDATED, WITH A NEW CHAPTER:
"DISSONANCE, DEMOCRACY, AND THE DEMAGOGUE"

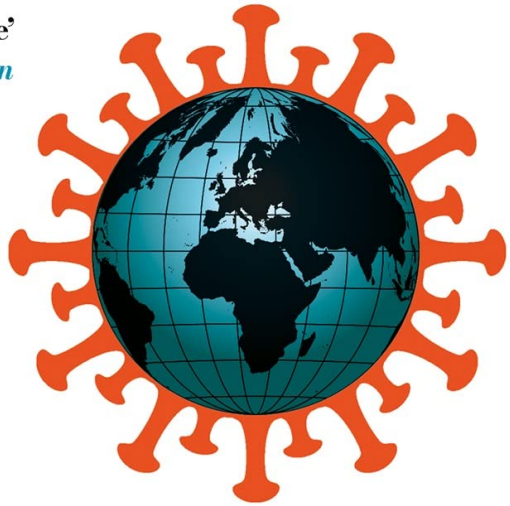
Carol Tavris *and* Elliot Aronson

TOBY GREEN
THOMAS FAZI

'A unique take'
New Statesman

'A bracing polemic'
LRB

'Brave, measured, essential'
El País



THE COVID CONSENSUS

The Global Assault on Democracy and the Poor – A Critique from the Left

Avoiding false dichotomies

Some "disappointing dichotomies" (Senn, 2003) of Covid pandemic:

Lockdown	vs	'do nothing'
Pro-lockdown	vs	'Covid denier'
'Protect the NHS'	vs	'NHS Collapse'
Saving life	vs	saving the economy
For universal vaccination	vs	'antivax'
Pro-SAGE	vs	'anti-science'
recession	vs	no recession
...		

Perhaps Fitting reality to the model vs Fitting the model to reality is a useful dichotomy, but this paper...

is concerned less with binary absolutes than with **degree**.

For example: Life is non-binary

When life is so multi-dimensional,
What units should loss-of-life be measured in?

There is no perfect answer, but...

- *years* is a unit that tends to align with **fairness**
- ... and far better than binarizing, alive or dead.

So we will tend to talk about years of life lost.

- By May 2023, Covid had been implicated in deaths of at least 0.1% of World's population.
- That is a life loss of about 3 days per capita.

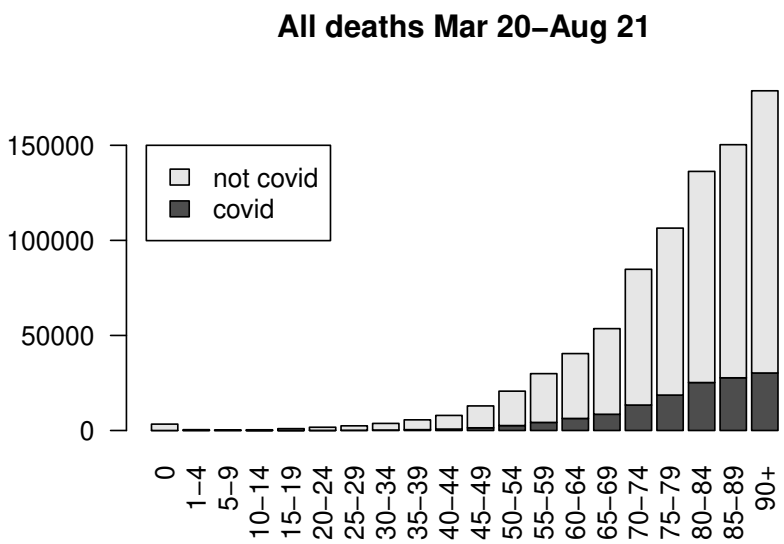
People react differently to 2 preceding figures: **units matter.**

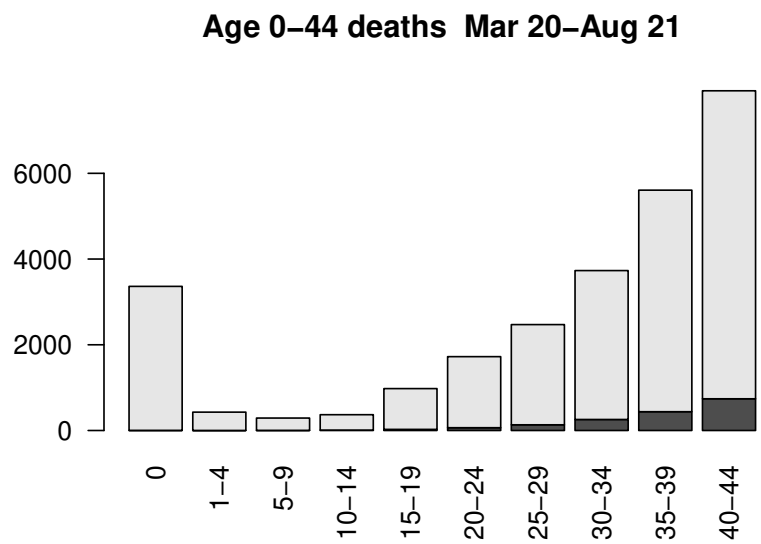
I. Exaggerated Risk Presentation

Covid risk presentation — early 2020

> *. . . a substantial number of people still do not feel sufficiently personally threatened; it could be that they are reassured by the low death rate in their demographic group. . .* **the perceived level of personal threat needs to be increased** *among those who are complacent, using hard hitting emotional messaging.*

– Scientific Pandemic Influenza Group on Behaviour (SPI-B), 22/3/2020.





Perceived threat level increased!

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As business bigwigs fight to end lockdown, the hero fending them off is ... Boris Johnson?

Joel Golby

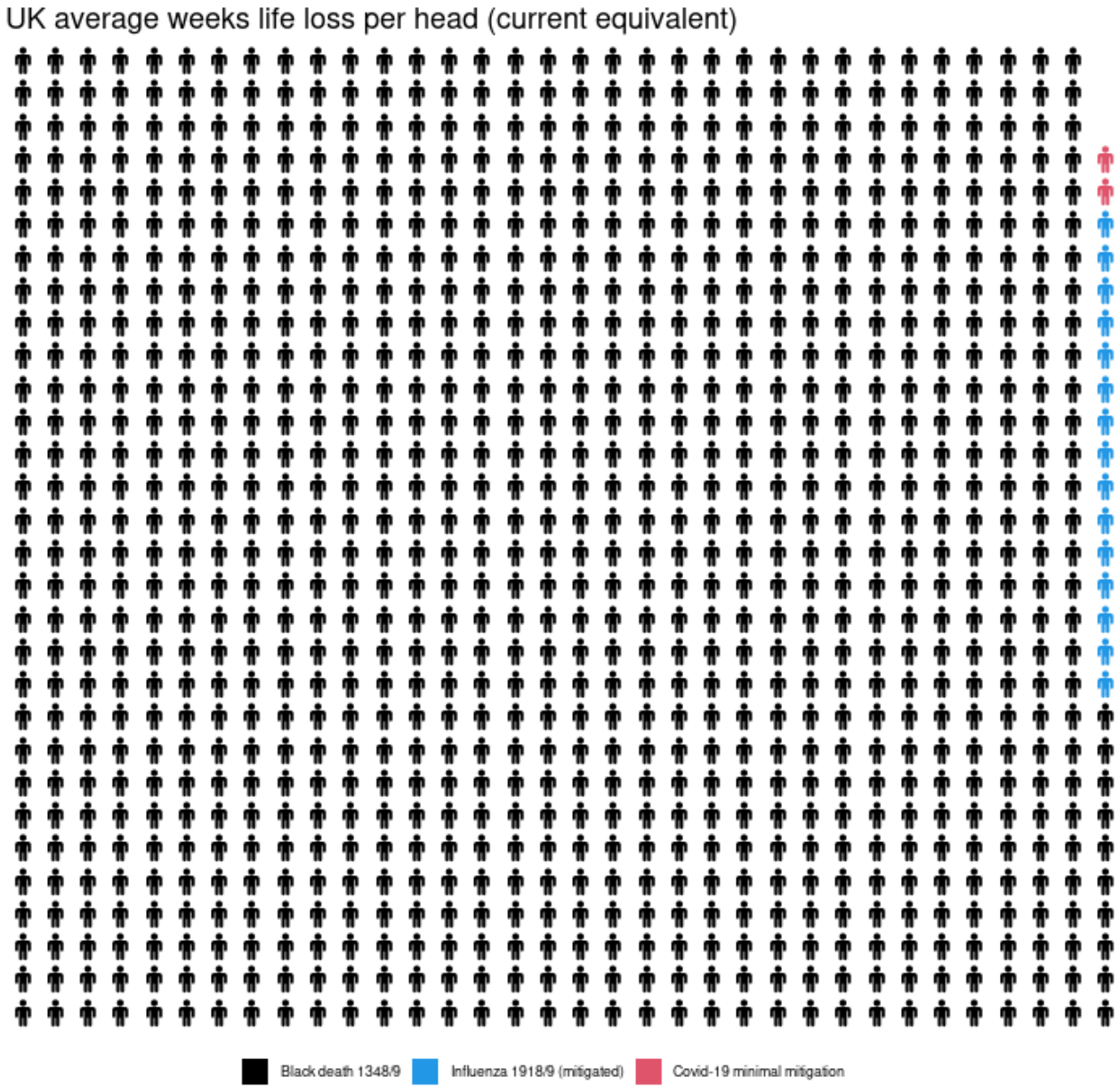
One fact I always used to repeat a lot when I was boring people in the pub - a treasured memory from a life I had 100 years ago - was the Black Death inadvertently led to the creation of the middle class. Peasants were overwhelmingly affected by the spread of the disease, population numbers dwindled, a recovering economy of landowners v workers evened the odds for those who ploughed the land, and the savviest among the survivors negotiated pay rises and land of their own in exchange for their services.

• • •

I can't help but feel that history won't quite repeat itself this time: if we "open up the economy" to help Tory grandees make money again, there won't be much economy left once the second wave of infections has finally settled down, because all the Topshops will have to be razed to make space for graves. Essentially: what's the point in being rich if there is no one left

27/4/2020. Actually arguing that Covid is *worse* than the Black Death.

Comparison with Black Death based on data



“Worst pandemic for a century”

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THE NEW STATESMAN

UK Edition

All Sections | Politics World Culture Ideas Long Reads Environment Business State of the Nation Spotlight Magazine

Science & Tech > Coronavirus | 24 January 2022

Why it’s a dangerous myth to claim that only 17,000 people died of Covid

If Covid-19 was not primarily responsible for the deaths of coronavirus patients, why did the UK suffer the highest number of excess deaths since the Second World War in 2020? Some may contend that an unusually high number of people with pre-existing conditions suffered unusually bad luck that year. But a more plausible explanation is that the worst pandemic for a century was responsible. Indeed, the estimated number of excess deaths during the pandemic – 151,000 – is strikingly close to the UK’s official Covid-19 death toll.

‘Worst pandemic’ only if old white straight lives matter more. WHO puts the AIDS death toll at 27-48 million. The life year loss per victim much higher than Covid. But UK pandemic excess deaths *were* above 1968/9 influenza.

Later 2020: Long Covid risk after mild illness

What is known:

- Serious pneumonia likely to have long term health consequences.
- Post viral syndromes are real (and bound to rise with new virus).

But evidence for an **exceptional** risk from Covid was weak:

1. Vague definition of syndrome.
2. Non representative samples of convenience.
3. Lack of control groups.
4. Low response rates, high and differential dropout.

Example: NICE 2022 definition of long COVID syndrome...

> *Signs and symptoms that develop* **during or after** *an infection* **consistent** *with COVID-19, continue for more than 12 weeks and are* **not explained by** *an alternative diagnosis.*

Good study example: Ballering et al. 2022

Properly conducted prospective cohort study:

- 381/1,782 had $\geq$ 1 symptom 90-150 days post Covid.
- 361/4,130 had $\geq$ 1 symptom 90-150 days post control event.

Initial Covid cohort size 4231,

- participants knew what the trial was about, of course.
- So dropout could have been informative.

Symptoms from *somatisation* subscale of Symptom-90 questionnaire:

- i.e. physical symptoms often caused by psychological stress.
- Blinding impractical.

Even ignoring these problems, cannot tell if non-hospitalized Covid patients had excess of any symptoms except loss of smell/taste.

Long Covid conclusions

Besides loss of taste or smell, **careful studies** tended to show

- low rates of persistent symptoms after mild Covid.
- self-reported long Covid at 5-10 times rate actually associated with having had Covid (ONS).

. . . but public messaging **stressed** risk of long Covid after mild illness.

Again, that there was exaggeration does not imply ‘no problem’

- ONS data imply up to 80 thousand economically inactive from long Covid,
- but for comparison, around 600 thousand inactive for each of musculoskeletal disorders and mental disorders.

II. Downplayed economic risks

Data distorted and downplayed: economic impacts

FINANCIAL TIMES

FRIDAY 8 MAY 2020 NEWS PROVIDER OF THE YEAR

Body of knowledge Head-to-toe Covid-19 symptoms challenge science

Britain on brink of worst recession since great frost of 1709, BoE warns

Bailey defends stimulus effort • Banks urged to keep lending • Ministers damp lockdown hop

CHRIS GILES — ECONOMICS EDITOR

The Bank of England has forecast that the coronavirus crisis will push the economy into its deepest recession in more than three centuries, with output plunging almost 30 per cent in the first half of the year.

The central bank predicted that output would slip 3 per cent in the first quarter and sink a further 25 per cent in the second, creating the fastest and deepest recession since the "great frost" of 1709.

Despite the dire warnings, the bank did not launch new stimulus measures. Andrew Bailey, the BoE governor, defended the decision, saying "aggressive" measures announced in March to spend £200bn on government bonds had yet to be exhausted. "We have made very clear commitment to do what it takes to support the economy consistent with the inflation target," he added.

The economic forecasts came as the government said next week's easing of social distancing rules would be "very modest" as it set out to damp expectations from the public.

Both death figures still rising sharply as health department said a further 596 people had died from the virus, the total to 30,615 – any loosening of the rules is expected to be minor, with allowing unlimited exercise and sitting in parks, and permitting businesses to reopen where social distancing is observed. Prime minister Boris Johnson is also expected to announce that schools will have three weeks to prepare for a possible "phased return".

The BoE's economic projections, which predict a 14 per cent annual contraction in GDP for 2020, included a warning that Britain's banks not to stem the economic damage by restricting lending.

The BoE governor said a failure to lend would risk a vicious cycle of more bankruptcies, higher loan losses hitting the banks themselves. He said: "The better way for banks is to keep lending . . . we will get this message home. If the banks ... ensures a good supply of loans], the better outcome." Commercial banks responded, saying they were committed to lending. Alison Rose, NatWest chief executive, said the bank would provide "our customers, communities and colleagues with the support they need". Jes Staley, Barclays chief executive, pledged that his bank would emerge with "a reputation as having stood with the citizens of Great Britain in this time of crisis".

But the BoE cautioned that, even with adequate lending, the economy would take a big hit; household spending has plunged about 30 per cent since March.

The central bank also forecast that inflation would dip to 0.5 per cent in 2021, before returning to its 2 per cent target the following year.

In contrast to the gloomy assessment of the current economic position, long-term projections were more upbeat, with the BoE predicting a V-shaped recovery and "only limited scarring to the economy". Mr Bailey said the rebound was likely to happen "much more rapidly than the pullback from the global financial crisis".

The BoE also tested whether the financial system could cope with the expected once-in-a-century recession. It assessed that banks would lose less money than in its latest stress test and concluded that "the core banking system has capital buffers more than sufficient to absorb losses".

It did, however, stress that the pandemic would severely hit corporate cash flow. The bank said that while UK companies normally operated with a cash flow deficit of £80bn, the crisis would raise that to £190bn.

Government support would plug some of the gap, but there remained a £60bn additional deficit that banks would need to cover to stop viable businesses from going under.

Additional reporting by Laura Hughes and George Parker in London

Inside Page 3

- Economists dispute Bank of England's predictions of V-shaped recovery
- Banks strong enough, says Bailey
- Johnson cautions over lockdown easing

2020 will compare with past recessions such as the great frost era, when markets were held on an icy Thames

Cold comfort

Annual falls in real GDP of more than 4.5 per cent (%)

1703 1705 1706 1709 1710 1729 1737 1808 1816 1826 1919 1920 1921 1931 1945 2020

0 -5 -10 -15

2020 = BoE 'illustrative scenario'

Source: Bank of England

Virgin Media and O2 seal £31bn deal to forge sector-changing rival for BT

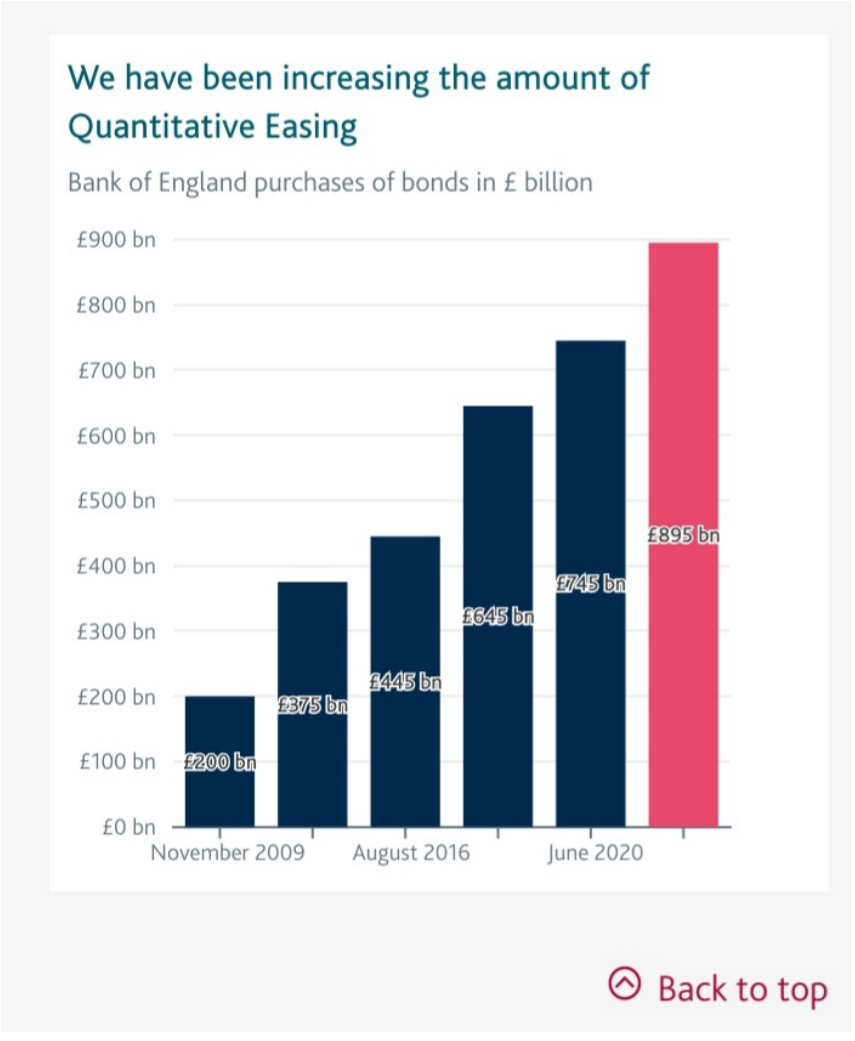
NIC FILDES AND ARASH MASSOUDI LONDON
JAMES FONTANELLA-KHAN — NEW YORK

The owners of Virgin Media and O2 have agreed a £31.4bn deal to combine coms sector by uniting the country's second-largest broadband network with its largest mobile network. It will create a business with £11bn in revenue and 46m customer accounts across mobile, broadband and pay-TV, while building a described the deal as a "game-changer in the UK".

Telefónica has been looking for a UK deal for a number of years. Its efforts have included trying to sell O2 to BT and agreeing a £10.3bn sale to mobile rival

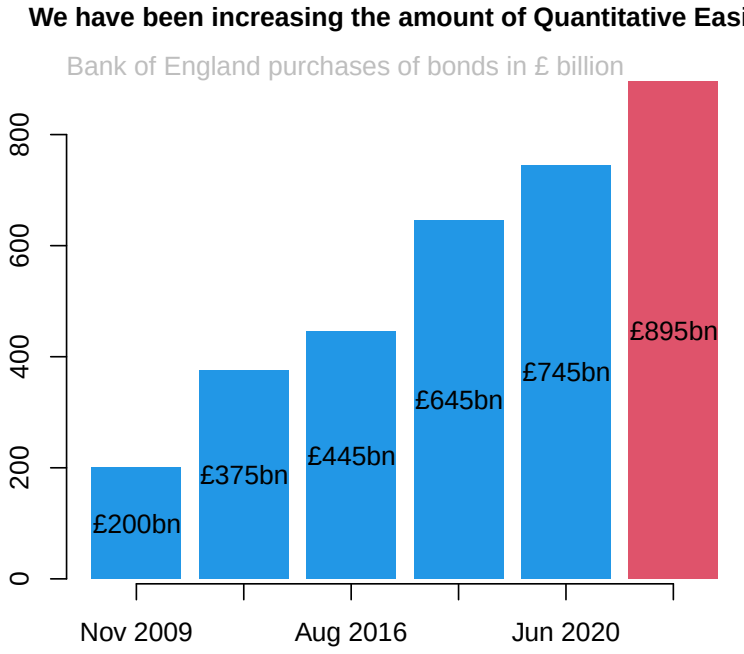
Ludwig Ferdinand Schnorr von Carolsfeld, detail from "Val d'Aymone with Mont Blanc," 1846

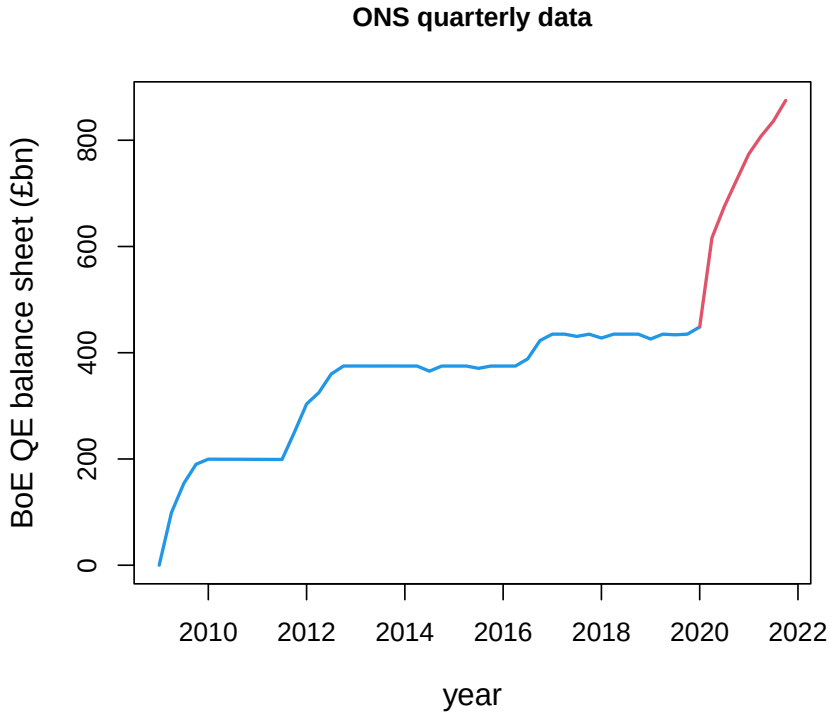
© LIECHTENSTEIN. The Princely Collections, Vaduz-Vie

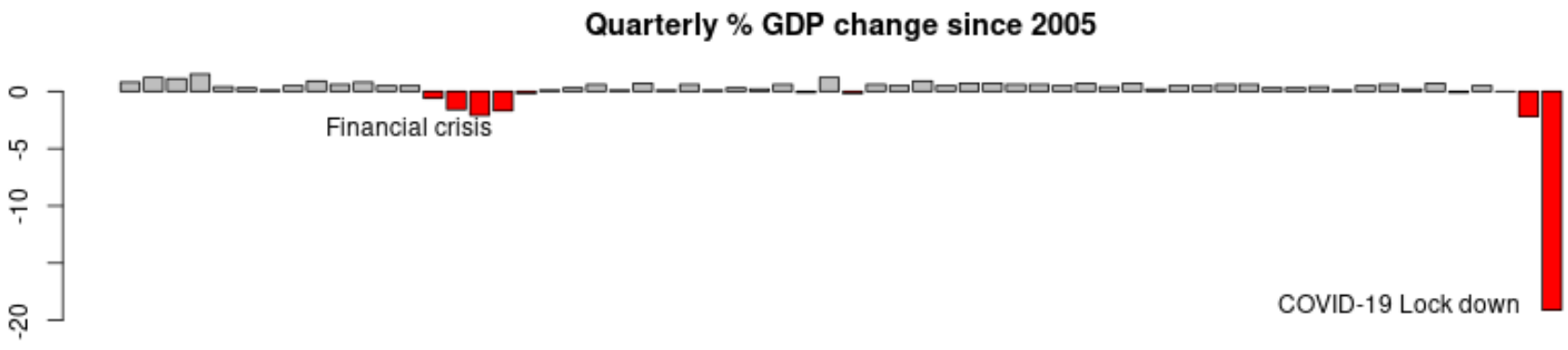


– from BOE website 2021.

QE undistorted and largest contraction in 300y







Saving life *versus* saving the economy?

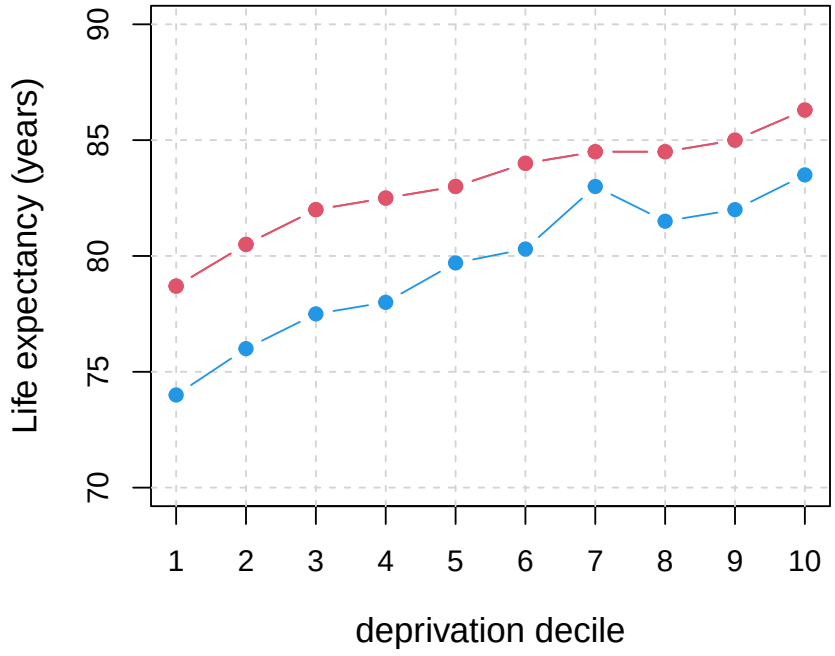
Marmot (2020, well before Covid hit):

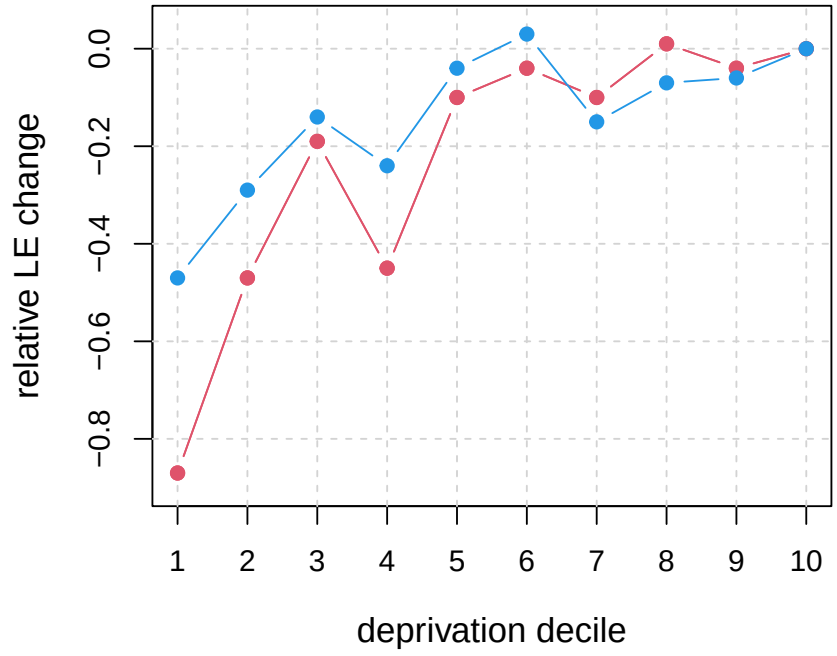
- Large UK life loss associated with economic deprivation/inequality.
- Loss increased after the economic shock of 2008 and response to it.

Economic shock from Covid response is largest for 300 years.

Our ability to avoid life loss from this shock is unclear.

Saving lives from Covid now or deprivation later?





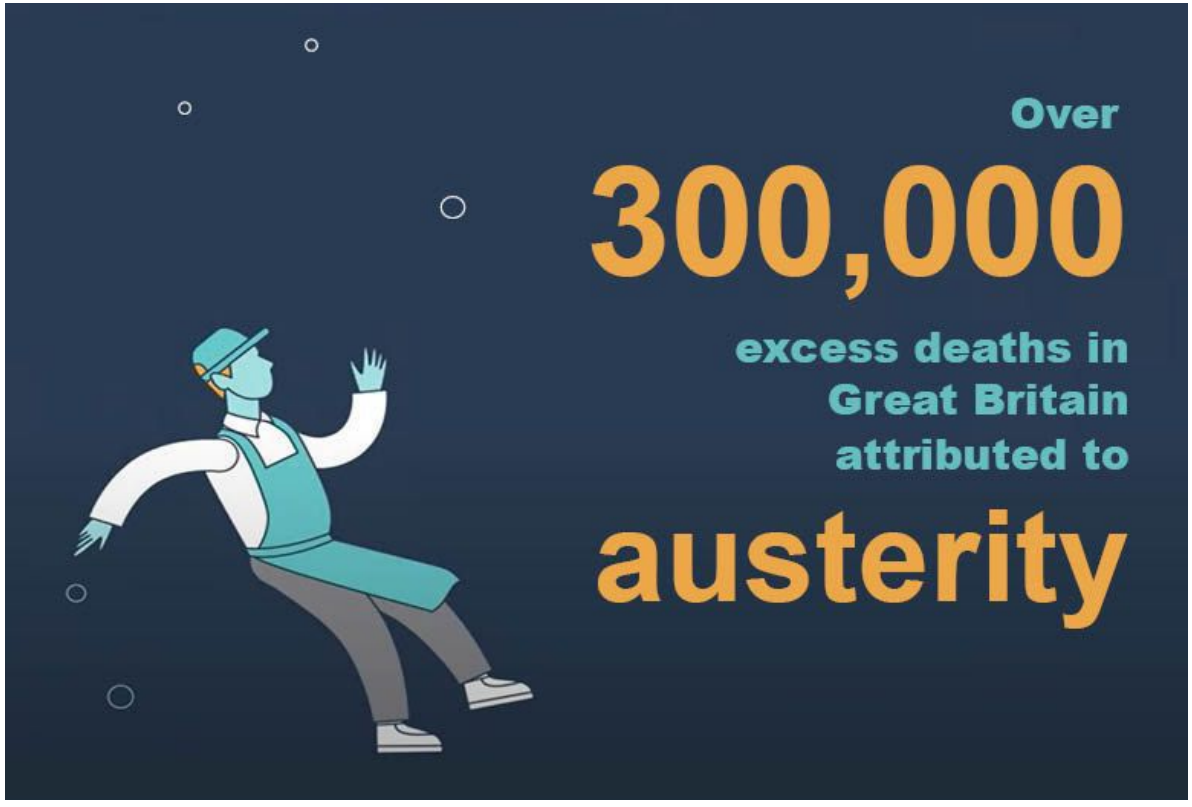
Left: LE vs area deprivation by population decile for women and men.

Right: LE change relative to not deprived, post 2008 crisis + response.

— a life loss increase of 9-12 Myears for current UK population.

— Why expect less from the Covid shock?

— ∼3 Myears life loss avoidable by measures, from early IC models.



III. Excess Deaths

Post hoc risk calibration: excess deaths

Strategy for calculating **excess deaths**:

1. Work out **expected deaths**

   if *things stay the same* as preceding 3-5 year reference period.

2. Excess deaths = actual deaths − expected deaths.

Post hoc risk calibration: excess deaths

Strategy for calculating **excess deaths**:

1. Work out **expected deaths**

   if *things stay the same* as preceding 3-5 year reference period.

2. Excess deaths = actual deaths − expected deaths.

Which *things stay the same*?

Conventionally: *deaths by week of the year*
Sometimes with statistical trend adjustment.

- Does not account for increasing deaths from population ageing.

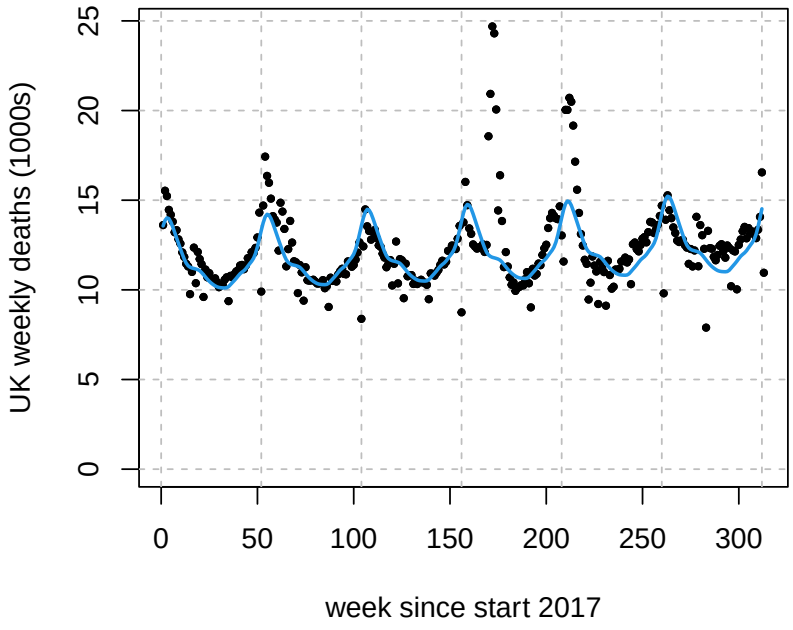
We argue: *age specific per capita death rates* (life tables)

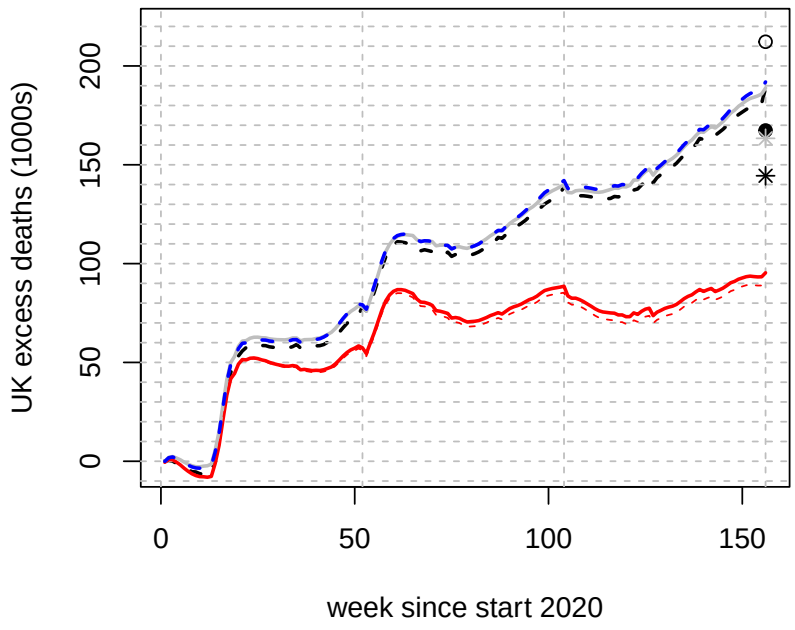
Just iterate the ageing and expected death process.

Constant life table excess deaths

Calculating expected deaths allowing population to age:

- Actual deaths exceed expected deaths during two waves, but
- ... cumulative excess deaths way below official ONS figure.

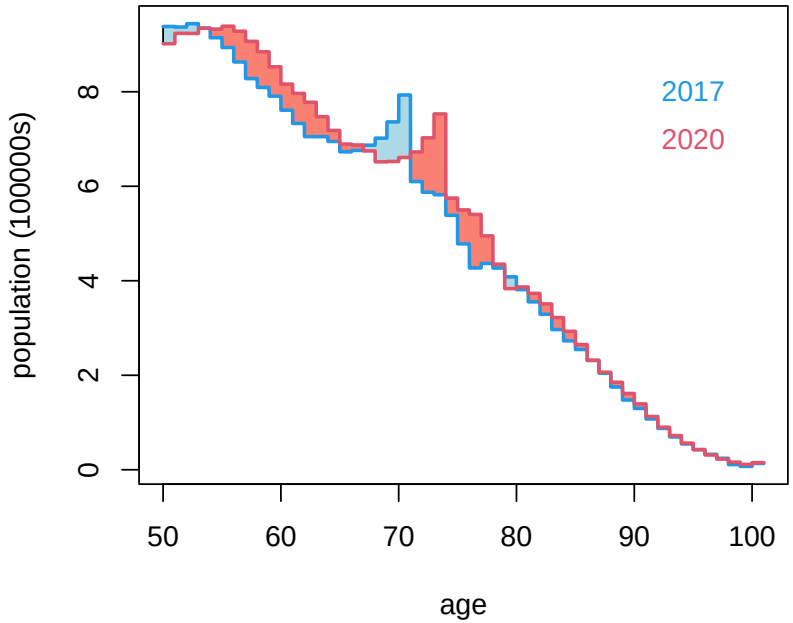


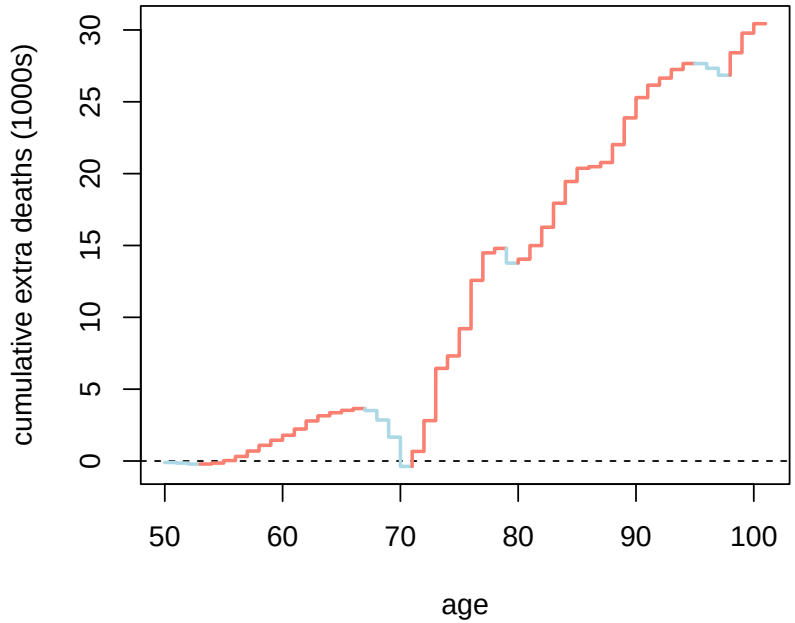


Note: There are about $640K$ deaths in the UK per year.
$90K$ is 20% above 1968/9 flu pandemic per capita.

Does ageing really make such a difference?

By 2017 the postwar baby boomers began advancing into their 70s





General population ageing (including boomers)

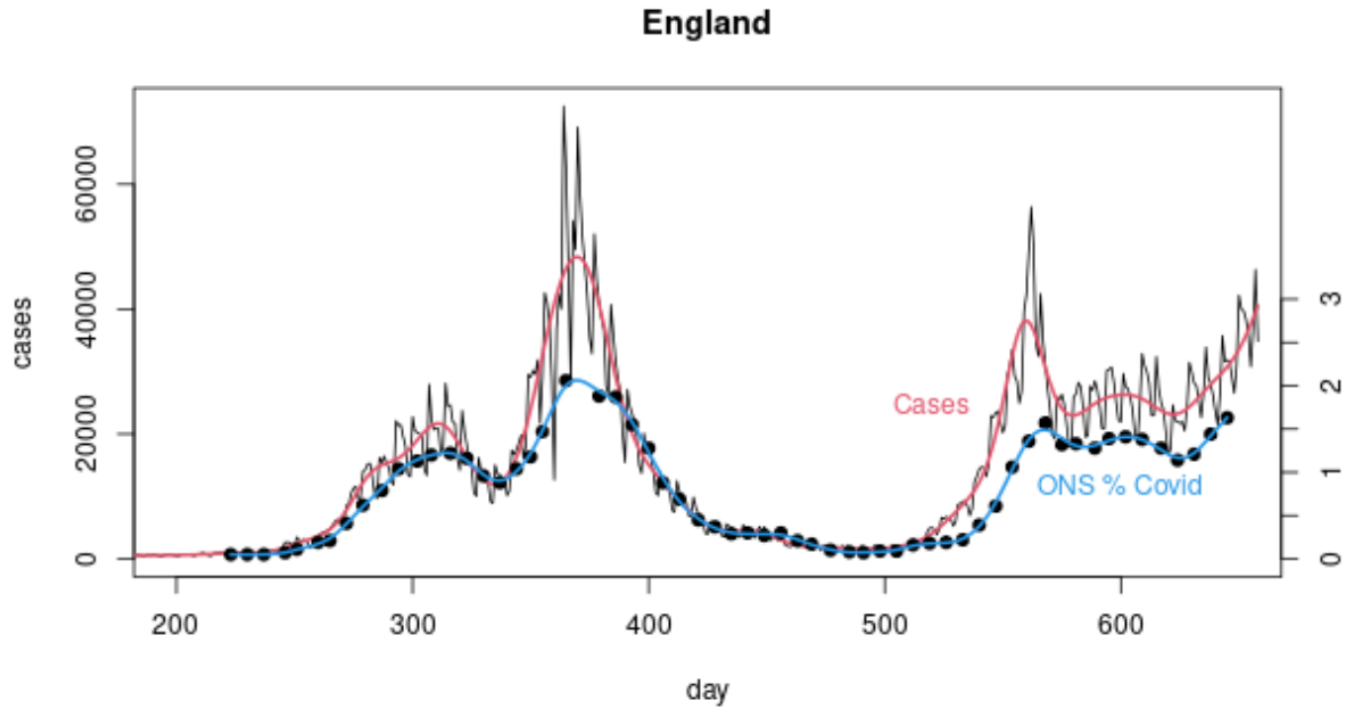
- would have caused 30K excess deaths per year,
- even *if death rates stayed same* (i.e. no Covid).

IV. Case against Case Data

Why the media and government focus on cases?

Basic question:

Of what population are **case data** a sample?



R closely related to rate of change of number infected

- *"cases reliable for R estimating over a short enough interval"*
- Inconvenient part of derivative then vanishes, or what?

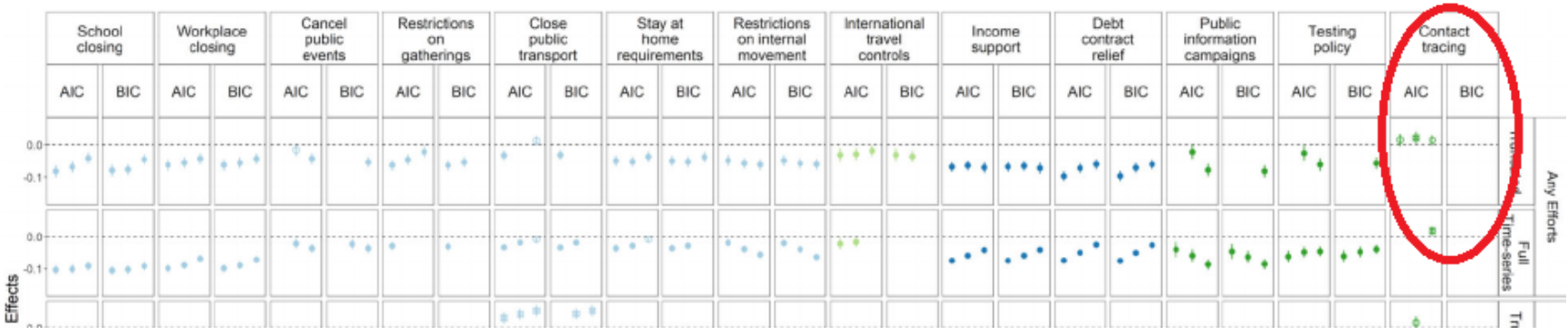
The case against case data II

Liu *et al. BMC Medicine* (2021) 19:40
https://doi.org/10.1186/s12916-020-01872-8

BMC Medicine

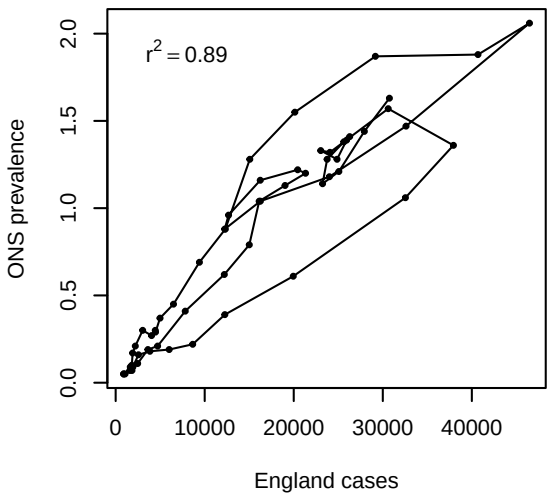
RESEARCH ARTICLE Open Access

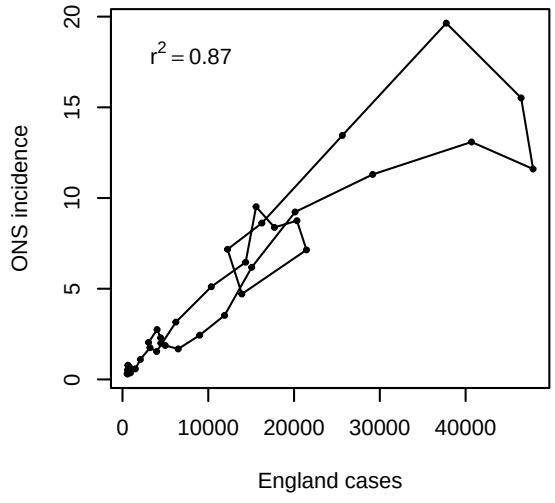
The impact of non-pharmaceutical interventions on SARS-CoV-2 transmission across 130 countries and territories

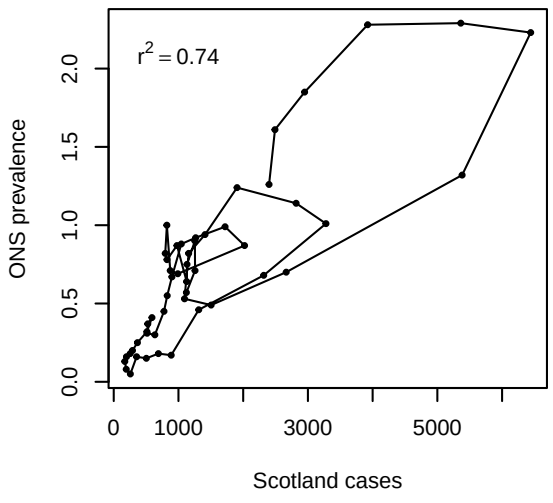


- Apparently test and trace *increases* R.
- R was estimated from case data.

‘But cases were highly correlated with prevalence’







— Cases were structurally off with respect to true prevalence.

V. Following the Science

Following the Science: fomites

Fomites a massive problem?

- Left sensible, right definitely not.

Fomites no problem?

- Left pointless, right might make sense if not outdoors.

Following the Science in Scotland

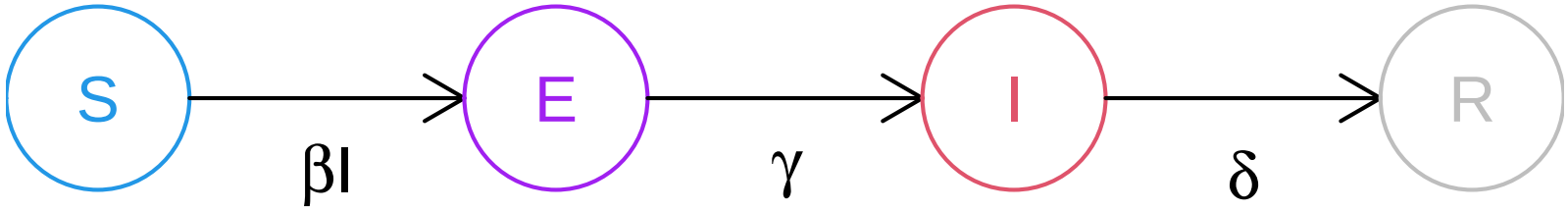
Scottish government advice:

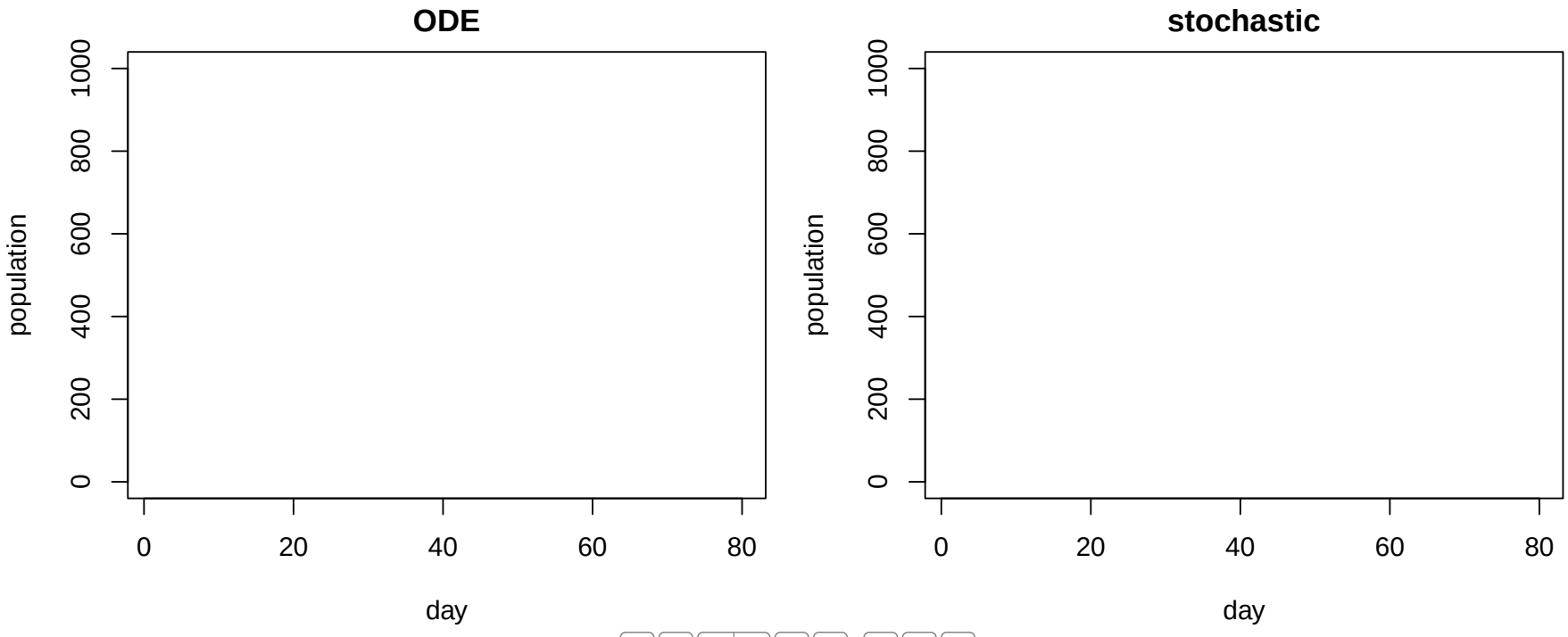
> *Scientific* **evidence** *and clinical and public health advice is* **clear** *that face coverings are an* **important** *part of stopping the spread of coronavirus.*

The cited scientific evidence:

> *. . . wearing a mask* **may slightly reduce** *the odds of primary infection with [Influenza-like illness] by around 6 to 15%*
>
> *. . . This was* **low-quality evidence**. . .

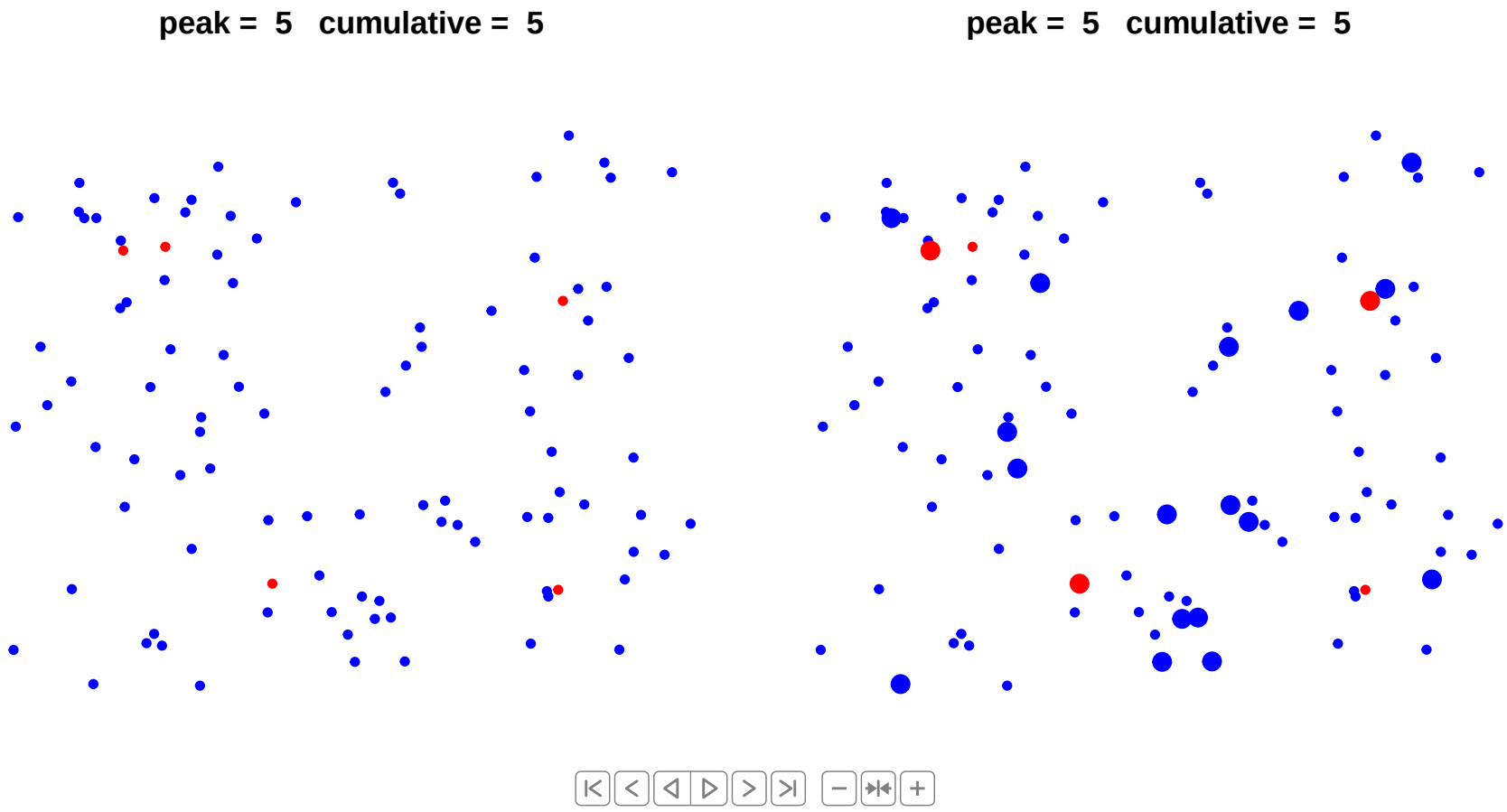
Following the Science: epidemic models





Heterogeneity matters in SIR processes

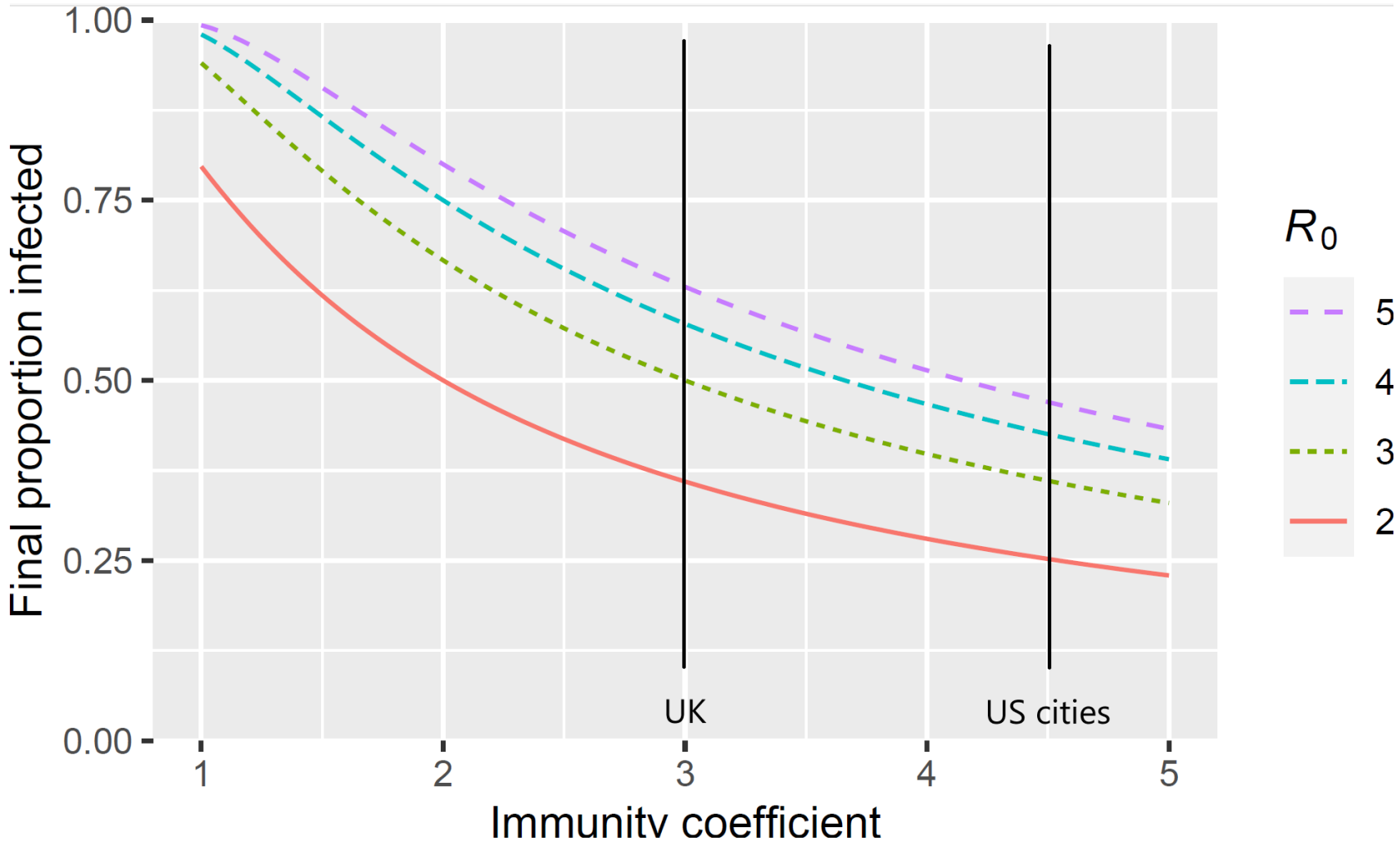
Same R_0 and average contacts per day. Healthy, infectious, recovered.



Homogenous contacts

Heterogenous contacts

Chance of being infected in a wave



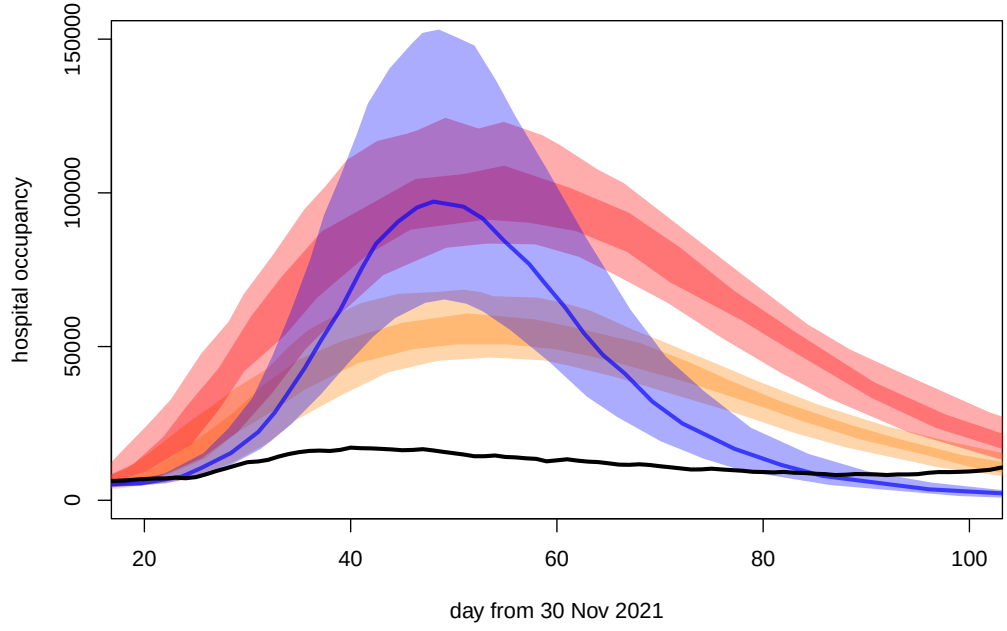
Other modelling omissions

1. Hospital acquired Covid: known to be a big problem from Wuhan and Lombardy.
2. Locked-down, Key-worker (low R, higher R) population strata.
   - R is average new infection *per infection*.
   - If lockdown effective, proportion of infections shifts to key workers over time post lockdown.
   - So after initial dip R must increase again.
3. Seasonal weather effects.
4. Non-mandated behavioural changes.
5. The negative consequences of policy scenarios (understandable but does not promote balance).

The most significant omission: validation for prediction

Models were never validated for predicting effects of interventions. . .

1. **Imperial Rep 12** projected $\approx 35K$ first wave deaths for a policy like Sweden's. $\approx 6K$ occurred.
2. December 2021 **SPI-M** predicted/projected serious problems
   - if UK did not introduce stringent measures, which it did not.
   - Projections (colour) and reality (black) are compared below.

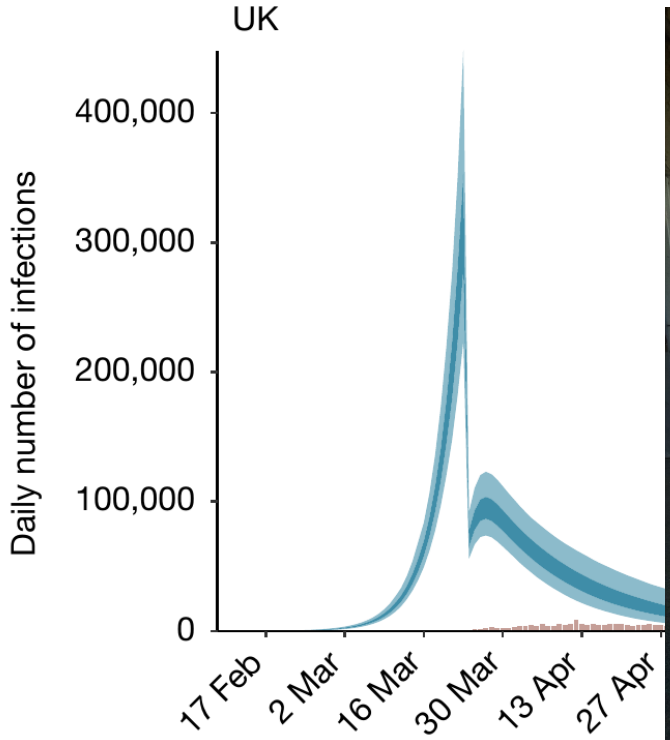


Unvalidated model predictions are mathematicalized opinions.

M6 England, 9.15 Monday May 25th 2020 (could be a movie)

VI. Lockdowns

March/April 2020: statistical sanity check



UK locked down 24 March 2020:

- soon modellers published incidence 'estimates' (above[1]).
- But middle picture was rush hour at Bristol 16th March 2020.
- Right is more like expected normal rush-hour and $R \approx 3$, not 30!

[1] This one from Imperial, but MRC Cambridge similar.

Thinking fast and slow[2] about lockdown necessity

The informal but persuasive argument

> *All over the world cases and deaths were increasing, then governments locked down, and then cases and deaths declined.* **Lockdowns must have done it**.

But cases and deaths occur days or weeks after infection and. . .

- No government would lockdown if cases were *not* increasing.
- Lockdown is measure of last resort, while cases and deaths must decline eventually.

. . . so *increase-lockdown-decrease* pattern is inevitable and irrelevant.

We need to know: **what were daily new infections doing?**

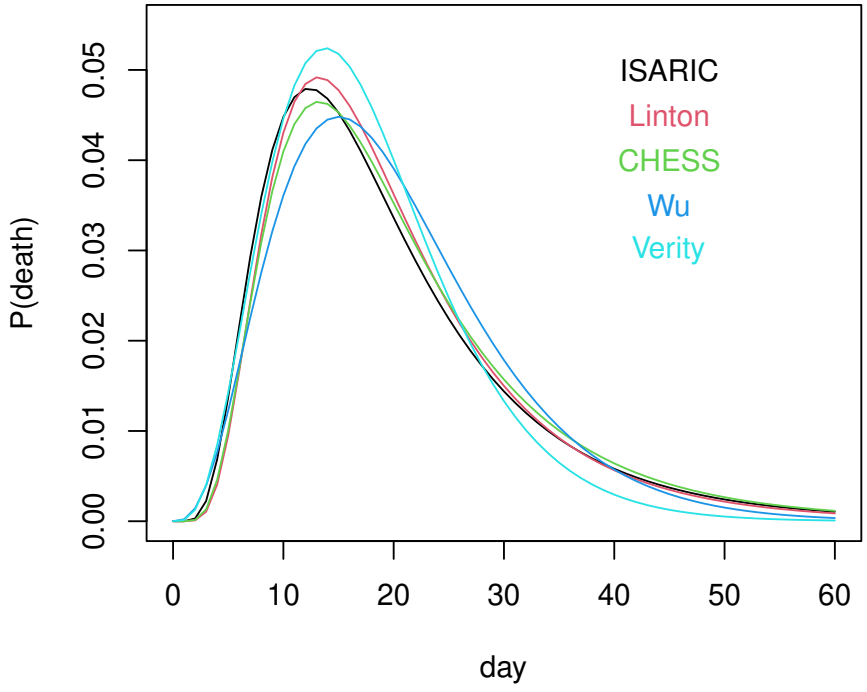
- Recorded cases are useless for this purpose (especially early on).
- Daily deaths and time-to-death data are more reliable: use these.

---

[2] in the sense of Daniel Kahneman, 2011, *Thinking Fast and Slow*

Time from infection or symptoms to death

First symptoms to death according to 5 different 2020 studies:



+ infection to first symptoms distribution well characterized by McAloon et al. (2020) meta-analysis.

$$\log(\text{infection to death duration}) \sim N(3.151, 0.469^2)$$

Infections to death model: convolution

Let f be log incidence and f_w be a cyclic function of day of week,

$$E[\texttt{deaths}_i] = \exp\{f_w(\texttt{dow}_i)\} \sum_{d=0}^{d^+} \exp\{f(\texttt{day}_i - d)\}\pi(d)$$

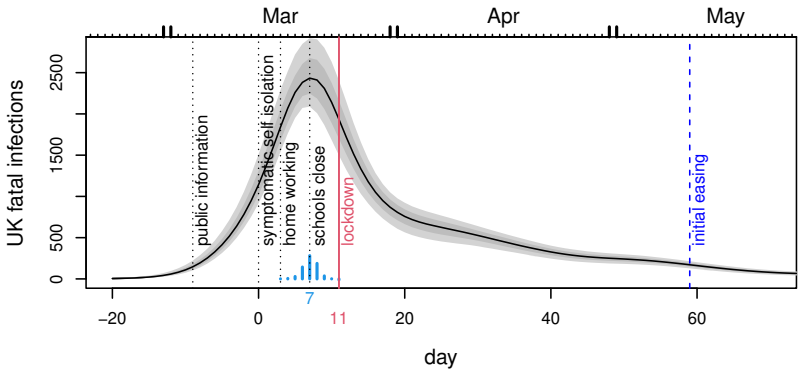
$\texttt{deaths}_i \sim$ negative binomial, f_w and f smooth[3].

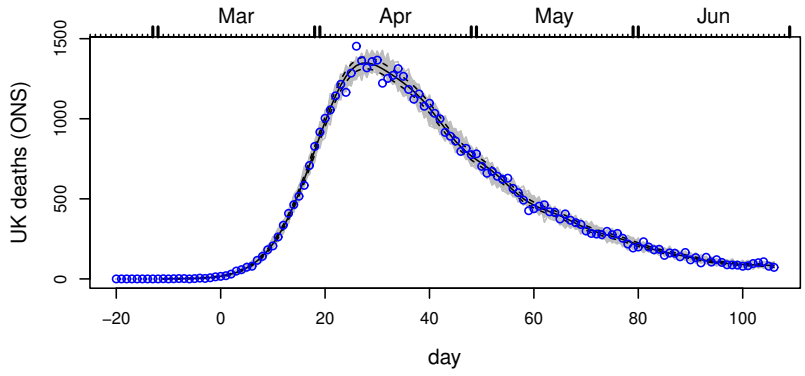
Note:

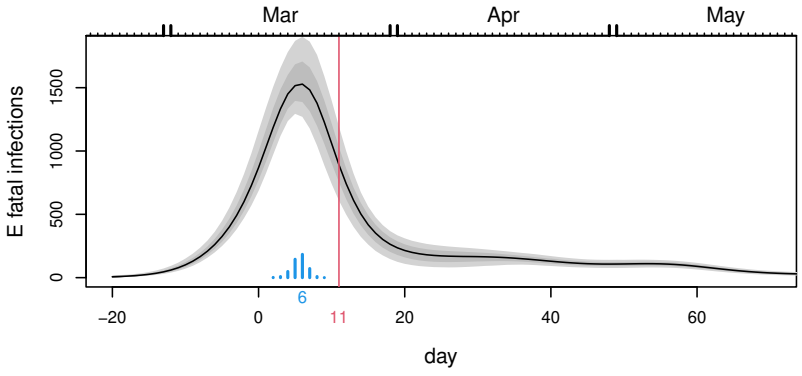
- Not a GAM, but can use a similar standard empirical Bayes approach, to estimate model and smoothness of components.
- Used daily deaths data from ONS, NHS England and Sweden.

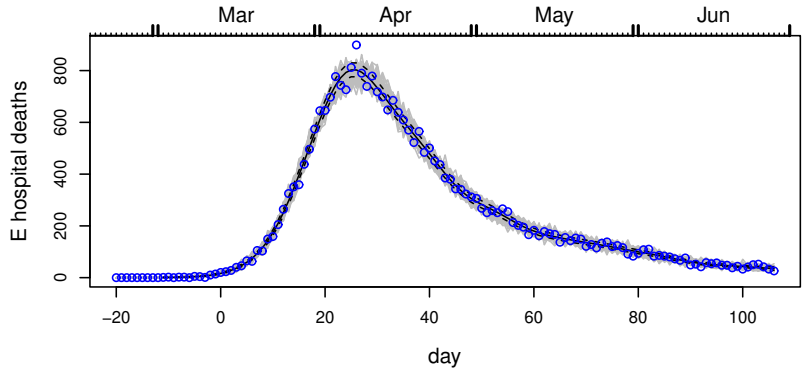
[3] $\Rightarrow$ epidemiologists r smooth

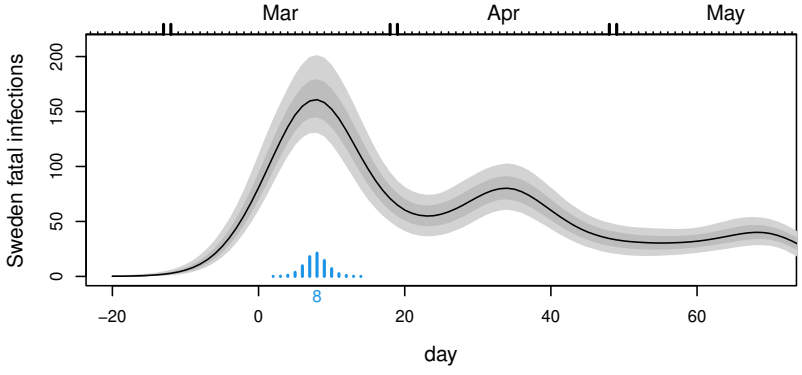
Fatal infections in UK, England, Sweden (from May 2020!)

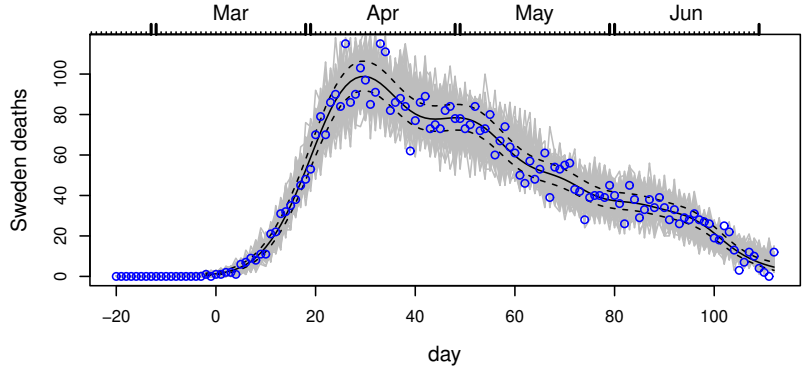






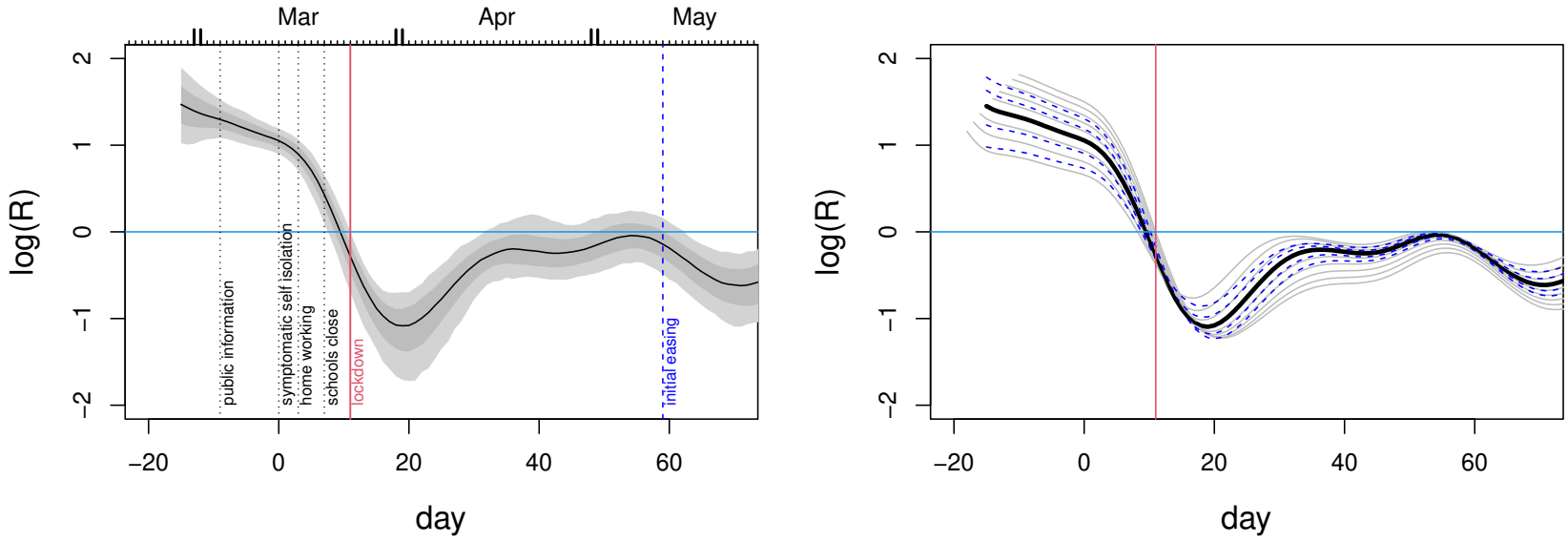






R estimates

Plug incidence estimates into SEIR, solve for I and compute R...

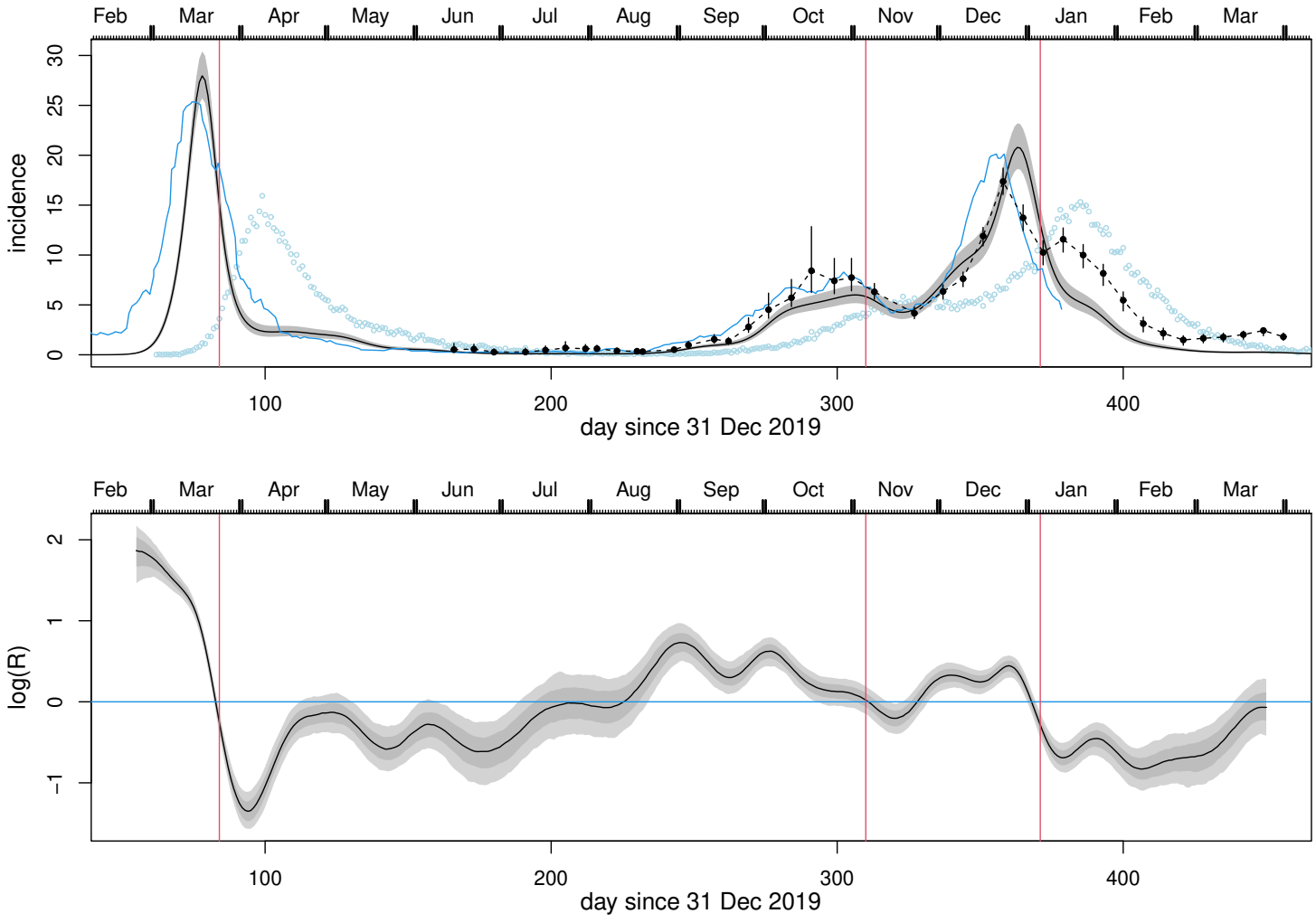


Left: estimate; right: sensitivity of estimate to $\gamma = 1/3$ and $\delta = 1/5$.

Self-censoring science

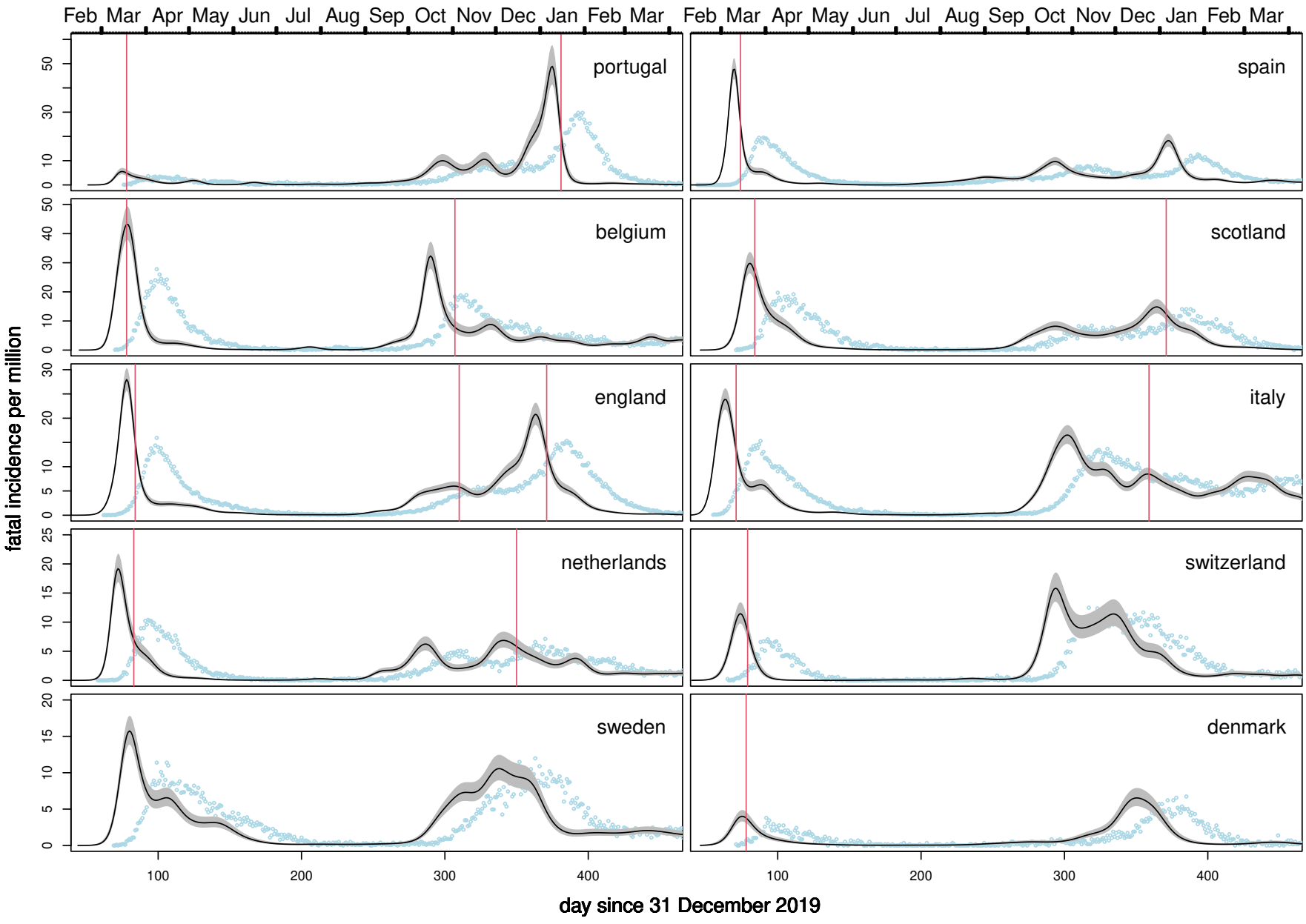
Without questioning results, referees withheld 'peer reviewed' status until March 2021, by which time...

Later waves, other studies, further lockdown

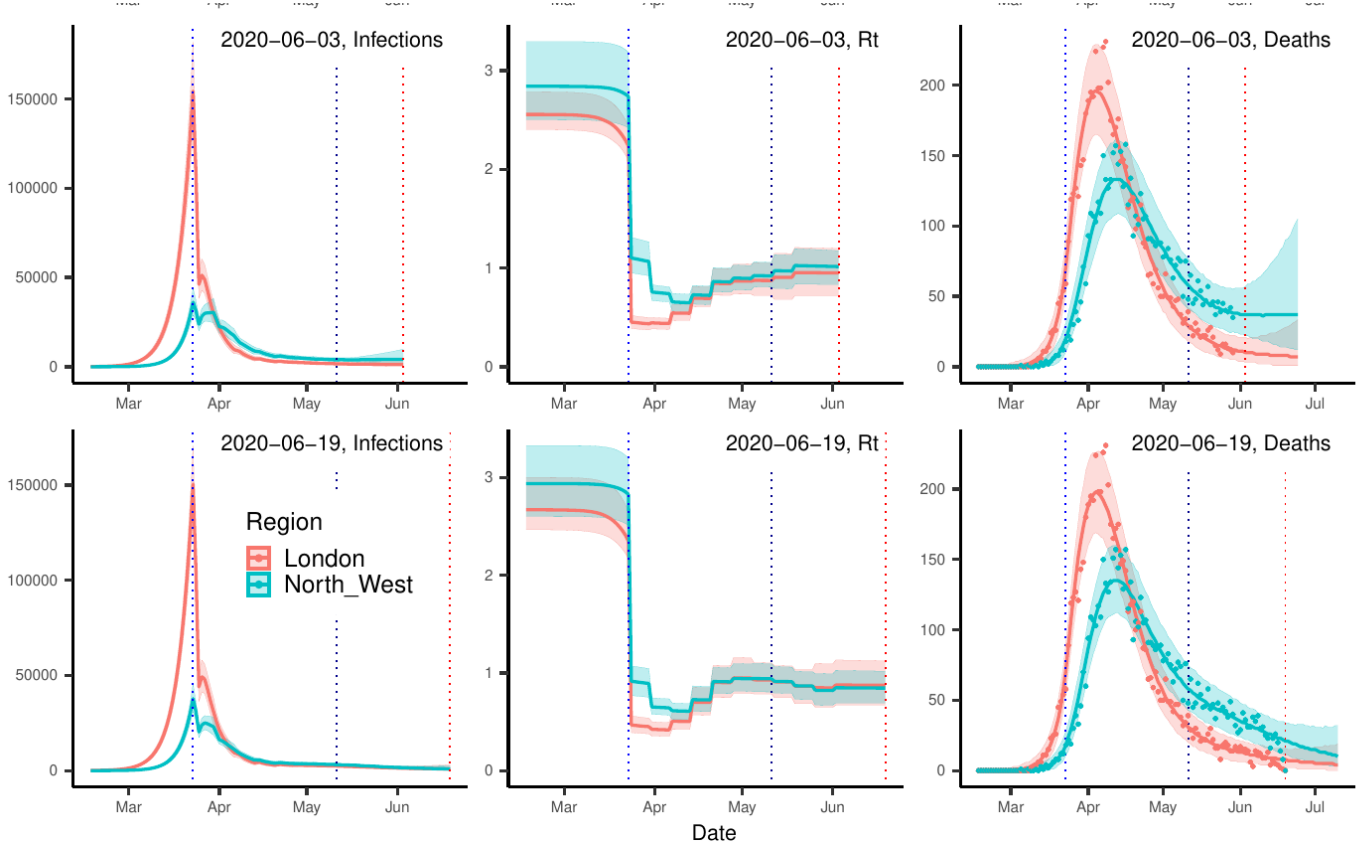


Fatal incidence from NHS England deaths. Blue line incidence from REACT-2 statistical survey. Black dashed-dot ONS survey incidence.

Other European countries



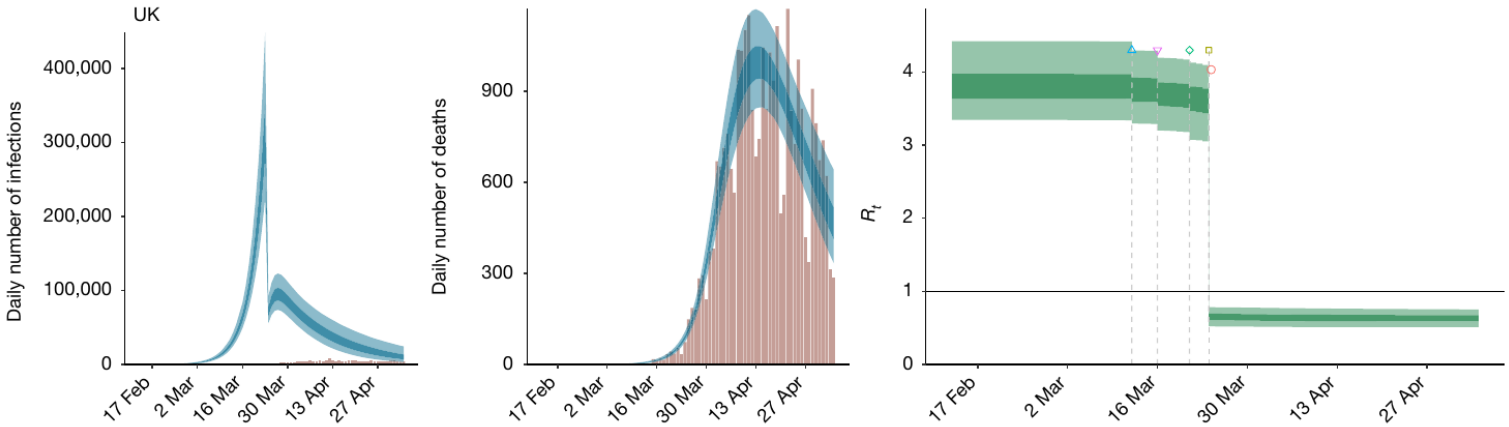
Alternative narrative: MRC Biostatistics unit[4]



- Dynamic disease model fit. Same time to death distribution.
- Estimated contact rate modifier changes weekly after lockdown, *but constant up until lockdown* (forcing surging incidence).

[4] e.g. Birrell et al. 2020 *Real-time nowcasting...*

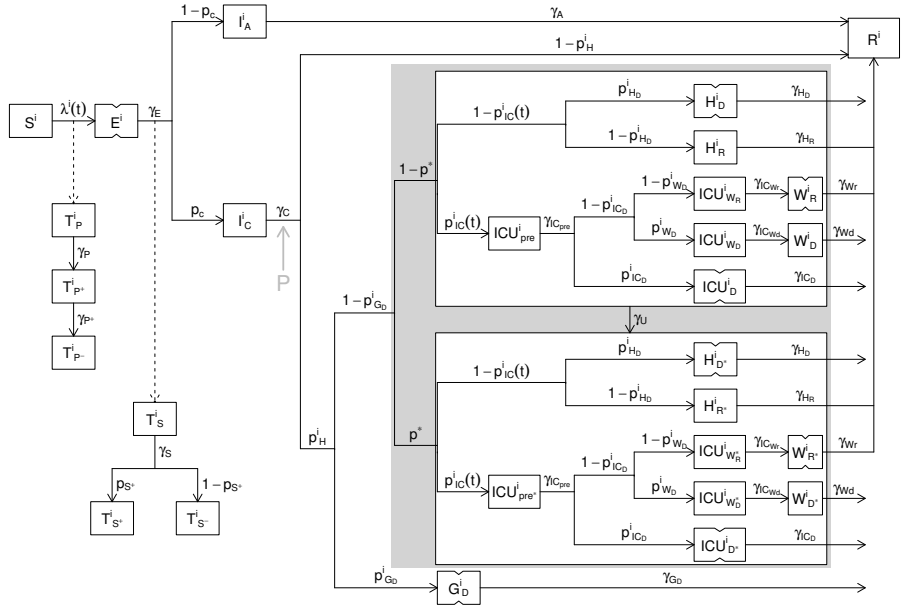
Alternative narrative: Flaxman et al. (2020)[5]



- Daily infections modelled by a renewal model
  - Infections mapped to deaths using Verity et al. dist. as above.
  - R_t is piecewise constant, changing only when NPIs change. Expected post-lockdown dip and recovery impossible.
  - Deaths by reporting day, not day of death.
- Use flexible spline for R_t and/or exact day of death $\Rightarrow$incidence peaks before lockdown.

[5] *Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe*, Nature, 584, 257-261

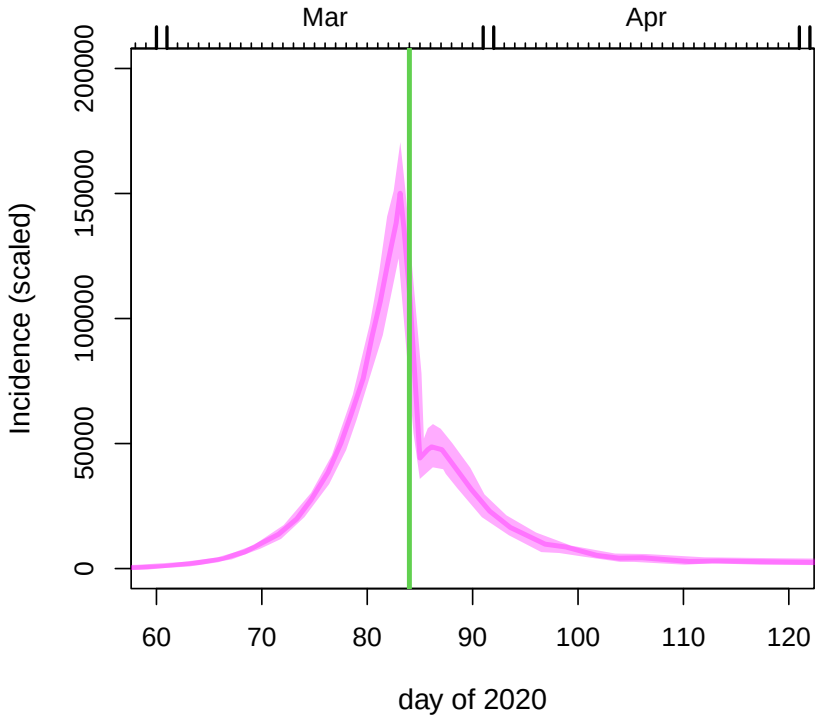
Alternative narrative: Imperial College Report 41 Dec 2020

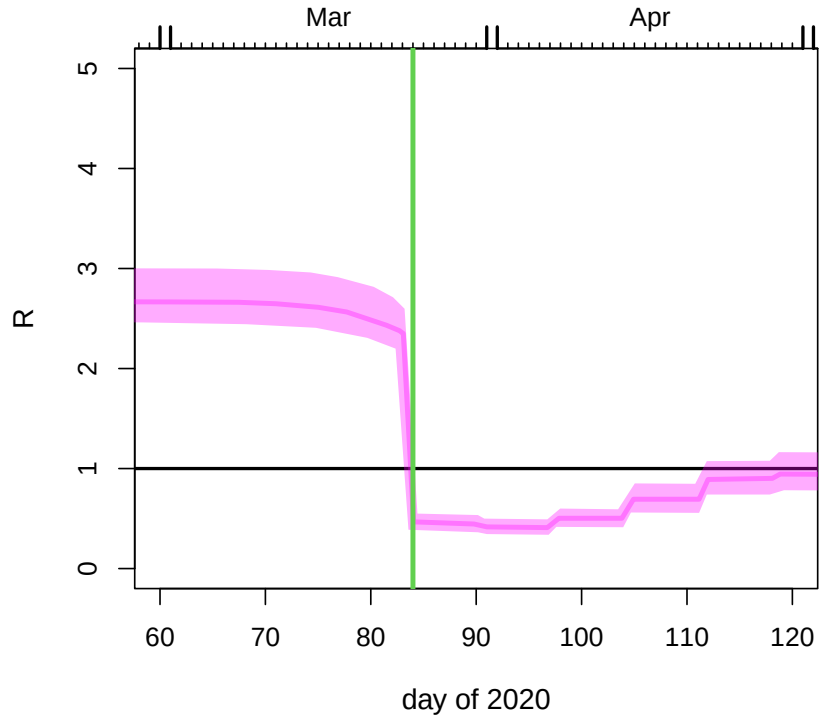


- 19 age classes, each with above model structure.
- Simple piecewise linear function controls change in R.
- Fit to deaths, hospital and testing data[6].
- Incidence apparently surging until lockdown.
- Likelihood hard to defend, some rates differ from cited sources.
- Fix, control R with flexible spline $\Rightarrow$ incidence peaks before lockdowns, with $R < 1$.

[6] *Report 41: The 2020 SARS-CoV-2 epidemic in England: key epidemiological drivers and impact of interventions*

Alternative narratives were built into the *R* models





- MRC built surging incidence until lockdown into assumptions.
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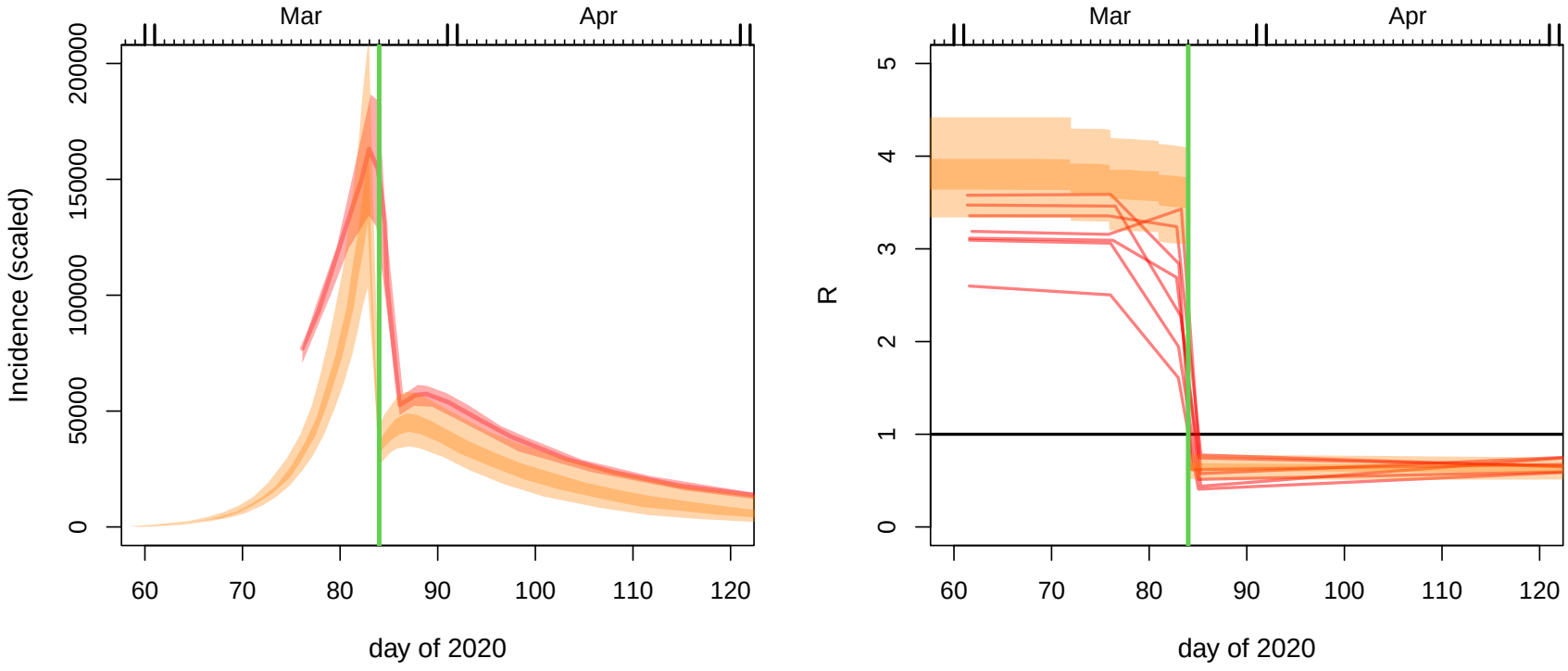
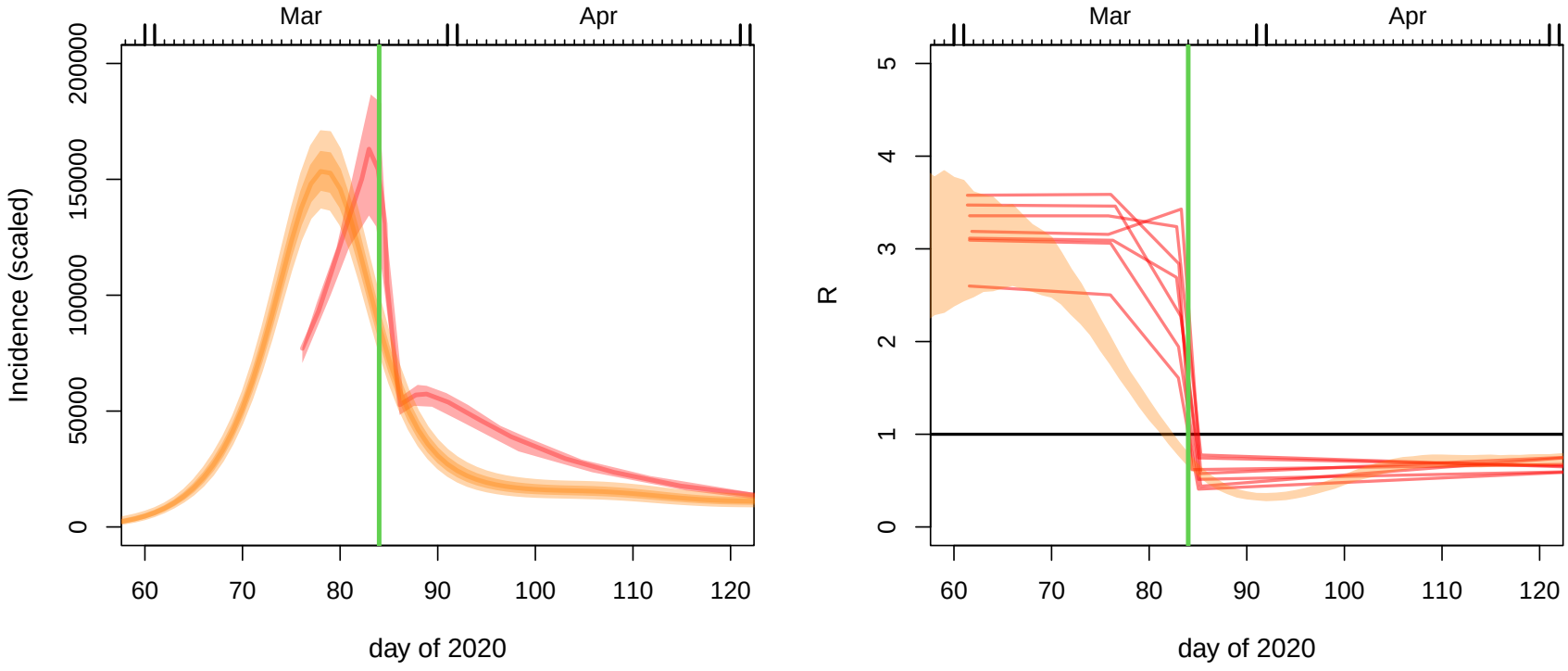
Alternative narratives were built into the *R* models



- MRC built surging incidence until lockdown into assumptions.
- IC Rep 41 (red) and IC Flaxman et al. (orange) made very strong assumptions about R post-lockdown.
- Relaxing the R assumptions for Flaxman. . .

Alternative narratives were built into the *R* models



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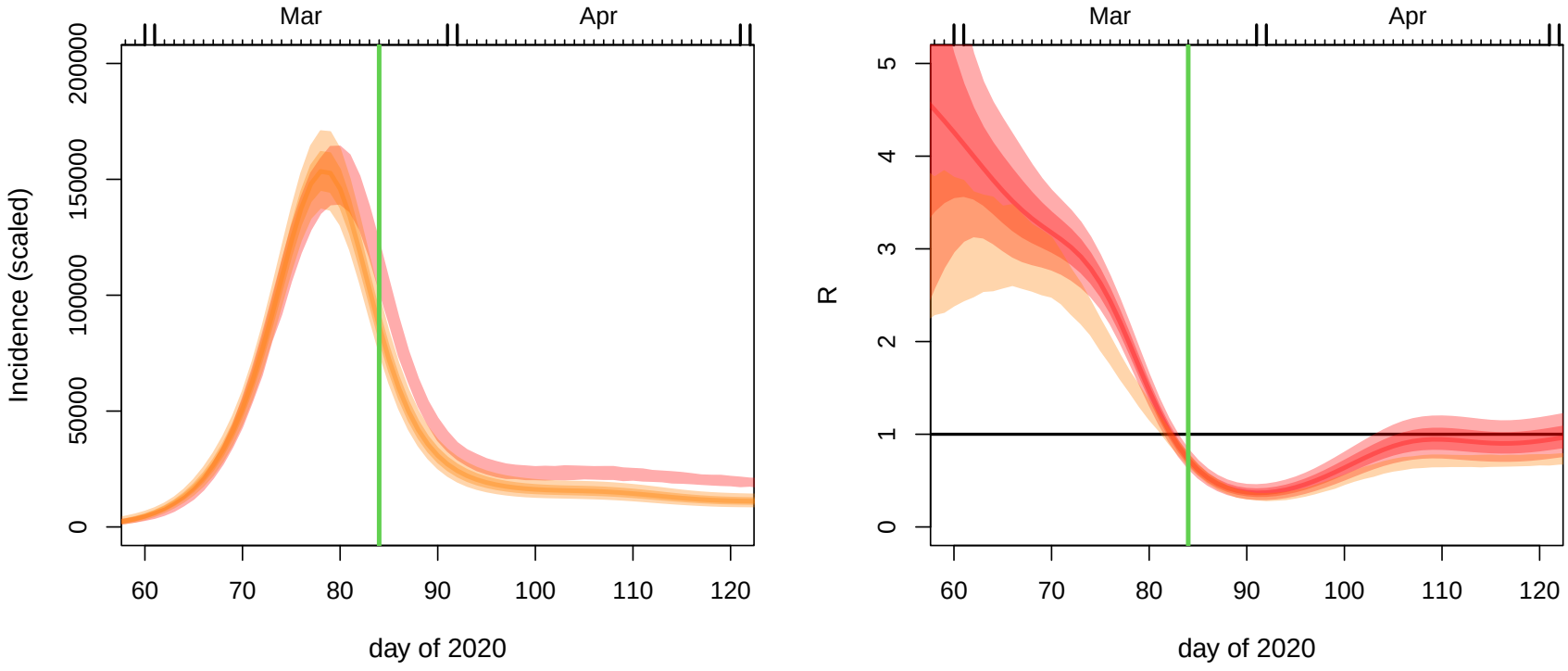
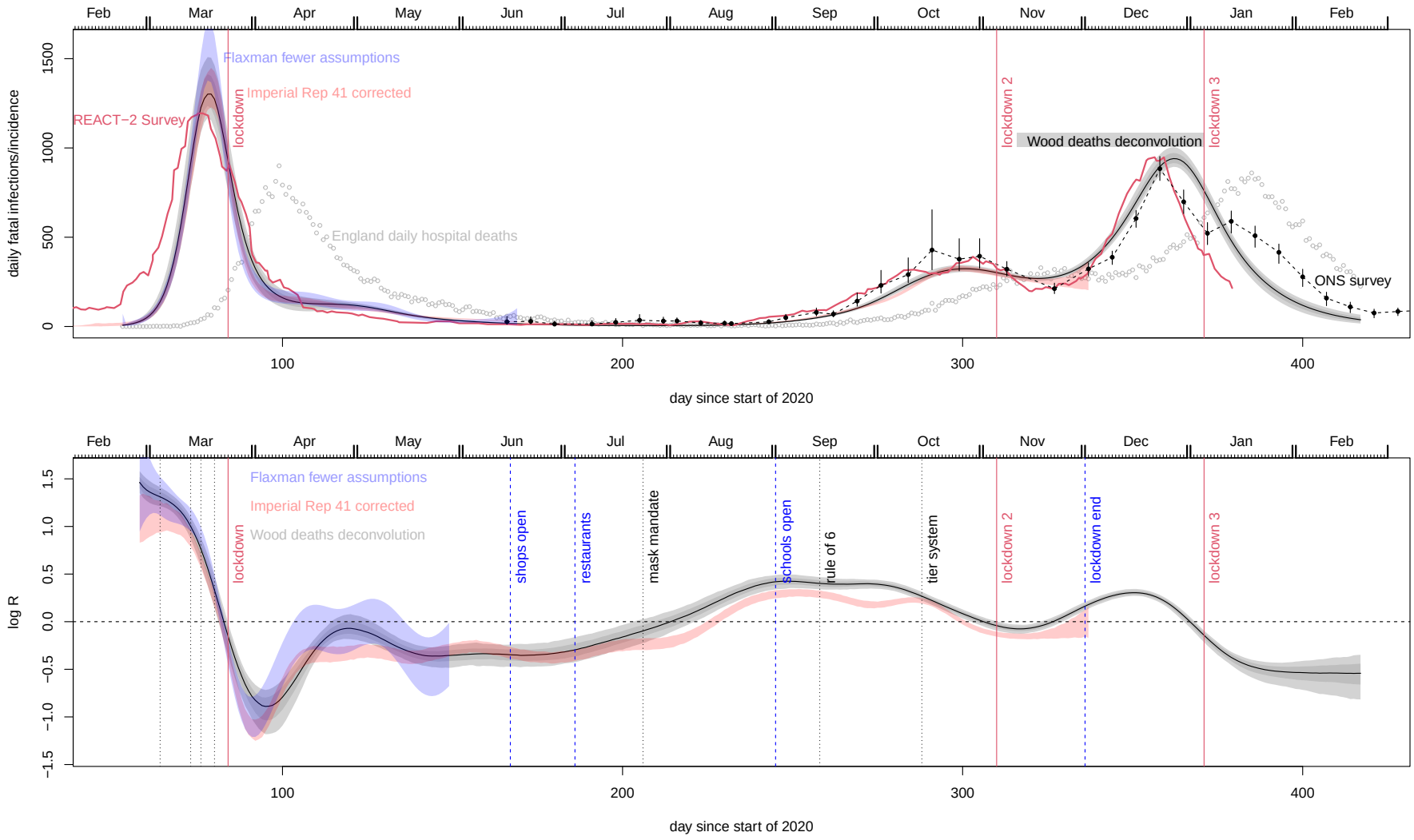


- MRC built surging incidence until lockdown into assumptions.
- IC Rep 41 (red) and IC Flaxman et al. (orange) made very strong assumptions about R post-lockdown.
- Relaxing the R assumptions for Flaxman and Rep 41 completely changes the conclusions.

Corrected alternatives and previous analyses



VII. Hindsight

All in it together in hindsight

Between their pre-pandemic high until March 2021 the world's billionaires gained $\approx$ US\$1.15 $\times$ 10^{12} in wealth (about 10%)[7].

According to the ILO[8] by 2022 labour's share of income had dropped by $\approx$ US\$0.63 $\times$ 10^{12} from its pre-pandemic steady state.

The signs of *building back better* are limited.

[7] Data from Oxfam and Forbes

[8] International Labour Organization https://ilostat.ilo.org/data/

Some health economics hindsight

> *. . . mortality in 2024 for ages 20-44 was materially higher than before the pandemic.*

— Institute and Faculty of Actuaries 25/2/25

IFA's Continuous Mortality Investigation is used by the pension industry to estimate future (cohort) life expectancy. It discounts 2020 and 2021 pandemic data in its calculations. . .

- Between the start of 2020 and 2024 LE at 65 dropped by 0.6 and 0.7 years for women and men.
- That is a life loss of some 10 million years for the UK.

Our collateral life loss lower bounds were probably over cautious.

Hindsight: did getting the science right matter at all?

Boris Johnson's chief advisor, Dominic Cummings, gave evidence to the Covid inquiry. Apparently…

- IC Report 9 had almost no influence on the lockdown decision.
- That was Cummings and 4 'incredibly able' people he turned to for advice: a pure mathematician, a chemist and two AI experts.
- Based on an exponential growth assumption their advice included to 'push extreme suppression immediately'.
- In consequence Cummings repeatedly warned the PM of the danger of a 'zombie apocalypse' and, on 18th March, of the need for lockdown or 'the NHS in London collapses in 15 days'.

With no hint of irony, he also criticizes a government tendency to have crises managed by '*A small group of people excluding practically all the smartest and most knowledgeable at the top of highly centralised and closed/secretive institutions*'.

Closing remarks

- Despite the excellent statistical work done during Covid, several serious statistical problems served to undermine policy.
- Fear of exaggerated Covid risk was used to obtain compliance.
- Long term economy-mediated risks were downplayed, and counter–evidence to lockdown's necessity ignored or resisted.
- The move to online working that accompanied lockdown probably promoted panic, groupthink and polarization, rather than fostering a measured response to risk.
- An overemphasis on modelling over measurement seems to have been unhelpful.
- A pervasive attitude, that to raise critical questions about the scientific basis of the measures would undermine the vital fight for public health, was
  1. unhelpful for achieving best management,
  2. undemocratic, and
  3. unlikely to promote public trust in science in the long term.