EDITORIAL

A model society: Maths, models and expertise in viral outbreaks

Viral outbreaks and public health emergencies obligate an urgent need for evidence to inform rapid responses. In the case of SARS-Cov-2, a novel virus linked to the fast-moving COVID-19 pandemic, mathematical models projecting disease outbreaks and the potential effects of interventions are playing a critical role. Modelled projections are not only evidence-making policy decisions, but are afforded power-of-acting in public understandings and in social life. We propose here that COVID-19 is coming to be known in maths and models. We trace this process not only in policy but in media stories of maths, mathematicians and models. We accentuate the social life of maths and models, which feed citizen science and social actions in relation to COVID-19. There are general lessons from the emergent evidence-making of COVID-19 for how we do science for public health.

Numbering control

Mathematical models and projections have become ubiquitous as tools of anticipatory governance. We see this in relation to financial markets, climate change, environment, humanitarian disasters, and global health. In public health, models play a critical role in producing evidence in response to novel viral outbreaks, as with Ebola, SARS, MERS and currently COVID-19, and in eliminating chronic infections, as with HIV, viral hepatitis, and tuberculosis.

Mathematical projections enact a sense of control through evidencing. A body of work in social science points to knowing futures as a means to taming the uncertainties of the present (Hacking, 1990), including through an imagined universal ‘trust in numbers’ (Porter, 1995). In the relative absence of evidence, models and abstractions offer a ‘bridge’ to knowing. Projections produce *what becomes known*, affording a sense of security through calculus: “By producing information about what has not yet happened”, projections “reduce social complexity and constitute problems for acting in the present” (Aykut et al., 2019: 2). Projections close down unknowns into a governable present.

Models and projections are therefore not mere theoretical possibilities, but are lived as *anticipated potentials*, affecting actions, publics and policies *in-the-now*. Through models, we move from limited actuals – based on case reports and empirical observations in particular sites – to generalised abstractions, to evidence what *could actually be*. While calculated in a mix of theoretical plausibility and mathematical probability, projections are *actualised* and *particularised* in *social practices* in the *present*. This is also why models and projections themselves can 'go viral', taking flight, as they are materialised in life worlds, with *affects*, far beyond scientific calculus (Callon and Law, 1998).

A model society

In viral outbreaks, there is the imperative to act swiftly to restore control. In response to COVID-19, and very quickly, models have projected transmission and epidemic futures and the potentials of infection control through quarantine, social distancing, travel restrictions, and population 'lockdown' (Kucharski et al., 2020; Hellewell et al., 2020; Ferguson et al., 2020). These projections are generating evidence for rapid policy decisions. National responses are contingent upon fast-evolving modelling assumptions. This is not without controversy. In the UK, for instance, the public communication of national responses to COVID-19 based on projections of 'herd immunity' received a mixed response. The strategy was said to play "second fiddle to mathematical modelling" (*Guardian*, 2020a). Models are reportedly afforded *too much agency*, with Government "instructions" said to result from attempts to "control the UK epidemic by mathematical modelling" (*Guardian*, 2020a). We are reminded of the dangers of modelled theoretical assumptions: "They are also solely intended to flatten the curve, when even a *flat curve will kill thousands*. These approaches would be an acceptable experiment if there were no alternatives, but we have strategies from elsewhere which have been shown to work". The UK has since shifted its national response based on assumptions of 'herd immunity' to one emphasising social distancing and restricted population movement. This about-turn was reportedly based on projections, from 'new' models (*Guardian*, 2020b), raising consternation about the need to make modelling evidence more transparent in public communications and policy decisions (Horton, 2020).

Modelling nowcasts, forecasts and 'coronacasts' are featuring heavily in media portrayals and public engagements in relation to COVID-19. Modellers are communicating their maths and projections directly to publics online, and are publishing quickly, unencumbered by peer review. There is not only a race to model to produce evidence for policy, there is a thirst for *knowing maths and models* as a means to *knowing COVID-19*. Epidemic projections are not isolatable to a world of science but deeply entangle in the *everyday*. Reflecting on how we come to know a virus in maths and models tells us something about what 'counts' as evidence and expertise as matters of *social concern*. The 'power-of-acting' of projections not only translates in science and policy but in citizen actions and social life. A 'model society' is enacted; a society which responds to uncertainty, at least in part, through evidence produced in maths and models.

Not only is there a thirst for maths and models as a means to knowing what the COVID-19 outbreak might *actually be like*, there is an emerging genre of outbreak communication which orientates around the objects of *maths* and *modellers*. Projected output is not enough, we also desire to know the *maths*, the *mathematicians*, and how the models *do their work*. The headlines in various media trace this novel way of attending to a virus, for example: "The maths of COVID-19 and how you can change it" (*New Zealand Herald*, 2020); "Here's how computer models simulate the future spread of new coronavirus" (Hsu, 2020); and "How maths is helping to answer crucial COVID-19 questions" (Kucharski, 2020). We can trace four elements in the making of 'model society' in media and public communication: the *mathematician;* the *model*; the *maths*; and transformations in *expertise*.

First, the *mathematician*. Here, stories pivot on the narrative of the mathematician transformed from 'geek' to "maths whizz crunching numbers to save us" (*Sunday Times*, 2020). No longer back-stage, the mathematician is brought forward as an actor *doing things*. Our interest expands from numbers to their architects. The experts doing the "number crunching" become valued in a crisis. There are multiple expressions of social media gratitude and respect for the modelling experts helping to control COVID-19. Here is one example (*Instagram*, 2020). COVID-19 might be *rehabilitating* some of the lost *trust* in expertise as this is *what we need* in the face of uncertainty. Rather than separated by their science, modellers are being *attached* inside *publics* in relation to shared matters of social concern. We learn, for example, that what makes the "good scientist" particularly "valuable" is not only their "dedication" but whether they can engage with publics as a "good communicator" (*Guardian*, 2020c).

Second, the *model*. Here, stories enact 'simple maths' as solutions to the complexity, unknowns and mess of emergencies. Models proffer 'clarity' amidst the 'confusion' and 'fog' of outbreaks. We are told that "in reality, we only ever see one version of an outbreak", and we "rarely see the full picture at first", and that models can instead "simulate dozens of alternatives" to tell us "how many cases there *really are*" and "how severe the disease *really is*" (Kucharski, 2020). Here, we have a case of *seeing past what is missing* to project what *could become*. In moving between the unknown and the possible, the actual and the abstract, the empirical and the theoretical, models *make* evidence as *potentials* and as *not yet knowns*. An evidence is produced which potentiates an action, even in the absence of knowing. We see national leaders on television enacting policies on the basis of the latest projections, standing before equations and epidemic curves, and voicing commitment to 'flattening the curve'. Even when performing the 'worst-case scenario' (a common feature of media reporting on models), an imagined universal trust in numbers is mobilised to moderate concern: "How worried should we be? The headlines shout 'killer virus', 'crisis' and 'confusion'. Italy accuses misleading media of creating an ‘infodemic’. But what do the numbers say?’… What do the cold, hard, numbers say?” (*The Day*, 2020).

Third, *the maths*. Maths has received a lot of attention in the evidence-making of COVID-19. Stories deconstruct the core elements of “SIR” (susceptibility-infection-recovery) models (*New Zealand Herald*, 2020). There is advice on calculating mortality rates and estimating unknowns through backwards calculation (*Economist*, 2020; Pueyo, 2020), with special attention given to R_0 (the basic reproduction number), *R* (the effective reproduction rate), and “flattening the curve” (of epidemic spread) (*Washington Post*, 2020; *New York Times*, 2020). We come to know COVID-19 infection control as a *calculation*. We are offered *maths lessons* on R_0 and *R*. As part of UK national television news on COVID-19, for instance, the BBC ran a slot on the methods of infectious disease modelling. The aim of the infection control calculus, we are told, is to “flatten the curve”, by spreading infections out over time: “If policymakers and public health officials are doing their job, and a trusting public pays attention, this should be less than R_0. The lower it gets, the flatter the curve.” (*Economist*, 2002). In the model society, ‘flatten the curve’ has become everyday speak for translating the calculus of infection control. Represented in graphics produced by the Centers for Disease Control, then reproduced by *the Economist*, and then popularised in social media, “#FlattentheCurve” has ‘gone viral’ (*New York Times*, 2020).

Lastly, there are transformations in *expertise*. People want to *input*, to *make* and *translate* evidence, not merely receive. Not only do citizens desire to know how to act to ‘flatten the curve’”, they engage via interactive models and through an emerging citizen modelling science (Pueyo, 2020; *Washington Post*, 2020; Dong et al., 2020). Take, for instance, the article “Coronavirus: Why You Must Act Now” (Pueyo, 2020). This translates projections, including their logics, into recipes for knowing the unknown and for acting in-the-now. When we accessed the article in March 2020, it had received 24 million views in the previous 72 hours. A core thread in its translation work is telling us how models can evidence the likely ‘true’ epidemic situation by bridging the gap, through backwards calculation, to what is actually known. We get to know how models work: “You only know the official cases, not the true ones. But you need to know the true ones. How can you estimate the true ones? It turns out, there’s a couple of ways. And I have a model for both, so you can play with the numbers too”. Not only do we get to know the maths, we are invited to work with, and *do*, the model. With COVID-19, abstract models translate into the mainstream as citizen action for infection control. Knowing maths is a means to knowing – and acting upon – the virus.

Conclusion

In novel viral outbreaks, evidence and intervention and infections infect each other (Rosengarten, 2018). What constitutes 'evidence', 'evidence-based decisions', and even 'science', are open to revision. With COVID-19, we see the critical role of modelled projections *making* evidence of *potentials* and *not yet knowns* as a means to *intervene*. By drawing attention to the 'power-of-acting' of mathematical models in policy as well as in social practices, we emphasise the complexity and fluidity of evidence and its multiple possibilities. With COVID-19, we see that maths and models have agency as drivers of social action, translating models into citizen science and advocacy. #FlattenTheCurve entangles science into social practices, calculations into materialisations, abstracts into affects, and models into society.

Declarations

The authors have no conflicts of interest to declare.

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Tim Rhodes, Professor of Public Health Sociology, London School of Hygiene and Tropical Medicine, London, UK; and University of New South Wales, Australia
tim.rhodes@lshtm.ac.uk
Orcid : 0000-0003-2400-9838

Kari Lancaster, Scientia Research Fellow, University of New South Wales, Sydney, Australia
Orcid : 0000-0002-2411-7970

Marsha Rosengarten, Professor of Sociology, University of London Goldsmiths' College, London, UK.

Orcid 0000-0003-3820-4810