CHAPTER 14

# Afterword: Quantifying, Mediating and Intervening: The R Number and the Politics of Health in the Twenty-First Century

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In 1985, Anthony Hopwood remarked as follows: "A world of the seemingly precise, specific and quantitative can in this way emerge out of that of the contentious and the uncertain" (Hopwood, 1988 [1985], p. 262). This was more than a decade before the "performative turn" in economic sociology and several years before the academic explosion of "New Public Management" studies. Hopwood was speaking here about accounting, and how costs, consequences and benefits come to be divided into the defined and the seemingly known, and the imprecise and the intangible, and how this can give a calculative priority to the economic rather than the social.

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But, as he and many others have shown since, and as the contributors to this volume show, the point is more general. Numbers have acquired an unassailable power in modern political life. Political authority and the stewardship of people's lives are today inseparable from the vast range of different sorts of numbers that are deployed in the governing of advanced liberal democratic capitalist societies. Debates about the health of "the economy" are inconceivable without numerical measures of various kinds. The same applies to the quantification of the social economy, whether this be a matter of transforming poverty into the number of people claiming benefits, public order into the crime rate, the state of family life into the divorce rate or the governing of sexual conduct into the rate of spread of AIDS. And, just as political decisions come to depend increasingly on quantification, there is a simultaneous "de-politicization" of politics. The boundaries between politics and objectivity are redrawn, by proclaiming that political decisions are little more than automated technical mechanisms that tell us what to do and when, and what to prioritize (Rose, 1991).

This much will be familiar to many readers of this volume. But even for those well aware of such issues, the phrase "follow the science", and its numerical counterpart the "R" number, has attained an ascendancy that none of us could have imagined only a few months ago.[1] This affirmation of scientific expertise is all the more remarkable, given its contrast with the statement by Michael Gove, the then Secretary of State for Justice, in the context of debates about Brexit in 2016, that "people in this country have had enough of experts" (*The Financial Times*, 3 June 2016).

At its simplest, in an epidemic the *R* number—the reproduction number—is one of the most important numbers. As almost every citizen now knows, if the *R* number is below one, then that is good news. For if it is below one, the number of new infections will fall over time. But if *R* is above one, that is definitely not good news. It means that the number of new infections is accelerating; the higher the number, the faster the virus spreads through the population.

The R number can be used as a device for shutting schools, shops, restaurants, hotels, gyms, factories, university campuses, international travel and indeed most forms of social life. In the other direction, it can also be used as a device for opening some or all such venues and interactions. Two newspaper headlines illustrate this well. The first was printed on 1 May 2020 in the *Financial Times*, and stated as follows: "R number: the figure that will determine when lockdown lifts". Describing the *R* number as the average number of new cases generated by an infected individual, the article went on to say that politicians viewed it as a key indicator for lifting lockdowns enough for significant social and economic activity to resume, without allowing a resurgence of the virus. Also, and crucially, it was viewed as a relatively simple number to convey success or otherwise to the general public. However, it also went on to say that unfortunately, and despite the repeated appeals to it in statements by politicians, things are more complicated. Not only is it incredibly difficult to measure, as an aggregate number for a large geographical area it is also potentially misleading or at least uninformative, because it does not tell you what is happening in your local area. Further, while it is widely described as if it were the actual number of new cases generated by an infected individual, in most countries the *R* number is in fact an estimate generated from mathematical models and simulations, with different modelling teams even in the same country arriving at different results.

The second headline, printed two weeks later in *The Financial Times*, was more cautious: "R numbers offer no easy answers for UK to lift lockdown". The starting point of this piece was the significant regional differences in the number of officially recorded new infections per day. In London, which previously had one of the highest number of new infections, the number of new infections was just 24 per day according to data from Public Health England (PHE) and Cambridge University, whereas the comparable figure in Yorkshire and North-East England was 4,320. This was cited as evidence of the difficulty of having uniform policies even across England. The modelling conducted by PHE and Cambridge suggested a median *R* of 0.75 for England as a whole, but varying from 0.4 in London to 0.8 in the North-East and Yorkshire. Other modelling groups, such as the London School of Hygiene and Tropical Medicine and Imperial College, London, gave higher figures for *R* in London, but all showed the number significantly below 1 in the capital. And things became even more difficult once differences in approach to the relaxation of restrictions between England and the devolved governments in Scotland, Wales and Northern Ireland began to appear. In rejecting the lockdown easing in England, all cited worries about the R number in their regions.

But the different R number estimates only partially explain the divergence in policy across the different parts of the UK. Statisticians reiterated that the *R* number was extraordinary difficult to calculate, the Scottish government's chief statistician commenting that the official R number in

Scotland takes 56 hours for an Edinburgh university supercomputer to calculate. Further, he emphasized that the number, even when checked against the numbers produced by the other models, should only be expressed as a range, rather than a single figure, as there is a roughly 50% risk that the *R* level is higher than any specific point estimate.

These differences in results arising from different modelling assumptions, when combined with the different approaches to the relaxation of restrictions in the devolved administrations, began to undermine the appeal of the slogan to "follow the science". An article in the publication *Wired* went as far as to adopt the headline: "Boris Johnson's brief love affair with science is well and truly over" (Matt Reynolds, 6 June 2020, Wired).[2] Moreover, it soon became clear that, while the R number needed to be below 1 to ease restrictions, no politician was willing to say how far below 1 it needed to be in order to ease restrictions. In addition, prominent scientific advisors began to distance themselves from specific government policies. For instance, on 3 June the Chief Scientific Adviser to the UK government refused to explicitly endorse the government's decision to impose quarantine on new arrivals to the UK with effect from the following week (*The Guardian*, Andrew Sparrow, "Evening Summary" 3 June 2020, updated 4 June 2020).

The R number is a key part of what one might call a conditional "trust in numbers" (Porter, 1995), albeit one where the authority of the number is tempered not only by political judgement but also by an array of other numbers, including GDP and unemployment, together with reports by official bodies predicting either a V-shaped or a U-shaped recovery, a further spike in infections, and much else besides. It thus stands at the heart of the politics of health in the twenty-first century, a perfect "mediating instrument" (Miller & O'Leary, 2007) linking the health and well-being of the population with the health of the economy. A calculative assemblage that facilitates a level of intervention in the lives and activities of citizens in advanced liberal democracies that is not only unprecedented but fundamentally at odds with so much that is at the heart of our political culture. As Foucault remarked of the politics of health in the eighteenth century, the biological characteristics of the population become relevant factors for economic management. It becomes necessary to organize around the population an apparatus that will ensure its subjection and even its enforced idleness so as to (hopefully) increase or at least maintain its utility as and when the pandemic subsides (Foucault, 1980 [1976]). Epidemiology, virology and statistical science thus assume an increasingly important place in the machinery of power.

Medico-administrative knowledge, albeit tempered by political expediency, has achieved a political hold on a population at the mercy of a virus that in just over a few months has certainly killed more than 50,000 people in the UK as of the time of writing, and may well have killed more than 60,000. And this display of medical knowledge has taken place in the most public manner. Daily briefings (initially), 92 in total, ending on 23 June,[3] saw government ministers flanked on most occasions by their most senior scientific advisers, and in most instances diplomatically endorsing the actions of the government. Perhaps the most notable exception to this being the critical comments made by the Deputy Chief Medical Officer Jonathan Van-Tam on 30 May, when asked about the behaviour of Boris Johnson's most senior special adviser Dominic Cummings. As the journalist John Crace remarked, the relationship between the government and the scientists never really recovered thereafter,[4] and Van-Tam did not appear again at the daily briefings.[5]

At every briefing there would be slides showing graphs of the number of new cases, the total number of cases, the 7-day rolling average, the number of patients on mechanical ventilators, the number of people in hospital with COVID-19, and, most depressingly, the number of deaths in the previous 24 hours, as well as the total number of deaths. This unprecedented public display of medical knowledge was backed up by various government websites that provided access to the materials displayed, while the Office for National Statistics, the National Records of Scotland, and the Northern Ireland Statistics and Research Agency provided further data. This included three different ways of measuring the number of deaths: those with a positive COVID-19 test result; those where the death certificate mentions COVID-19; and the third being the number of "excess" deaths for the time of year. As of mid-/late June, the three numbers for the UK as a whole stood at 43,414, 53,009, and 65,138, respectively.[6]

The political ascendancy of the beguilingly simple $R$ number is all the more remarkable, as it is a relative newcomer to epidemiology. Now regarded as arguably the most important quantity in the study and control of epidemics (Heesterbeek, 2002), it was only clearly defined for the first time in 1975 by the German mathematician Klaus Dietz, as follows:

> The quantity R is called the reproduction rate, since it represents the number of secondary cases that one case can produce if introduced to a susceptible population. (Dietz, 1975, p. 106)

Yet, despite the existence of this clear definition, it still took a number of years for epidemiologists to fully embrace the R number. Two events in 1982 provided the stimulus for the R number to become central to the analysis of epidemics by epidemiologists. The first was an article published in February that year in the journal *Science*, which made extensive use of $R_0$, calling it "the intrinsic reproduction rate" (Anderson & May, 1982a, p. 1055). The second was an influential workshop held in the Berlin suburb of Dahlem in March of that year (Anderson & May, 1982b), with almost all contributors using $R_0$ as if the concept had been used in epidemiology for decades, which was certainly not the case (Heesterbeek, 2002, p. 200).

There had of course been earlier attempts to model the spread of epidemics, most notably through the work of Ronald Ross (1857–1932), a medical doctor, a colonel in the British army, a minor poet and a self-taught mathematician, and the first Briton to be awarded a Nobel Prize (Heesterbeek, 2002, p. 192). He led several anti-malaria campaigns, dissected many mosquitoes, and discovered in 1898 that (bird) malaria was transmitted by mosquitoes, rather than by "bad air" from marshes as was previously believed. He received a Nobel Prize for this discovery in 1902.

His work in modelling epidemics started with showing that trying to control malaria by fighting mosquitoes was a real possibility. This was in contrast to general opinion at the time that fighting mosquitoes was not viable because it would be impossible to kill all mosquitoes locally and therefore impossible to stop transmission of malaria. Ross identified the main factors in malaria transmission and calculated the number of new infections arising per month as the product of these factors. He referred to his discovery as the "Mosquito Theorem". His conclusion was that instead of having to eradicate all mosquitoes in a given area, it was sufficient to depress the ratio of mosquitoes to man below a particular threshold. There was, he argued, a "critical density of mosquitoes" below which the malaria parasite could not be sustained.

While the notion of a critical threshold (critical community size) was helpful for the study and control of malaria, it was not conducive for the development of the notion of a reproduction threshold or rate. As Ross himself had discovered, malaria is a vector-transmitted infection, rather than a directly horizontally (i.e. person to person) transmitted infection. Ross published a series of three papers (two co-authored with Hilda Hudson) (see Ross, 1916; Ross & Hudson 1917a, 1917b) in an attempt to develop a general theory of epidemic phenomena, a "theory of happenings". He referred to his approach as "a priori pathometry" (Heesterbeek, 2002, pp. 192–193; see also Kucharski, 2020). This led Heesterbeek (2002, p. 193) to comment that Ross was the first to try and develop a general theory of epidemic phenomena using prior assumptions about mechanisms that could be acting in the spread of infections, rather than trying to obtain insight a posteriori by studying real epidemics. Heesterbeek concluded that this work represents the first development in abstract or modern epidemic theory, even if it did not result in the formulation of $\mathrm{R}_0$.

But it was to be more than 50 years before the notion of the reproduction rate was to be formulated in epidemiology. This, despite Ross's aspiration to "establish the general law of epidemics", and his encouragement to McKendrick, a medical doctor who served in the British army under his command in Sierra Leone in 1901 during one of the anti-malaria campaigns, to continue his work further. As Ross remarked rather ambitiously to McKendrick: "We shall end by establishing a new science. But first let you and me unlock the door and then anybody can go in who likes" (Ross, in a letter to McKendrick in 1911, cited in Heesterbeek, 2002, p. 195).

Meanwhile, in 1925, and within demography rather than epidemiology, the concept of $R_0$ or the reproduction rate was formulated in a paper titled "On the true rate of natural increase", published in the *Journal of the American Statistical Association* (Dublin & Lotka, 1925). One of the authors was Alfred Lotka, who worked for the Metropolitan Life Insurance Company in New York. Lotka had started the chain of reasoning with a short note in *Science* in 1907 on the "rate of natural increase per head", which he called $r$, of a population with constant birth and death rate.

The 1925 paper was published just one year after President Coolidge had signed into law the Immigration Act of 1924, the most stringent US immigration policy up till then in the nation's history. The paper began by remarking that "The present policy of restricting immigration into the United States lends a particular interest to inquiries into the powers of natural increase of our population" (Dublin & Lotka, 1925, p. 305). The paper went on to comment that the excess of birth-rate over death rate may appear to provide a measure of natural increase. However, that would be misleading because it fails to take into account the age distribution of the population. If one factors in reduced immigration, which would over time result in a reduction of productive and reproductive members of the population, combined with a falling birth-rate, then sooner or later the birth-rate would become stationary or nearly so. Numerically, this would mean that the excess of the birth-rate over the death rate would fall from 11 per thousand per annum to 5.5 per thousand per annum, that is, it would be reduced by one half (Dublin & Lotka, 1925, p. 307). Having considered fecundity, mortality (i.e. a life table), together with the age schedule for fecundity of females in the United States in 1920, the authors conclude as follows:

> The net result is that if we follow the history of 100,000 females at the current rate of fecundity we find that throughout their life they give birth to 116,700 daughters; or, on average, one female gives birth to 1.168 daughters in the course of her life. This, then, is the ratio of the total births (of daughters) in two successive generations. *It will be convenient for future reference to denote this ratio by the symbol* $R_0$. (Dublin & Lotka, 1925, p. 310, emphasis added)

This way of expressing things enabled the authors to speak of a "standardized" or "stable natural rate of increase" under specified conditions of maternity and mortality. While our interest here is primarily in terms of this early formulation of $R_0$ within demography, it is difficult in our current socio-political circumstances to avoid remarking on this linking of the positive impact of immigration on the productive and reproductive health of the population. Once the impact of reduced levels of immigration, combined with a rapidly declining birth-rate, have had time to manifest themselves, the authors remarked that the country would no longer have a disproportionately high population in the productive and reproductive age group, something that is rarely remarked on publicly in current debates concerning the age profile of the UK (Dublin & Lotka, 1925, p. 328).

The 50-year gap between Dublin & Lotka's formulation of $R_0$ in demography, and the formulation with regard to epidemics by the German mathematician Klaus Dietz in 1975, is even more remarkable as Lotka worked in the fields of both demography and epidemiology. Despite this:

> It took a long time for modellers in epidemiology to realise that the formulation in terms of reproduction potential is a much clearer and more powerful concept for infectious diseases as well, which is moreover much more amenable to generalization to heterogeneous populations, and can be tied much more easily to data and hence applications. (Heesterbeek, 2002, p. 190)

Heesterbeek attributes this to the much closer link to data in the field of demography, than was the case in the early development of epidemiology. Researchers working in the field of epidemiology were "much more interested in presenting a mathematically coherent theory" than in engaging with data (Heesterbeek, 2002, p. 191). This was compounded, he suggested, when a large number of mathematicians "took over" the field of epidemiology in the early 1950s (Heesterbeek, 2002, p. 197). Unfortunately, many of these depended on a review of the field by Norman Bailey published in 1957, devoted entirely to the mathematical study of epidemic phenomena. It was unfortunate because, although it opened up the subject for mathematicians, it neglected to extrapolate from a paper by George Macdonald published in 1952 in the *Tropical Diseases Bulletin*. Macdonald was the Director of the Ross Institute at the London School of Hygiene and Tropical Medicine. He devoted his paper entirely to malaria, but also in the appendix took a more general view of epidemic phenomena, which included the "basic reproduction rate". Although Bailey had, apparently, read the paper by Macdonald, he did not recognize the potential of the definition for a much more general class of infections. It is no wonder, Heesterbeek remarks, that none of the mathematicians was enticed to read the original Macdonald papers for a number of years to come, for "mathematicians would not easily be led to read a paper in the Tropical Diseases Bulletin unless they would be told that it contained a mathematically interesting idea" (Heesterbeek, 2002, p. 197).

So, although the theory of epidemics blossomed for a number of years, by the end of the nineteen-sixties the field had come no closer to defining $R_0$. As already noted above, it was not until 1975 that the concept was finally formulated clearly within epidemiology, fifty years after it had been formulated within demography, and twenty-five years after its potential had been registered within epidemiology, even if the symbol $Z_0$ rather than $R_0$ had been used. At last, the use of the concept $R_0$ in examining the spread and control of infectious diseases with epidemiological models could start to grow.

## Conclusions

The emergence of the *R* number in multiple and dispersed sites will be no surprise to those sociologists of science who have long demonstrated the non-linear nature of scientific discovery. That said, the bifurcation or compartmentalization of demography and epidemiology in this instance is quite remarkable, not least given the existence of key figures who worked in both disciplines. However, it is perhaps reassuring that the challenges of interdisciplinary work are not limited to the social sciences. Also, it is possibly unsurprising to see the close links between a particular calculative instrument within epidemiology and the politics of health in the twenty-first century. As noted above, this linkage between medicine and governing was already established in the eighteenth century, if not before. As for the almost totemic significance of the R number, a number which turns out in fact to be a range rather than a single number; again, researchers studying accounting, management, macro-economics and no doubt many other domains have demonstrated the power of the single figure. What is somewhat unusual though, in the case of COVID-19, is the prominence such a number has rapidly achieved in popular social and political discourse.

The current crisis also reminds us more generally of the fraught relationship between expertise and government, whether in the UK or beyond. In the UK, and in the current pandemic, "Following the science" has turned out to be more a slogan than a description of policy formulation. The R number has acted here as a crucial mediating instrument, linking the health and well-being of the population with the health of the economy, and supporting arguments both in favour of and against restrictions of various kinds. As this volume demonstrates, the triptych of quantification, administrative capacity and democracy is far from harmonious. For now, perhaps the best we can hope is that if and when the pandemic finally subsides, responsibility for key decisions will be laid at the door of those who made the decisions, rather than those medics who sought to offer advice, however difficult that would have been in light of the data available. Also, and even more importantly, let us hope that not too many more people will suffer and die, or lose their jobs, before a vaccine is discovered for COVID-19.

## Notes

1. This piece was written in July 2020, when the pandemic was only a few months old.
2. Matt Reynolds, 6 June 2020, Wired. Wired is a monthly magazine based in San Francisco and focusing on emerging technologies and how they affect culture, the economy and politics.
3. These resumed briefly on 2 July (and intermittently thereafter), to address the issue of schools reopening in England with attendance becoming mandatory, quite possibly in light of the low attendance until then among those eligible to return to school. The following day the government announced that later in the year there would be White House-style daily televised press briefings.
4. John Crace, "A daily dose of world-beating waffle ends", *The Guardian*, 24 June 2020.
5. As of the time of writing.
6. See the following link for the slides and datasets displayed in these briefings: https://www.gov.uk/government/collections/slides-and-datasets-to-accompany-coronavirus-press-conferences, accessed 14 July 2020. See also https://www.statisticsauthority.gov.uk/news/covid-19-and-the-uk-statistics-system, accessed 14 July 2020.

## References


Anderson, R. M., & May, R. M. (1982a). Directly transmitted infectious diseases: Control by vaccination. *Science, 215*(4536), 1053–1060.

Anderson, R. M., & May, R. M. (Eds.). (1982b, March 14–19). *Population biology of infectious diseases. Report of the Dahlem workshop on population of infectious disease agents, Berlin*. Springer-Verlag Berlin.

Dietz, K. (1975). Transmission and control of arboviruses. In D. Ludwig & K. L. Cooke (Eds.), *Epidemiology* (pp. 104–121). Society for Industrial and Applied Mathematics.

Dublin, L. I., & Lotka, A. J. (1925). On the true rate of natural increase. *Journal of the American Statistical Association, 20*(151), 305–339.

Foucault, M. (1980 [1976]). The politics of health in the eighteenth century. In C. Gordon (Ed.), *Michel Foucault: Power/ knowledge—Selected interviews and other writings 1972–1977* (pp. 166–182). Harvester Press.

Heesterbeek, J. A. P. (2002). A brief history of R0 and a recipe for its calculation. *Acta Biotheoretica, 50*, 189–204.

Hopwood, A. G. (1988 [1985]). Accounting and the domain of the public: Some observations on current developments (The Price Waterhouse Public

Lecture on Accounting, University of Leeds, 1985). In *Accounting from the outside: The collected papers of Anthony G. Hopwood*. Garland Publishing.

Kucharski, A. (2020). *The rules of contagion: Why things spread and why they stop*. Profile Books Limited.

Miller, P., & O'Leary, T. (2007). Mediating instruments and making markets: Capital budgeting, science and the economy. *Accounting, Organizations and Society, 32*(7–8), 701–734.

Porter, T. M. (1995). *Trust in numbers: The pursuit of objectivity in science and public life*. Princeton University Press.

Rose, N. (1991). Governing by numbers: Figuring out democracy. *AccOunting, Organizations and Society, 16*(7), 673–692.

Ross, R. (1916). An application of the theory of probabilities to the study of a priori pathometry – Part I. *Proceedings of the Royal Society, London A, 42*, 204–230.

Ross, R., & Hudson, H. P. (1917a). An application of the theory of probabilities to the study of a priori pathometry—Part II. In *Proceedings of the Royal Society, London* (pp. 212–225)

Ross, R., & Hudson, H. P. (1917b). An application of the theory of probabilities to the study of a priori pathometry—Part III. In *Proceedings of the Royal Society, London* (pp. 225–240).