COVID-19

A major epidemic—or pandemic[1]—may only occur once a century, or less frequently,[2] hence unlikely to be within living memory. The present outbreak began at some point—very likely from a single source—in the last quarter of 2019. Intensive efforts are being devoted to pinpointing its origin, both temporally and geographically. It was only officially named (by the World Health Organization, WHO) on 11 February 2020. One month later it was declared to be a pandemic and, especially in the train of the severe restrictions now imposed on citizens by many governments, has almost wholly supplanted climate change (global warming) as the leading preoccupation of the public. From the viewpoint of the scholar, COVID-19 is even more multidisciplinary than climate change, encompassing medicine, virology, ecology, mathematics, surface physics and chemistry, biochemistry and molecular biology (nanobiology) and economics to name just a few—it requires a truly pandisciplinary approach.

The major question, for citizens and their governments alike, is how to respond. Despite the existence of overarching organizations such as WHO, an agency of the United Nations, there is considerable diversity in national responses (as yet, we have not seen much diversity within countries), albeit not as much as would be desirable for swiftly discovering the most effective response. Contemporary governments are, presumably, concerned above all with their own survival. In the UK, for example, it has been stated that the government would not survive if there was a large numbers of fatalities. It has also been stated that it would damage the UK's international reputation, although this is perhaps too vague an assertion to be significant. Among the representative and direct democracies of Europe, there seems to have been little thought given to maintaining, or even advancing, national ascendancy.[3] On the other hand, in China the goal of global dominance, with hegemony seen as key to the long-term survival of the ruling Communist Party, may provide the underlying policy direction. Furthermore, having a big population has been part of policy since the days of Mao Zedong.

The most common response has been the imposition of severe restrictions on the movement of citizens in an effort to limit contagion. Essentially, all activities deemed "nonessential" have been banned. Only shops and markets selling food and hardware (which includes sanitary items like soap) are allowed to remain open. Essentially the entire entertainment industry, including professional sport and restaurants, has been closed down. Motorized travel is severely discouraged; road traffic is down to a tenth or less of what it was before the pandemic, rail services have been greatly curtailed and entire airlines grounded. This has led to a significant shrinking of the economy—a decline of ten or more percent of gross domestic product (GDP) has been mooted, although it will take some time before quantification

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[1] For discussion of definitions, see H. Kelly, The classical definition of a pandemic is not elusive. *Bull. World Health Organization* **89** (2011) 540–541.

[2] The last comparable event was the outbreak of "Spanish flu" that began in 1918.

[3] Cf. J.J. Ramsden, Maintaining national ascendancy. *Nanotechnol. Perceptions* **11** (2015) 75–87.

Nanotechnology Perceptions **16** (2020) 5–15
Received 31 March 2020

doi: 10.4024/N03RA20E.ntp.16.01

is possible. Elsewhere in this issue,[4] a corollary of the known correlation between life expectancy and GDP[5] is analysed using the J-value, with the conclusion that the nation's quality of life will suffer more from a GDP reduction of greater than 6.4% than from an almost "worst case scenario" of 400,000 deaths from COVID-19 (figures for the UK). Attempts are being made to offset the anticipated economic decline by the creation of enormous amounts of money.[6] The effects are unknown, but it has been pointed out by Darryl Davies that it seems ridiculous to spend, effectively, 1.2 million GBP per person on prolonging lives that would not, perhaps, be very long anyway.[7]

Undoubtedly the disease is unpleasant. It seems to be rather contagious, with a high probability of transmission from person to person. The minimum number of virus particles needed to initiate infection is unknown. Doubtless it depends on a person's immune status. A newly infected person appears to be asymptomatic for a few days, but may nevertheless be already shedding viruses, above all from respiratory secretions, since the virus, a close relative of the coronavirus that is the agent of severe (or sudden) acute respiratory syndrome (SARS), primarily infects the respiratory passages. Unlike SARS, the result of infection with the agent of COVID-19, named SARS-CoV-2, is already labeled a disease, even though symptoms are varied, including one or more of a dry cough, fever and loss of the senses of smell and taste. These develop after a few days. Epithelial cells in the respiratory tract weakened by viral infection may then be colonized opportunistically by *Streptococcus pneumoniae*; mostly elderly patients contracting pneumonia was what was first noticed in Wuhan last December. Although mortality rises sharply with advanced age, and for those with other respiratory complaints, an increasing number of deaths among much younger and otherwise healthy people, even teenagers, is now being reported, suggesting that (epi)genetics may play a role.

The vast majority of infected people appear to recover after about two weeks. It is presumed that they then have immunity. It is not known how long the immunity lasts. Estimates of mortality rate are presently highly uncertain, partly because only hospital deaths are reliably recorded, and partly because the number of disease carriers may be far greater than the number of confirmed cases.[8] Among hospitalized patients, mostly the elderly, the mortality rate seems to be around 10%.

Modeling

The classical SIR model of an infectious disease is shown in Figure 1, and can be described by three differential equations:

$$\frac{\mathrm{d}s}{\mathrm{d}t} = -\beta s i \tag{1}$$

[4] P. Thomas, J-value assessment of how best to combat COVID-19. *Nanotechnol. Perceptions* **16** (2020) 16–40.
[5] P. Thomas, Does health spending need to outpace GDP per head? *Nanotechnol. Perceptions* **13** (2017) 17–30.
[6] J.J. Ramsden, Sovereign money. *Nanotechnol. Perceptions* **14** (2018) 3–7.
[7] D. Davies, Counting the cost. *Daily Telegraph* (21 March 2020).
[8] Confirmation presently relies upon analysis of sputum and similar materials for the presence of the RNA of the virus.

$$\frac{\mathrm{d}i}{\mathrm{d}t} = \beta si - \rho i \tag{2}$$

$$\frac{\mathrm{d}r}{\mathrm{d}t} = \rho i \tag{3}$$

where s is the fraction of susceptible people in a total population N, i the fraction of infected people and r the fraction of recovered people, with

$$s + i + r = 1\,. \tag{4}$$

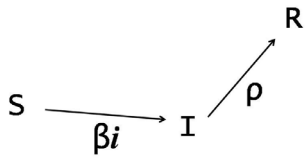

Figure 1. Kinematic diagram of the SIR (susceptible–infected–recovered) model of infection.

There is no analytical solution, but a numerical solution is straightforward. Typically s_0 (the number of susceptible people at the beginning) is set to $1 - i_0$. i_0 cannot be zero; it is realistic to consider that it is a very small number. r_0 would normally be expected to be zero.[9] This model predicts a rapid initial peak of infected people, which equally rapidly declines as the pool of susceptible people declines, to be replaced by recovered (resistant) people. By setting the right-hand side of equation (2) to ≤ 0, one obtains the *immunization criterion*

$$\frac{\rho}{\beta} \geq 1; \tag{5}$$

if it is satisfied then i cannot increase. The "reproduction number", usually labeled R_0, which is the mean number of secondary infections created by a primary infected individual, is defined as

$$R_0 = \frac{\beta}{\rho}. \tag{6}$$

A simple and straightforward way to model the infection and recovery process is as a Markov chain. I have extended the model of Figure 1 and equations (1–3) by explicitly including death as a possible outcome of infection, with probability of mortality μ, and allowing for the possibility that the immunity conferred by recovery may lapse, with probability λ (Figure 2).

[9] An interesting extension of the classical SIR model is the infectious recovery model, in which the right-hand side of equation (3) is multiplied by r. This was used by Cannarella and Spechler to model online social network (OSN) dynamics (adoption and abandonment),[10] with the prediction that Facebook activity would decline in the future, as MySpace did already. It appears that the current régime of social distancing and isolation has given OSNs a new lease of life, however.

[10] arXiv preprint available at https://arxiv.org/abs/1401.4208. It appears that this paper has never been published in a regular journal, perhaps because when it first appeared, it provoked a vast outcry among Facebook *aficionadi*, who did not, however, respond with refutation, but with rather feeble attempts to ridicule the work.

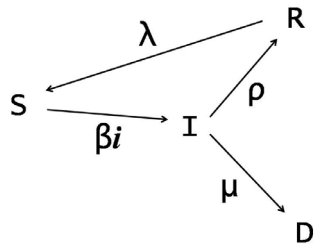

Figure 2. Kinematic diagram of the SIRD (susceptible–infected–recovered–dead) model of infection with the possibility of immunity lapsing, regenerating susceptibility.

The transition matrix is:

→	S	I	R	D
S	$1 - \beta i$	βi	0.0	0.0
I	0.0	$1 - \rho - \mu$	ρ	μ
R	λ	0.0	$1 - \lambda$	0.0
D	0.0	0.0	0.0	1.0

with which the row matrix (*s*,*i*,*r*,*d*) is repeatedly multiplied, starting with the initial conditions (0.9999985,0.0000015,0,0). The value for i_0 corresponds to 100 infected people having started the epidemic in the UK (N = 65 million) after arriving from abroad. I have not attempted to precisely fit the kinetics to data on the number of cases or deaths from the UK or any other country, not least because of the large uncertainties in these numbers, but such data has informed the choice of transition probabilities. After the SARS epidemic in Hong Kong in 2003, intensive research was carried out into many aspects of the syndrome and much useful data was gathered.[11] For example, typical numbers of daily contacts between people were established.[12] Using such data, and the fact that under conditions of normal life R_0 seems to lie between 2 and 3, I set β equal to 0.3. It is natural to consider each iteration as lasting one day. Hence, from estimates of recovery duration, ρ = 0.1, and from estimates of mortality I set μ = 0.001. In the first simulation, λ = 0. Results are shown in Figure 3 (upper left panel). It well illustrates classic SIR(D) behaviour. Infection peaks in less than 100 days and is almost over after about 150 days. No more deaths occur after 237 days. In this scenario (i.e., no action, or "business as usual") the total number of deaths would be almost 566,000, or about 0.87% of the population. To put this in perspective, in 2018 there were 616,014 deaths in the UK.[13] Allowing recovery with a probability of λ = 0.01 yields a much higher steady level of susceptible people and a significantly lower fraction of recovered people. Hence the infection never completely dies out and the number of deaths keeps rising.

[11] This may explain why Hong Kong seemed well-prepared for the COVID-19 outbreak and has been rather successful in keeping it under control.

[12] E.g. K. Leung et al., Social contact patterns relevant to the spread of respiratory infectious diseases in Hong Kong. *Sci. Rep.* **7** (2017) 7974.

[13] Another perspective is that the Black Death in 14th century Europe is estimated to have killed about 60% of the population over 7 years.

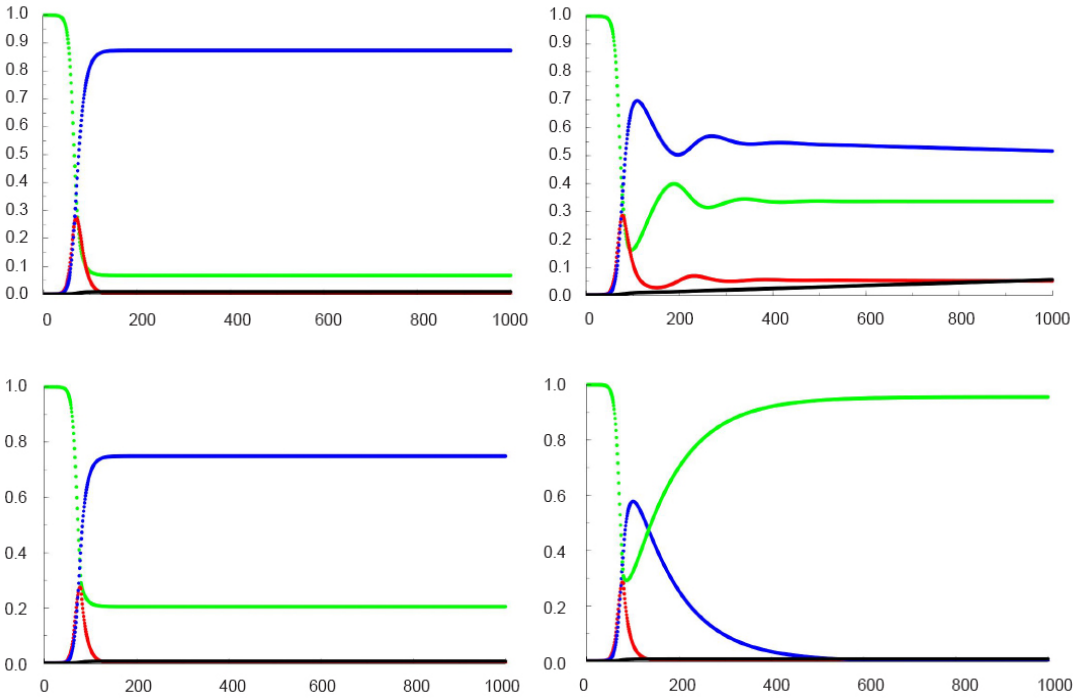

Figure 3. Results from the Markovian realization of the SIRD model. Horizontal axes: iteration number (number of days elapsed). Green points (colour online), susceptible fraction; red, infected fraction; blue, recovered fraction; black, dead fraction. Parameters are given in Table 1.

Table 1. Parameters for the SIRD model.[a]

Position[b]	β	ρ	μ	λ	d_∞
Fig. 3 UL	0.3	0.1	0.001	0.00	0.008736945
Fig. 3 UR	0.3	0.1	0.001	0.01	[c]
Fig. 3 LL	0.3[d]	0.1	0.001	0.00	0.007497489
Fig. 3 LL	0.3[d]	0.1	0.001	0.01	0.008179990

[a] i_0 was invariably 0.0000015.
[b] UR denotes 'upper right' etc.
[c] Increasing linearly by about 3300 deaths per day in the UK.
[d] Changed to 0.1 on day 80.

On 24 March 2020 "lockdown" was enacted in the UK, whereby people were essentially confined to their homes. At a stroke the number of daily contacts was drastically reduced. This is simulated by changing β to 0.1 on day 80. Qualitatively the difference is not all that great; quantitatively, significantly fewer people contract the disease and the final number of deaths is lower at 487,336, reached on day 245. The effect of lockdown is far more significant if immunity lapses. At the time of writing, whether immunity lapses, and how long such lapse

might take, is one of the big unknowns about the disease.[14] Lockdown enables the infection to be completely eliminated, albeit that it takes some time: the final death occurs on day 991, when the total number reaches 531,699. Without lockdown, 3,574,756 people or about 5.5% of the population would already have died by then.

Obviously other parameter values could be explored. Here I have just looked at those suggested by what has already been observed about the disease. Similarly, the effects of other interventions, such as lifting the lockdown after three months, and so forth, could be predicted.

Lourenço et al. (Sunetra Gupta and her group) have applied the SIR model (Figure 1) to the epidemic in the UK and Italy, fitting the parameters to the cumulative number of deaths; mortality is considered to occur with a certain probability among a subset of those infected.[15] The calculation uses a Bayesian Markov chain Monte Carlo (MCMC) approach already implemented in earlier studies by the group, with more sophistication and detail (such as distributions of attributes rather than a single value and inclusion of a category of the population vulnerable to severe disease), but the results are qualitatively similar to those of the simple model described above.

A different approach has been adopted by Ferguson et al.[16] Their model is not actually described in their report; the reader is referred to an earlier paper,[17] which also does not directly describe the model, but in the supplementary information for the paper one reads that "the model is a stochastic, spatially structured individual-based simulation, details of which have been given in past work", referring in turn to an earlier paper,[18] in the supplementary information for which a reasonably full description is indeed given. The model incorporates a great deal of microscopic detail but given the present uncertainties of the primary parameters such as infection rate and mortality one might well ask whether there is merit in introducing such a wealth of detail, especially when the price of doing so is opacity and it is difficult to validate the results. The immediate predecessor to this COVID-19 modeling effort was an influenza pandemic in south-east Asia,[18] but essentially the same model had been developed earlier for the 2001 outbreak of foot and mouth disease in the UK; it was severely criticized during the following years.[19,20]

The advantage of the simple Markov chain model is that it can be implemented and played around with by anyone with a modicum of mathematical knowledge and programming ability.

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[14] A similar effect would occur if the virus frequently mutated and was again able to infect people who had recovered from an earlier form.

[15] J. Lourenço et al., Fundamental principles of epidemic spread highlight the immediate need to large-scale serological surveys to assess the stage of the SARS-co-V-2 epidemic. medRxiv preprint available at https://www.medrxiv.org/content/10.1101/2020.03.24.20042291v1

[16] N.M. Ferguson et al., Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand (16 March 2020).

[17] N.M. Ferguson et al., Strategies for mitigating an influenza pandemic. *Nature* **442** (2006) 448–452.

[18] N.M. Ferguson et al., Strategies for containing an emerging influenza pandemic in Southeast Asia. *Nature* **437** (2005) 209–214.

[19] R.P. Kitching, M. Thrusfield and N.M. Taylor, Use and abuse of mathematical models: an illustration from the 2001 foot and mouth disease epidemic in the United Kingdom. *Rev. Sci. Technique* **25** (2006) 293–311.

[20] L.M. Mansley, A.I. Donaldson, M.V. Thrusfield and N. Honhold, Destructive tension: mathematics versus experience — the progress and control of the 2001 foot and mouth disease epidemic in Great Britain. *Rev. Sci. Technique* **30** (2011) 483–498.

Were policymakers, or their advisers, to fall into that category they could quickly themselves acquire a feeling for the implications of possible courses of action, which are anyway blunt instruments in mathematical terms. The detailed and sophisticated models created by teams of "experts" could then be used for confirmation and refinement.

Public health policy

The classic policy measures for dealing with a pandemic are mitigation and suppression. At its crudest, the former may be little more than organizing the prompt and efficient removal of the bodies of those who succumb to the disease. By the time of the Great Plague in England (1665–6), even though man was still ignorant about the microbial causes of infectious diseases, sensible suppression measures were enacted, such as the University of Cambridge sending home its students. One happy outcome was that Isaac Newton, sitting in the garden of his family home at Woolsthorpe, observing the fall of an apple in contemplative mood, suddenly had the idea of gravity.

Lockdown is a drastic suppression measure and, as we have seen, it is effective in reducing transmission from human to human. In city states, such as Hong Kong and Singapore (which also benefited from having been epicentres of SARS in 2003 and hence acquired valuable and directly relevant experience) it has been complemented by a minutely organized system of tracing individuals known to be infected and their contacts, and placing them in quarantine. This relies on having adequate testing capacity. The test for infection is based on identifying the known RNA sequence of the virus, and although a little cumbersome, is routine and reliable. It is hoped in the fairly near future to complement it by a test for "recovered" status, by identifying the presence of specific antivirus antibodies in the blood. Germany, a large country with a legendary capacity for good organization, has also adopted this strategy.

Modern mitigation methods include drugs for curing a disease, such as antibiotics against bacterial infections. Similarly, molecular targets are available for viruses.[21] The rapidity of the emergence of COVID-19 has, however, meant that no specific drug against it is currently available. In any case, many infected people recover without the need for any drug and only relatively mild symptoms. Those more severely affected, who often have comorbidities, are likely to require hospitalization. A particularly unpleasant aspect of COVID-19 is the onset of acute respiratory distress syndrome (ARDS),[22] albeit often presented in atypical form. For this, intensive care is required in the hospital.

Vaccination falls somewhere between the extremes of mitigation and suppression. It is an intervention that immediately converts people from "susceptible" to "recovered" status without having to go through the intermediate status of being infected. However, given that no vaccine is currently available, nor is one likely to be in the near future, the intervention remains hypothetical.

Maintaining a healthy population makes sound economic sense. One can discern from the debates around the inauguration of the UK's National Health Service the sentiment (among others) that "a healthy worker is a more productive worker than an unhealthy one".[23] Indeed,

[21] J.S. Oxford et al., New antiviral drugs, vaccines and classic public health interventions against SARS coronavirus. *Antiviral Chem. Chemotherapy* **16** (2005) 13–21.
[22] M.A. Matthay, J.M. Aldrich and J.E. Gotts, Treatment for severe acute respiratory distress syndrome from COVID-19. *Lancet Respiratory Med.* (published 20 March 2020).
[23] J.J. Ramsden, A National Health Service. *J. Biol. Phys. Chem.* **18** (2018) 63–66.

some would argue that the economic justification is the sole reason for government involvement in health. Collateral benefits of good health, such as happiness and general well-being, are properly matters for the individual to deal with.[24] Given that the correlation between life expectancy and GDP (the Bristol curve) is well established,[5] it is surprising that the governments of developed countries have opted for draconian suppression measures for which there is a very severe economic price to pay.[25] As already mentioned, an analysis elsewhere in this issue thoroughly elaborates on the health implications of economic contraction.[4] To be sure, the Bristol curve was established by many decades of gradual improvement of health, brought about by better sanitation and diet as well as advances in medicine,[26] whereas now we have an extraordinarily sudden change, exceeding even the speed of onset of the recession that followed the financial crisis around 2008.[27] The present emphasis on social distancing and complete self-isolation of the elderly may in itself increase mortality,[29] albeit that the cited study was carried out long before the era of online social networks.

It could perhaps be argued that the primary motivation for the draconian lockdown measures was to limit the numbers of workers, especially in essential industries, who would be at least temporarily incapacitated through becoming infected. This could also be modeled but I have not seen any attempts to do so. It has been asserted that the reason for the abrupt change in UK government policy from, initially, a path similar to that still being followed by Sweden to one more akin to that being followed by France was the realization that without drastic suppression of transmission the nation's health services would have been swiftly overwhelmed. This, it was felt, would lead to scenes at hospitals deemed wholly unacceptable by the general public. Hence the emergence of the curious mantra "Protect the NHS", a service that was conceived in order to protect the population. The policy has been successful, although practically nothing apart from dealing with COVID-19 patients is now being done in UK hospitals. It should certainly be pointed out that the high incidence of ARDS, requiring intensive care and hence consuming significant hospital resources, among COVID-19 patients was not appreciated in the early days of the outbreak.

Underlying the lockdown policy, deeper than protecting the NHS, appears to be the desire to minimize the loss of life from the pandemic. This comes at a time when the population of the UK has never been greater. As a corollary, nor has the substitutability of individuals ever been greater. One sees this in the ever-decreasing duration of time in office. One would have thought that this would have made it easy for people to acquiesce in a temporary doubling of the death

[24] Similarly, it is a matter for the individual to weigh the disbenefits of ill health induced by lifestyle choices against the pleasures arising from those choices.

[25] At the time of writing, Sweden is a notable exception.

[26] Diet is perhaps disputable; for many decades or even centuries the trend towards less fibre, more sugar, fewer vegetables, fewer vitamins, less variety, more processing and refrigeration etc. etc. may have resulted, overall, in a less healthy diet than formerly.

[27] In fact, although there were short-term negative impacts, such as a great increase in suicides, there was a surprising range of positive benefits, including declines in deaths from liver diseases and road accidents.[28]

[28] V. Toffolutti and M. Suhrcke, Assessing the short-term health impact of the great recession in the European Union: a cross-country panel analysis. *Preventive Med.* **64** (2014) 54–62.

[29] L.F. Berkman and S.L. Syme, Social networks, host resistance, and mortality: A 9-year follow-up study of Alameda County residents. *Am. J. Epidemiol.* **109** (1979) 186–204.

rate. Behavioural insights have been used to assess the practicability of a lockdown, and to direct appropriate behavioural nudges; they could equally well have been used to make the mortality consequences of "business as usual" acceptable. Most glaringly in the case of motorized road traffic, almost since its inception the annual occurrence of thousands of fatal accidents has been accepted as the price worth paying for the convenience of the private motor-car, hence there would be nothing anomalous in applying similar reasoning to the response to COVID-19.

Perhaps one has to go even deeper to understand the prevailing outlook—*l'obsession de la santé parfaite*, as eloquently expounded by Ivan Illich.[30] Neither old age, nor pain, nor death—instead, the prolongation of life to infinity, an attitude which Illich considered to have started to develop during the latter part of the 20th century. Perhaps only this can explain the policies that we see unfolding around us. Yet, when those whom the policies are ostensibly designed to protect most of all start to call them ridiculous,[7] perhaps we are headed towards a rethink.

(In)competent government?

Uniquely in Europe, perhaps only Britain possesses a vigorous tradition of scrutiny and criticism of government. Switzerland, that bastion of direct democracy, is perhaps in second place.[31] Especially since the draconian lockdown that began on 24 March, there has been a good deal of entirely justified censure of manifest administrative mediocrity at the highest levels and thence in more detail, such as: the absence of checks of passengers arriving from overseas regions known to be heavily infected; significantly reducing the number of trains running on London's underground railway system, because of the significant reduction in the number of travelers, but thereby making it impossible for passengers to observe social distancing; the paucity of reliable and systematic testing of individual infection; general confusion about what is "essential" (supplies and activities); repeated changes needed in the economic support measures as errors and omissions were pointed out (at least in that case the Treasury listened to criticism); and, overall, seemingly an almost complete lack of preparedness for a pandemic. There are many incongruities about this state of affairs.[32] One is that the top officials of the "quangos" supposedly taking the lead in responding to the crisis are extremely well paid; their salaries are around ten times the median. Yet nowadays most professional lawyers, scientists, engineers or medical doctors find that they possess a level of competence far above those manifested by these top officials, Secretaries of State (let alone ministers) and so forth. To counter this disparity it has long been the custom for high-ranking ministers and other officials to appoint advisers. One thinks, for example, of François Leclerc du Tremblay, adviser to Cardinal Richelieu. Both were extraordinarily eminent by global standards. Move on 400 years

[30] I. Illich, L'obsession de la santé parfaite. *Le monde diplomatique* (March 1999) p. 28. See also the author's *Medical Nemesis*. New York: Pantheon Books (1976).

[31] There has been remarkable progress in recent years, as evinced for example by the publication of *Die Schweizer KZ-Häftlinge. Vergessene Opfer des Dritten Reichs* by B. Spörri, R. Staubli and B. Tuchschmid. Zurich: NZZ Libro (2019).

[32] Which is far from new. See, for example, J.J. Ramsden, The role of systems thinking in modern society. *Nanotechnol. Perceptions* **14** (2018) 90–98. Since then there have been many further examples, notably during and after the severe flooding in the winter of 2019/20, especially concerning the Environment Agency.

and one can barely recognize an analogy. The present process for appointing these advisers is obscure. It is obviously not on merit—and indeed should not and can not be, for no one at the top of his or her profession would wish to give up independent work to become a bureaucrat.[33] The erosion of standards may have already begun after the First World War. For example, Keyserling wrote in 1928, "A Dresden bookseller once said to me: 'Before, when we still had a King, I could close up my shop and go home and look up at the lights in the castle with a feeling of security; on holiday evenings *he* was still at work, on things beyond my understanding. Today I feel insecure'."[34] In 2012 my erstwhile colleague Frank Taylor wrote, "What should be avoided at all costs is giving information that can easily be checked and found to be misleading. This makes the Government and the Civil Service look foolish and incompetent ... I feel it necessary to point out that in my younger days I had considerable correspondence with the authorities concerning various safety matters and I almost invariably received a serious and considered reply. Often I did not fully agree with the reply but that was fine, the door was open for intelligent discussion ... Somehow this standard and quality of response seems to have been lost".[35]

The aftermath

The conventional view is that the economy will come roaring back as soon as restrictions are lifted—the so-called "V-shaped" recovery. It is hard to envisage this really happening. Although the lockdown has been in force for only a short time (it already seems much longer!) new habits formed in the coming weeks will likely persist for years. People will feel uncomfortable in the presence of large numbers of other people and this discomfort will surely outweigh the pleasure of, say, dining in a restaurant. And even before the pandemic, sitting next to a random person on a long intercontinental flight was a fairly reliable recipe for acquiring at least the common cold. Those who, initially perhaps rather unwillingly, had to start working for their employer from home are rapidly adapting and after a few weeks they may not wish to return to the old routine, especially if it involves traveling in a packed train. Nearly all children have had to try home schooling, formerly so rare as to be almost eccentric, and doubtless many advantages are being discovered.

Given that we still know so little about the disease, especially about how durable recovery from infection will be, it is perhaps premature and overly speculative to make such predictions. But, in any case, "roaring back" is not even desirable. So many things were wrong before the pandemic, and yet unreformable because of the ramified inertia of our social, political and economic system, it would be tragic not to use the opportunity to enact widespread reform.

Ideally, such reform should start at the bottom. The habit of asking ourselves whether a journey is really necessary may have already become ingrained. Do we really wish to return to the former level of road traffic, with its endemic traffic jams? The new tranquillity of our towns

[33] In this regard Switzerland does rather better than the UK because the old tradition of the *Milizsystem* still persists—experts normally working in industry or academia are seconded for short periods to serve as honorary advisers to political leaders (so named after the system for fulfilling military service).

[34] H. Keyserling, *Europe* (tr. M. Samuel), p. 115. London: Jonathan Cape (1928).

[35] Letter to the UK Department for Transport (16 August 2012).

is a delicious luxury not to be given up lightly. In shopping we have learned, through necessity, what we can do without—and despite the attention given to remanufacture and recycling, doing without is the most important action we can contribute to sustainability, followed by reuse and repurposing, at which we are also becoming adept. This is what we must do to achieve the circular economy.[36] What may have taken decades to introduce may now be realized in less than a year.

Past pandemics of plague were generally beneficial to labour, because the resulting shortages made it more precious, causing wages to rise and resulted in more favourable contracts for the worker. Stahel long ago pointed out the merits of substituting labour for energy.[37] A pandemic was not the way he envisaged introducing the performance economy,[38] but it looks as though it will be by far the most effective way.

Much will become irrelevant. David Cameron's "bonfire of the quangos", effete before it was even ignited, will be enacted far more effectively than even its most ardent patrons dared to hope. A different approach will be needed to provide seasonal labour for fruit picking. Perhaps a compulsory "volunteer week" could be brought in—much as Soviet scientists had to spend a fortnight harvesting potatoes in the autumn. It was generally felt to be an enjoyable break in a refreshingly different environment.

Very likely the "green" agenda has permanently lost the leading position it had achieved just before the pandemic. At a stroke carbon dioxide and other polluting emissions have been drastically cut without any special effort by its advocates. The survival of civilized humanity has been swiftly perceived to be far more multifaceted than zero carbon alone.

The pandemic has dealt with different countries and different groups within each country very unequally. Those countries that will turn out to be the most resilient and best placed to be the new global leaders will be those that find the way to a new spirit of social solidarity, between groups and between generations, in which all can play their part according to ability.

J.J. Ramsden

[36] W.R. Stahel, *The Circular Economy: A User's Guide*. Abingdon: Routledge (2019).
[37] W.R. Stahel and G. Reday-Mulvey, *Jobs For Tomorrow: The Potential for Substituting Manpower for Energy*. New York: Vantage Press (1981).
[38] W.R. Stahel, *The Performance Economy* (2nd edn). Basingstoke: Palgrave Macmillan (2010).