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The Independent Scientific Advisory Group for Emergencies (SAGE)

The Independent SAGE Report

COVID-19: what are the options for the UK?

Recommendations for government based on an open and transparent examination of the scientific evidence

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Submitted to The UK Government and the People of Great Britain & Northern Ireland by Sir David King, former Chief Scientific Adviser, UK Government, Chair of Independent SAGE

Independent SAGE Report of 12th May 2020

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Preamble

On 4 May 2020 a 13-strong committee convened by former UK government Chief Scientific Adviser Sir David King discussed some aspects of the science behind the UK strategy in a two and a half hour meeting. Leading experts in public health, epidemiology, primary care, virology, mathematical modelling, and social and health policy, raised ideas and issues for consideration which we are pleased to share.

We recognise the enormous efforts of many in the development of new vaccines and therapies, which may be critical to long term control of this pandemic. Our report does not aim to critique such work. Rather, we recognise that such solutions will take time and will still require an appropriate public health infrastructure to maximise their benefit. This is the focus of our first report and the meeting aimed to offer some constructive ideas to the governments of the UK and the devolved nations about how best to tackle this crisis, to save lives, suppress the coronavirus and get the economy moving again.

Executive Summary

Our Independent SAGE focuses on the priorities for measures to be taken to support a gradual release from social distancing measures through a sustainable public health response to COVID-19. This will be essential in suppressing the virus until the delivery of an effective vaccine with universal uptake. We do not address, except as it is directly relevant, the clear structural and procedural weaknesses that contributed to the current situation as we expect these to be addressed in a future inquiry. We draw extensively on the policy considerations proposed by the World Health Organization, which provide a clear structure on which an effective policy should be based given the inevitability that the virus will continue to cross borders.

Our main recommendations are:

1. The government should take all necessary measures to control the virus through suppression and not simply managing its spread. Evidence must show that COVID-19 transmission is controlled before measures are relaxed. We detect ambivalence in the government's strategic response, with some advisers promoting the idea of simply 'flattening the curve' or ensuring the NHS is not overwhelmed. We find this attitude counter-productive and potentially dangerous. Without suppression, we shall inevitably see a more rapid return of local epidemics resulting in more deaths and potentially further partial or national lockdowns, with the economic costs that will incur.
2. The government should refocus its ambition on ensuring sufficient public health and health system capacities to ensure that we can identify, isolate, test and treat all cases, and to trace and quarantine contacts. Quarantine should be for 14 days and not seven. The government must develop a clear quarantine and messaging policy which takes account of the diversity of experiences of our population, variations in household structures, and with appropriate quarantine facilities in the community. This should be accompanied by real time high quality detailed data about the epidemic in each local authority and ward area.
3. Government ministers, NHS bodies and their officials should adhere to the Code of Practice for Statistics and the UK Statistics Authority should reports breaches of the code. There is concern about inaccurate, incomplete and selective data presented by government officials at the daily PM press briefings. We recommend the involvement of statisticians responsible for analyses, and the Office for Statistics Regulation should publish further assessments of these data. The UK Statistics Authority, an independent body responsible for oversight of the statistics produced by the Office for National Statistics and other government departments and public bodies has a Code of Practice. The Code requires i) trustworthiness: confidence in the people and organisations that produce statistics and data, ii) quality: data and methods that produce assured statistics and iii) value: statistics that support society's needs for information. It is vital the public has trust in the integrity and independence of statistics and that those data are accurate, timely and meaningful.
4. The government evaluates alternatives to complement conventional epidemiological modelling, such as dynamic causal modelling—e.g., via the expertise established by the RAMP initiative. Dynamic causal modelling (DCM) enables real-time assimilation of data quickly and efficiently to estimate the current levels of infection and ensuing reproduction rates (R). The computational efficiency of DCM may allow pressing questions to be answered; for example, would a devolved social distancing and surveillance policy—based on local prevalence estimates—be more efficacious than a centralised approach? In short, there is a pressing need to evaluate alternative approaches (and hypotheses) that may support real-time policy-making.
5. Recognising the centrality of human behaviour in virus transmission, the government should ensure that as social distance measures are eased, measures are taken to enable population-wide habit development for hand and surface disinfection, using and disposing of tissues for coughs and sneezes and not touching the T-zone (eyes, nose and mouth).

6. Outbreak risks must be minimised in high vulnerability and institutional settings. No-one should be discharged from hospital to another high-risk setting such as a care home without having been tested and found to be non-infectious. The government should rapidly invest in the elimination of transmission in the currently recognised "high risk" settings, including but not limited to social care and health service facilities, prisons and migrant detention facilities, homes with multiple occupancy, and households that are overcrowded or contain multiple generations. This includes staffing, testing, protective equipment and guidance for effective household isolation. Community facilities and requisitioned hotels are likely to be needed to house a significant proportion of infected people and their contacts.
7. Ensure preventive measures are established in workplaces, with physical distancing and support to enable personal protective behaviours. Health and safety regulations appropriate for COVID -19 suppression and adequate surveillance should be agreed with trade unions and other staff representatives, with sanctions that are large enough to deter unsafe practices. There should also be a facility for workers to report unsafe working conditions, with no victimisation for those using it.
8. There must be reform of the process of procurement of goods and services to ensure responsive and timely supply for primary and secondary care, and community infection control, in anticipation of a second wave of infection. This reform must take account of the documented challenges and failures of procurement over the last three months.
9. Managing the risk of importing cases from other countries, with consequent high-risk of transmission, is vital. This should be introduced as soon as possible, treating Great Britain and the island of Ireland as distinct health territories. We welcome the government's recent commitment to establish a port control and quarantine strategy as an adjunct to other control measures. Managing the testing, thermal assessment, collection of contact details and quarantine facilities, such as requisitioned hotels, will be essential to stop imported cases.
10. Communities and civil society organisations should have a voice, be informed, engaged and participatory in the exit from lockdown. This pandemic starts and ends within communities. Full participation and engagement of those communities on issues such as childcare and public transport will assist with enabling control measures. Conversely, a top-down approach risks losing their support and trust. We are deeply concerned about the effects of the infection and the lockdown on BAME, marginalised, and low-income groups. There is an urgent need for government to demonstrate such active participation from communities from around the country.
11. The government should take steps to ensure all children, irrespective of their backgrounds, have access to technology and internet at home, and where required additional learning support which does not rely on parents at home. The government should also ensure that resources are available for schools to conduct remote learning. The closure of schools due to the COVID-19 pandemic has caused unprecedented challenges for everyone involved – students, teachers and parents- but we are particularly concerned about the detrimental impact (and widening of educational inequalities) of long-term social distancing measures on learning for children from lower socio-economic backgrounds. Education is a human right which should not be compromised in the context of COVID-19.
12. The government must ensure that health and social care services are planned, strengthened, and prepared for future waves of infection while continuing to provide the full range of services to all. For health services, this will require planning to ensure there are capacity and resources to meet need safely and to resume elective services including hospital, mental health and community health services. For social care this will require having accurate data on all staff and needs of residents; making good the serious shortages in staffing, increasing qualified staffing levels, and ensuring all staff terms and conditions of services include full sickness benefits when they fall ill.
13. The government should rapidly strengthen the social safety net, including addressing low income benefits and housing, thereby ensuring protection of the most vulnerable in our population. It is

now clear that COVID-19 has disproportionately affected older people, low income groups living in deprived areas, BAME communities, and those who are otherwise marginalised. We also note the over-representation of BAME communities as low paid care workers in health and social care settings which makes them vulnerable to COVD-19-related infection and deaths.

14. The management of often multi-organ COVID-19 disease has been based in hospital and ICU settings. Hospitals have had to radically alter non-COVID patient flows in order to deal with these pressures, and Nightingale facilities have also needed to be developed. There is clear evidence of increasing non-COVID mortality in association with the pandemic. The government should work with the Royal Colleges and professional societies to ensure that capacity and treatment guidance is updated and disseminated as evidence emerges.
15. There should be a re-evaluation of current plans to reduce overall hospital beds in the NHS per head of population and consider ICU bed and staffing requirements to provide future surge capacity. We also recommend a rapid engagement with primary care and community health settings to support those recovering from COVID-19 disease, and the sequelae, including mental health problems, as well as support to rapidly identify and manage future local outbreaks.
16. The government should urgently review and improve co-ordination in the response to the pandemic across the multiple bodies tasked with pandemic planning, both within England, including different government departments, the NHS, PHE, and local authorities, and others, among the Westminster and devolved administrations.
17. In order to underpin our recommendations, the future long-term management of the pandemic should be based on an integrated and sustainable public health infrastructure. The government has adopted a top-down approach with vertical structures for test and trace programmes. The over-dependence on outsourcing of key operational functions limits the sustainability of this approach. A more appropriate infection control response will require adaptation for local needs. Leadership from local public health and primary care professionals is essential. We do not specify which organisations should be responsible for these roles and functions as this will vary in the four nations of the United Kingdom but, in each of them, there should be a clear system map setting out responsibilities, accountability, and lines of communication.
18. In the longer term we recommend that legislation to enable an integrated National Health and Social Care System for England is considered, along the lines of the NHS in Scotland and Wales and the integrated NHS and social care system of Northern Ireland.
19. The Independent SAGE will continue to meet to consider some of these specific recommendations and to offer constructive solutions to government to ensure that the coronavirus is suppressed, that lives are saved and that the economy is able to recover as rapidly as possible.

The current state of knowledge.

After the first cases of SARS-CoV-2 community transmission within the UK on 28th February 2020, an exponential growth in cases followed until growth flattened following lockdown. To date (12 May 2020), the UK has had well over 215,000 confirmed cases and 31,000 deaths, with both certain to be underestimated. While debate about how best to measure the disease burden continues, it is clear that, whether measured by seasonally adjusted excess mortality or deaths per million population, the UK has experienced one of the highest COVID-19 death rates in the world. Even taking into account a range of proposed explanations, such as population density or timing of the epidemic, it is clear that the UK can and must do better in preventing as many infections as possible and protecting our disadvantaged and vulnerable populations as we emerge from lockdown.

It is easy to forget that we are only five months into the existence of this new human virus infection and many questions remain. It has taken many years of detailed biological, clinical, and epidemiological studies to generate a strong evidence base of understanding prevention, treatment and immunity for other infections. By contrast, despite more than 4,000 peer reviewed research publications since January, we remain pretty much in the dark regarding the nature of immunity, the pathogenesis of disease, optimal diagnostic tests, its transmission pathways and duration, and appropriate prevention, treatment and vaccines. Despite this uncertainty, we need to develop recommendations for UK control and management of the pandemic based on current knowledge and first principles, to limit further loss of life and economic hardship.

What is known?

Susceptibility: Given that this is a new virus, scientists have assumed 100% population susceptibility. This may be true, although studies of outbreaks on cruise ships, for instance, demonstrate less than 50% attack rate.[1] Overall susceptibility therefore remains unclear, and it is possible susceptibility grows with age,[2] with young children in particular having reduced risk of infection. Nevertheless, those highly exposed, such as health care workers, and household contacts, are more likely to become infected.

Infectivity: Infected individuals are most infectious from 2-3 days prior to onset of symptoms to around 7 days after onset.[3] Up to 40% of transmissions may come from those who are asymptomatic, creating a challenge for optimal interruption of transmission.

Disease: Age, co-morbidities such as hypertension, heart disease, respiratory disease, diabetes, obesity, and factors such as socio-economic disadvantage and BAME are all associated with higher risk of disease severity.[4] However, caution is needed in interpreting the available evidence because of uncertainties about causal pathways involving multiple risk factors where there are risks of confounding or collider bias that could produce misleading conclusions.

Diagnostics: PCR from throat/nasal swabs remains the gold standard for diagnosing infection, although even in the absence of a positive test a characteristic clinical and radiological presentation can be used as a diagnosis. The role of antibody tests in acute diagnosis appears very limited at present. However, once they have been assessed to be of sufficient sensitivity and specificity these tests will be useful for population estimates of exposure. Their role in providing "immune passports" remains unclear for three main reasons. Firstly, we do not know whether antibodies fully protect from subsequent infection; secondly, we are not confident that these immune responses are durable; and thirdly a policy of "immune passports" might actively encourage people to get infected, particularly the economically vulnerable who need to work.

Prevention: There is good evidence for the effectiveness of increasing protective behaviours of social distancing and hand cleansing, less for interventions to increase appropriate tissue use, not touching eyes, nose and mouth, disinfecting surfaces and wearing face masks in the community. There is good evidence for the effectiveness of wearing personal protective equipment in high-risk situations.

Treatment: There remains scanty evidence for efficacy of any drug therapy. Effective therapy is likely to include a combination of antiviral treatment, life sustaining therapy, including support for respiratory and renal function as appropriate, treatment to reduce the effects of the virus on different tissues, for example by stabilizing endothelial cells, and damping of the hyperimmune response seen in severe cases. In the first category, a phase 2 trial of combination of interferon beta-1b and two types of antiviral therapy, lopinavir–ritonavir, and ribavirin, achieved alleviation of symptoms and shortened the duration of viral shedding and hospital stay in patients with mild to moderate COVID-19, although as the authors noted, a larger trial is needed.[5]

Vaccines: Very rapid vaccine development in underway, with early clinical trials in progress. However, it may take 12 months or more to demonstrate clinical efficacy, and there is no certainty that we can depend on this route out of the pandemic. A challenge is that the candidate vaccines are using a very wide range of approaches, including nucleic acid (DNA and RNA), virus-like particles, peptides, viral vectors (replicating and non-replicating), recombinant proteins, live attenuated viruses, and inactivated virus approaches.[6] Several of these draw on methods used in other fields, such as immunotherapy for cancer, and have not been used previously for viral vaccine production.

Multiple epidemics: The COVID-19 pandemic is not just one large homogenous epidemic. It is made up of hundreds, if not thousands, of outbreaks, each at a different stage, in progress throughout the country. Whereas England had its first confirmed cases on 30 January and its first death was reported in early March, Scotland did not have its first confirmed cases until 1 March, via a traveller returning to Tayside from Northern Italy, and its first death until 17 March. Some parts of Scotland and, indeed England (like Rutland, Hartlepool and Blackpool and Isle of Wight) had no reported cases until late March or early April. Molecular epidemiological studies confirm multiple introductions of virus into the UK. Serological surveillance to understand progression of the pandemic is now underway through several initiatives. Coordination of these efforts is required.

The International Context

By 24 February, the World Health Organization (WHO) had published a compelling and informative WHO China mission report – but as the WHO assistant director general, Bruce Aylward, commented: '*Much of the global community is not yet ready, in mindset and materially, to implement the measures that have been employed to contain COVID-19 in China'.* He went on to say: '*These are the only measures that are currently proven to interrupt or minimize transmission chains in humans. Fundamental to these measures is extremely proactive surveillance to immediately detect cases, very rapid diagnosis and immediate case isolation, rigorous tracking and quarantine of close contacts, and an exceptionally high degree of population understanding and acceptance of these measures.'*

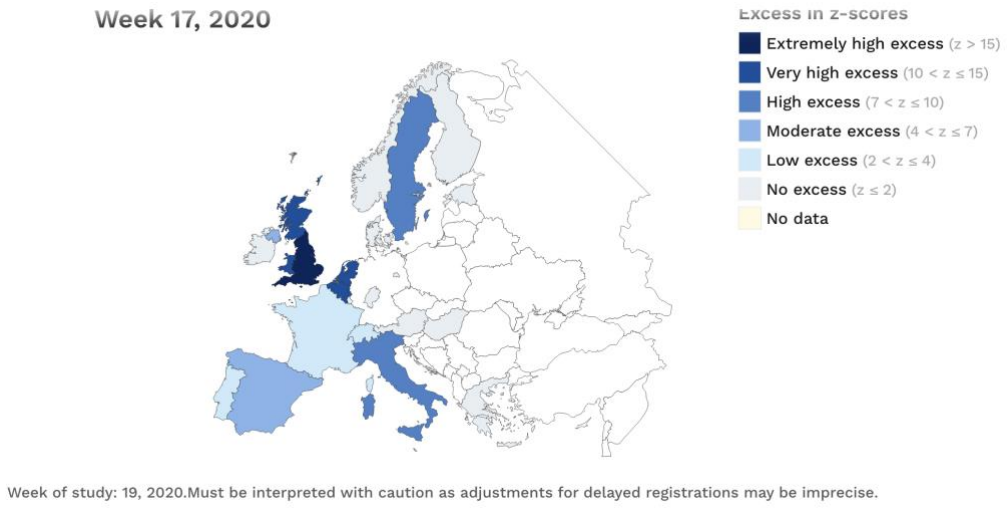
How has the UK done?

Inevitably, there has been much interest in comparisons of the course of the pandemic in different countries. Thus, in its daily press briefing, the UK government regularly presents graphs showing the number of cases in the UK and in other countries. The data presented indicate that the UK is experiencing one of the most severe epidemics in Europe. However, ministers, other politicians, and political commentators have stressed the limitations of such comparisons, invoking arguments such as differences in population density, age distribution within the population, and extent of trading links.

We recognise that there are many limitations to these data. Professor Sir David Spiegelhalter has raised concerns about constructing league tables of deaths at a time when mortality data collection methods vary across countries. But he has also pointed out that useful international comparisons can nonetheless be made at this stage. We agree.

It is important to take account of differences in how data are reported, with some countries measuring only deaths in people that have had a positive test, and some only those occurring in hospitals or care homes. The problem can be seen from an analysis undertaken by The Economist, which started from the number of seasonally adjusted excess deaths in a country. In the absence of any alternative explanation, it is likely that most of these are caused directly by COVID-19, while some may be associated with the unintended consequences of countermeasures, especially those who should attend hospital for an acute and serious condition but do not. The figures calculated by The Economist show that the percentage of all excess deaths attributed to COVID-19 varies considerably, as follows: Germany 97%; France 93%; Sweden 91%; Belgium 87%; Spain 71%; UK 54%; The Netherlands 51%. We also know that things can change. For example, until recently, the UK only reported deaths in hospital but now also reports those in care homes too. Given these challenges, there is a strong case for focusing attention on weekly figures for excess all-cause age and seasonally adjusted mortality, based on data reported by ONS. For European comparisons, data can be obtained from the website of the EUROMOMO project (Figure 1), although caution is required because of time lags in reporting, as in Ireland, and incomplete coverage of some countries such as Germany.[7] Other data using this approach are collated by the Financial Times, which include both countries beyond Europe and sub-national comparisons in some, such as the UK, USA, and Italy. Using their data, the most striking comparison is the difference between countries that took action quickly (S. Korea, Hong Kong, Japan, China, Taiwan, Singapore, Vietnam, Thailand, Greece, Germany, Norway, Denmark) and those that did not (Italy, Spain, UK, Netherlands, Sweden, Brazil and the USA).

Figure 1 Excess mortality in European countries reporting to EUROMOMO



Source: https://www.euromomo.eu/graphs-and-maps/

Given the limitations of the existing data, we recommend that mortality attributable to the pandemic is most appropriately tracked by means of weekly age and seasonally adjusted excess all-cause mortality. We are aware that discussions are taking place among European statistical offices to enable the publication of timely data and we urge the government to engage with other countries through appropriate multinational mechanisms to advance this process. Ideally, these data should be reported at subnational level in large countries. Thus, using data published by the Financial Times, we can see that Italy was successful in limiting excess all-cause mortality to under 50% of what would be expected normally in all but four of its 20 regions, while the UK has a much more generalised epidemic, with excess mortality exceeding this figure in seven of the 12 reporting units.

In the meantime, recognising the exceptional efforts that ONS are putting into reporting data on a timely manner, we hope that further analyses be undertaken to understand better the contribution of COVID-19, through its diverse direct and indirect effects, to the overall excess mortality being observed.

Learning from others

While most countries are adopting broadly similar policies, with a few notable exceptions, there are some individual differences and they are progressing at different rates. We commend the various international initiatives to bring together the necessary evidence, such as the COVID Response Monitor website produced by the European Observatory on Health Systems and Policies and European Regional Office of the World Health Organization,[8] as well as work by OECD. We note statements that the government is learning from the experiences of other countries, but we would wish to see more detailed evidence of how this learning is feeding into UK policies.

Some examples of where we believe that the UK could have learnt lessons include the experience of South Korea, which rapidly expanded their testing programme on 22 February when they had suffered just three deaths and 433 confirmed cases. They did not undertake more than 19,000 tests on any single day however, and they introduced only a partial lockdown in two of the 17 provinces. They also used a digital app to help monitor symptoms from cases and contacts, and to monitor quarantine. They suppressed their new cases within three weeks. So far, they have had 256 deaths in a population of 51 million, with only seven cases reported per day over the past week.

Greece introduced a partial lockdown on 27 February when their first three cases were reported without a death, and a full lockdown on 22 March when they had 624 confirmed cases and ten deaths. On 7 May they had suffered 148 deaths from a population of 11 million, with only 15 cases reported.

By contrast, in the UK the government pivoted community testing and tracing towards hospitals on 12 March when we had eight deaths and 459 confirmed cases. On 13 March Sir Patrick Vallance said "Our aim is to try and reduce the peak, broaden the peak, not suppress it completely; also, because the vast majority of people get a mild illness, to build up some kind of herd immunity so more people are immune to this disease and we reduce the transmission, at the same time we protect those who are most vulnerable to it. Those are the key things we need to do" The policy revised again shortly after and national lockdown was imposed on 23 March when confirmed cases had risen to 8,164 and we had seen 423 deaths. By 7 May we had suffered 30,689 deaths, 207,977 confirmed cases and 5,064 new daily cases on average during the previous week.

Transitioning from lockdowns and closures

The World Health Organisation has published detailed guidance on transitioning from lockdowns and closures.[9,10] It sets out four key components to managing transitions and modulating restrictive measures, six conditions that should be used as the basis to implement transitioning measures, and four cross-cutting mechanisms. We believe that these provide an appropriate, evidence-based framework for action and we have structured our report around this guidance, and specifically the six conditions for easing restrictions, adapting them to the situation in the United Kingdom. The guidance is as follows:

Four key components to managing transitions and modulating restrictive measures
1. Public health and epidemiological considerations must drive the decision-making process.
2. Available capacity for dual-track health system management to reinstate regular health services, while at the same time continuing to address COVID-19.
3. Leveraging social and behavioural perspectives as tools for responsive engagement with populations.
4. Social and economic support to mitigate the devastating effects of COVID-19 on individuals, families and communities.
Six conditions should be used as the basis to implement/adapt transitioning of measures
1. Evidence shows that COVID-19 transmission is controlled.
2. Sufficient public health and health system capacities are in place to identify, isolate, test and treat all cases, and to trace and quarantine contacts.
3. Outbreak risks are minimized in high vulnerability settings, such as long-term care facilities (i.e. nursing homes, rehabilitative and mental health centres) and congregate settings.
4. Preventive measures are established in workplaces, with physical distancing, handwashing facilities and respiratory etiquette in place, and potentially thermal monitoring.
5. Manage the risk of exporting and importing cases from communities with high-risks of transmission.
6. Communities have a voice, are informed, engaged and participatory in the transition.
Four cross-cutting mechanisms that are essential enablers throughout the transition process
1. Governance of health systems.
2. Data analytics to inform decisions.
3. Digital technologies to support public health measures.
4. Responsive communication with populations.

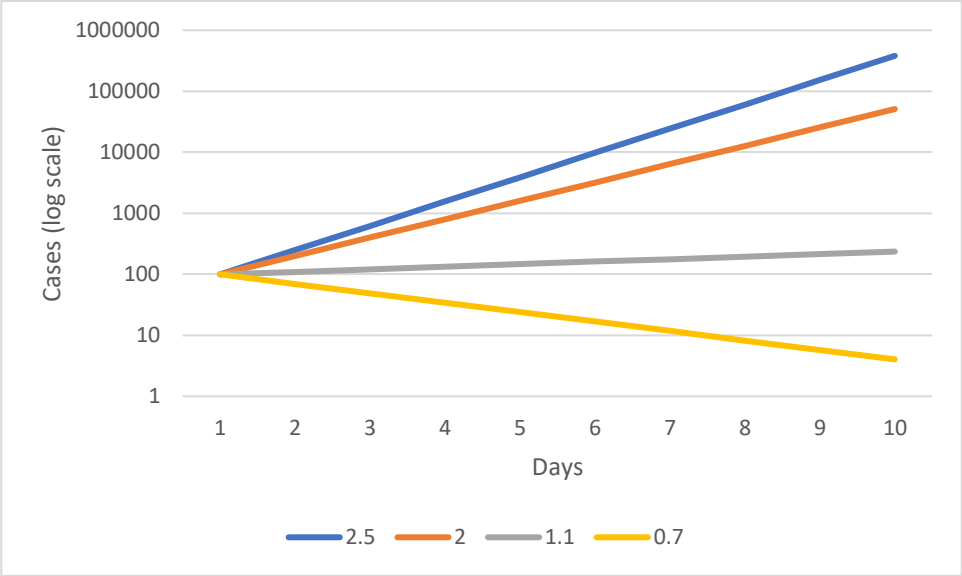
Source: WHO

Control COVID-19 transmission

By definition, the pandemic is under control when the reproduction number (R) is consistently below 1. Current estimates are that R is between 0.5 and 0.75.[11] However, R may be misleading in this context, since it is not uniform across the population – as Prof John Edmunds said on 7 May in evidence to parliament,[12] although community transmission is now low, transmission is high in hospitals and care homes, and these pockets of infection combined with a vulnerable population in these locations is causing infections and deaths to stay high. Whatever we do next, the government must urgently reduce the spread in these places through measures such as rigorous testing and tracing, supporting quarantine of affected people, regular deep cleaning of physical spaces and effective protective gear for all staff.

The importance of achieving this can be seen in Figure 2. Starting with 100 people who are infected, it assumes that each transmits the infection to the number of people implied by the value of R on each of 10 consecutive days. Current best estimates suggest that this value is between 2.5 and 3 in the absence of any restrictions. Consequently, in this scenario being modelled here, the 100 cases would increase to over 380,000 new cases by day 10. Reducing this to 0.7 would reduce the hundred cases to only four on day 10. However, if this crept up even slightly above one, to 1.1, there would be 235 new cases by day 10.

Figure 2 Impact of different values of R on numbers of cases



Measures to keep R low

While lockdown has worked to reduce R, the hope is that not all of the measures that are included in lockdown are necessary and that we can ease some restrictions. There are challenges in monitoring R, described further in the appendix, but we recommend that every easing of a restriction should be accompanied by a statement of the expected impact on R and the underlying prevalence of infection—as well as any mitigating measures that might be taken to reduce this increase.

Other countries have instituted their own versions of lockdown and are now emerging with different policies. There are also countries that have controlled R via aggressive test, track and trace policies

(South Korea being the most notable example). As noted above, it is essential that we learn from the global experience to design a set of measures suitable for the UK. Equally important is that we design in flexibility to allow for rapid escalation or de-escalation of measures as new evidence emerges (either of changes in the UK effective R or efficacy of mitigation measures).

Hunter et al have recently reviewed global social distancing measures.[13] The evidence suggests that the most effective strategies are banning mass gatherings and closure of some (but not all) commercial businesses, such as the hospitality industry. Closing educational facilities also appeared effective, but whether the main effect was for primary, secondary or tertiary education is as yet unclear (but important to determine with future evidence). Closing all non-essential businesses and stay at home orders appear to have less effect. The evidence of the use of face coverings in public or for workers with high person-to-person interaction (e.g. shop assistants, bus drivers, home health visitors /carers, some factory workers) is too preliminary to determine its impact. On the one hand, face coverings have been supported by an evidence review[14] and by a report by the Royal Society[15] but on the other, attention was drawn to a Bayesian review, noting that people's everyday behaviour of touching their masks/coverings as they wear them and take them off provides an additional potential vector for viruses on hands to be transmitted via fomites, as does putting face masks/coverings onto surfaces after wearing them.[16] This is an issue on which members of Independent SAGE disagree, in part because of differences in whether they are viewed as protection for the wearer or for other people and the extent to which data from studies of other respiratory infections apply to coronavirus.

Hellewell et al used mathematical modelling to show that a highly effective test, trace and case isolation policy (successful tracing of >90% of contacts) is sufficient to control a new outbreak of COVID-19 within three months even with R of around 3.5.[17] This may seem unachievable in the UK, but importantly, Hellewell et al also show that if R is only moderately higher than 1 (between 1 and 1.5), then control of an outbreak might be achieved with a test and trace effort that only manages to successfully trace 50% of contacts. This seems much more achievable.

Thus if measures such as banning mass gatherings and closing some commercial businesses, general hygiene and social distancing were in place and kept R below 1.5, then even a moderately effective test, trace and isolate policy across the UK could be enough to contain any outbreaks of COVID-19 over the coming year.

This is not a recommendation that the UK aims for an R of about 1.5 nor that we should aim for a mediocre track, trace and isolate policy. Instead, we believe that the reasoning that perfect tracing is impossible is no justification for not implementing a case finding, test, trace and isolate policy alongside social distancing measures.

On modelling and data

A recurrent theme in our discussions was the distinction between strategic advice from the WHO (with an explicit focus on public health) versus the management policies that appear to be adopted by the UK government. This divergence was seen in relation to PPE and recommendations for the duration of isolation, but is also evident in terms of the distinction between short-term management of the current outbreak (to prevent flare-ups) and longer-term strategic considerations (to prevent a second wave).

The difference between short-term policies and long-term strategies was acknowledged at several levels. Given this, it may be important not to conflate the two – and acknowledge that they have different objectives, epidemiological mechanisms, and testing imperatives.

Short- and long-term objectives

The short-term objectives are to avoid a rebound by premature relaxation of social distancing. This highlights the pressing need to assess the level of immunity (irrespective of the protection it affords) to better predict the impact of relaxing lockdown. Furthermore, these policies should be predicated

on appropriate metrics and criteria, including prevalence of infection, transmission strength, interpersonal contact etc. In turn, prevalence rests upon estimates that require large scale PCR testing (for which the government has already built the capacity).

The strategic long-term issues have a distinct focus and accompanying set of unknowns. The mechanism behind a second wave (in a few months) is very different from a flareup or rebound. This mechanism rests upon the degree to which short-term immunity is lost, either through an influx of susceptible people into the population or through loss of immunity. The unknowns here are the degree to which antibodies are neutralising and—if they are neutralising—the ensuing period of immunity. These are crucial unknowns that will only be disclosed in the fullness of time.

In the interim, there is a window of opportunity, during which the prevalence of infection makes it feasible to implement testing, tracking, and tracing. The aim here is to defer any second wave (due to loss of immunity and hidden levels of infection). This deferment can only be to an epidemic equilibrium – where levels of infection are stable in the population. That level of infection may or may not be affected by a vaccine (the hope is that a vaccine would reduce levels to near zero, but there is no certainty that this can be achieved). This suggests that the focus on vaccination should be replaced by a more pressing focus on the virology that determines immunity and its loss.

The UK government has already committed to a centralised response mode. This is somewhat counter to the provisional (modelling) evidence from the USA[18]. In brief, a local (regional) approach is preferred over a national (federal) response at several levels. First, the criteria that underwrite policies are better based on local estimates of prevalence—not pooled estimates at the national level. Second, the mediation of this kind of policy will require proper [re]building of primary health care capacity and devolved control. Note that a policy that has consensus at a national level can be enacted at a regional level, based on regionally specific quantitative criteria and thresholds.

How should statistics be used?

We should refocus reporting the measured consequences of the pandemic (e.g., new cases) onto estimates of the causes (e.g., prevalence of infection). Further, we should operationalise policies in terms of (estimated) latent causes—using real-time (dynamic causal) models and data assimilation—to complement conventional epidemiological models.

The data presented at daily press briefings are compelling but may not be useful indicators of the underlying causes of the pandemic—and might come to be regarded as politicised metrics of government performance. The data, in and of themselves, are useless:[19] it is the underlying latent causes of the epidemiology that matter. These can be estimated using a forward or generative model (that generates consequences from causes). In turn, these estimates should be evaluated as the basis of policies (e.g., the prevalence of infection today, as opposed to R over the past week).

Note, that the consequences of social distancing are expressed days or weeks later (e.g., occupancy of critical care units, deaths, etc.). In short, the useful aspect of data is that they reduce uncertainty about states of affairs that will be manifest in a week or so. An interesting example of this is the use of the effective reproduction rate (R). This is a statistic that reflects the consequences of at many latent causes. Perhaps this issue is not so important, in terms of quantifying progress; however, it becomes operationally crucial, when predicating social distancing policies on one quantity or another. Put simply, there is no point in implementing a control theoretic approach using effective reproduction ratio if it reflects what was happening a week or so ago. Using data to guide policy making requires us to infer the current prevalence of infection, transmission strength, number of contacts etc. that determines the reproduction rate in the forthcoming weeks. This will require real-time modelling; possibly using variational modelling (e.g., approximate Bayesian inference), as opposed to Monte Carlo simulations (e.g., approximate Bayesian computation).

With real-time modelling is put in place, it may be easier to forecast what will happen when we move from this level of social distancing to another—and share this with the public in a clear, quantitative

and explainable fashion. The analogy here would be the flood warnings issued by the meteorological office: people know that they are subject to a force of nature, they know there is a known uncertainty, and can prepare appropriately in a measured fashion.

Test, Trace, Isolate, Support, Integrate

In Wuhan, the lockdown and travel restrictions were accompanied by local intelligence gathering and local, on-the-ground contact tracing and medical observation. Even without mass testing capacity (it appears there were only 10,000 RT-PCR tests conducted in a population of 11m) the Chinese authorities controlled the infection, combining contact tracing with house-to-house symptom checking and quarantining and isolation, travel restrictions, and lock down. All these measures were necessary and had been increased.

Public Health England (PHE) lacked sufficient capacity to undertake contact tracing: it had fewer than 300 staff to do contact tracing operating out of just nine regional hubs covering 151 top-tier local authorities. No attempts were made to strengthen this capacity initially. By 12 March, when all community testing and contact tracing was stopped, PHE had only contacted 3,500 people of which around 125 were confirmed positive on testing.

Test

There was also perceived to be a lack of testing capacity - fuelled by the now administrative separation of PHE from NHS laboratories, and the delay in delegating the initiative to hospital laboratories. As a result, we currently have a mixed model for SARS-CoV2 PCR testing; PHE laboratories, NHS laboratories (and allied university sites), and standalone Lighthouse laboratories, linked to drive through testing centres run by private contractors. Reports of confusion and lack of integration of data from the Lighthouse led testing programme are concerning. Care home testing has also not been dealt with appropriately through this system, and local Public Health Directors have been asked to intervene.[20] Recent modelling also suggest that the current testing strategy itself may be suboptimal for pandemic control.[21]

The Lighthouse laboratories are staffed by many volunteers (university scientists, for instance) and with equipment from research institutes elsewhere, which limits their long-term existence. They are therefore inadequate to deal with the next phase of the pandemic, which will be likely be characterised by peaks of infection on the background of lower overall incidence over a significant period of time. There is an urgent need to plan for migration of testing back from the emergency Lighthouse laboratories into a more integrated future “normalisation” of such increased capacity across our existing PHE/NHS laboratories, in order to monitor for the inevitable future waves of infection, and local outbreaks. Even more local use of forthcoming point of care (POC) PCR tests based, for instance, in primary care /community settings may play an important role, providing sufficient integrated NHS/PHE data sharing.

We underline the importance of viewing “testing” as merely one component of the pathway from initial symptoms through to diagnosis, and subsequently a clinical and/or infection control process. The goals of “total number of tests”, or “test capacity” are no alternative to an integrated prevention and infection control structure.

Trace

With further waves of the epidemic likely, resumption of contact tracing is critical. Each of the four nations needs to institute scores of locally-led, nationally-coordinated and funded teams to trace, find and test contacts. Based in top-tier local authorities in England and health boards in Scotland and Wales, their composition should be locally determined, drawing from a range of expertise, especially amongst local Directors of Public Health, field epidemiologists, EHOs, GPs, local NHS laboratories, NHS 111, test centres, plus volunteers if required. In England, strong public health regional leadership

of the system, in conjunction with NHS England should be established reporting directly to the Chief Medical Officer.

The potential advantages of app-based contact tracing have been widely discussed. We note that symptom-based (as compared to positive test-based) identification of cases will severely over-estimate the number of cases, and that it remains unclear whether a sufficient proportion of the population will agree to use these. Concerns over privacy and security of data, and users potentially being financially penalised for following app advice to quarantine for 14 days on the basis of symptom-based case finding are likely to undermine engagement and hence effectiveness. Given the importance of rapid testing of potential cases, the 50-mass drive-in test centres need to be better integrated with local NHS capacity and directed to support local contact tracing, as well as strategically targeting most at-risk groups.

Isolate

The current position of seven days isolation seems to be untenable given our knowledge of the possible period of infectivity. The WHO recommendation of 14 days appears to be evidence-based, more generally accepted, and should be adopted. Evidence from China suggests that while maximum viral shedding after symptoms arise is in the first seven days, in more severe cases it can be longer, especially in those with severe symptoms. However, it is important to take account of the possibility that some examples of apparent continued shedding may be due to detection of non-infectious RNA fragments. This would have particular relevance in respect of the UK's only land border, which is with the Republic of Ireland. In many countries, identification of an infected case is followed by moving sick patients to hospital; mild/moderate cases to community adapted facilities for care, isolation and monitoring; and, asymptomatic cases to either self-isolate or to be offered requisitioned hotel accommodation if they are unable to isolate at home. It remains unclear what is the UK quarantine policy and availability of facilities, let alone specific recommendations for isolation in multioccupancy homes.

Support

It is far easier for some people to self-isolate than others. Policies must take account of the challenges that face those who are living alone, who are living in homes in multiple occupancy, who do not have access to gardens, who are in abusive relationships, need financial support to remain at home, or who lack social support, for example, to bring them groceries. While recognising that some measures have been taken to alleviate these challenges, much more needs to be done. A recent review of the wider consequences of restrictions on mobility identified the many different facets of life that are affected.[22] We urge the relevant authorities to develop appropriate plans that address these issues, taking particular account of the challenges of working across organisational boundaries that seem to have been so problematic already in the course of this pandemic.

Integration

We note that GPs and primary care workers form the backbone of a future sustainable response, closely linked with local authority outbreak management teams within a coordinated public health structure. Initially, general practitioners were assumed to play a limited role as patients were directed to NHS111 COVID centres. Patients were told to stay at home if they had symptoms and not phone their GPs.

The key characteristics of our future "case find, test, track, trace, isolate, support" system should therefore be integrated locally, ease of access for those requiring a test, speed (from sampling to receipt of result), and rapid infection control action. This should include flexibility of response where for instance there is a need for more active surveillance of high-risk environments, such as healthcare and social care settings. It should also include engagement of communities in discussing this to promote understanding of and engagement with the system.

Mindful that various mobile platforms are in late development for enabling self-reporting of symptoms and identification of close contacts, we caution that less than 20% of initial COVID-19 type symptoms may actually be due to the virus, with this proportion decreasing as underlying COVID-19 incidence declines. It is paramount that we ensure viral diagnostic confirmation (rather than symptom-based infection control) if we are to avoid a large amount of unnecessary isolation and quarantining, loss of income and possibly of jobs for those in low paid and precarious employment.

We argue that a future sustainable system is based locally, making full use of existing primary and secondary care networks, including local laboratory capacity, as well as local authority based public health and social care. Partnerships should be engaged with local and national organisations representing the community e.g. faith-based and mutual aid organisations. Examples of innovation include the further use of mobile devices to transmit important data on cases, and contacts, but also a mode of communication with health providers; the use of real time information dashboards to ensure community engagement, and near real time virus sequencing (as established through the UK COVID genomics consortium) to facilitate linkages within local outbreaks, and providing opportunities to break transmission chains.

Such examples of innovation would build on the existing strength of NHS IT integration, and more traditional contact tracing where necessary. The adaptation of these approaches to all localities will minimize the social inequalities in access to high quality COVID-19 prevention services and ensure that co-morbidities and clinical risk assessment can be undertaken at source. Essentially, we are supporting a systematic mapping of the functions that need to be in place, from accurate population registers to quality control of tests, and with a particular focus on mobilising an in-location workforce, based in local authority public health and environmental health departments.

Trust is too often undervalued. It is not encouraged by giving contracts to unproven commercial entities with uncertain reputations in the public eye. The least the government can do is to provide clarity on all the functions needed to implement a test, trace, and isolate strategy and then overlay it with every organisation necessary to make it happen, with clear lines of communication, performance management and accountability. If this does not include a strong role for local government and, especially, its public and environmental health departments, it will fail.

Coming out of lockdown

There is no doubt that lockdown reduced the spread of COVID-19 in the UK, even in the absence of a test, trace, and isolate policy. If the reproduction number, R, is equal to 1 across the UK, then each infected person will on average infect one other person, so that the number of new infections will stay about the same every day. But as long as daily new infections are high (in the thousands as currently), even a stable number of new infections will cause significant burden on the NHS while also making it much harder to keep R low. This is why the timing of lifting of lockdown measures has to be determined by a combination of current effective R number and current prevalence of COVID-19.

Once daily numbers of new infections are sufficiently low they can, in principle, be managed in the medium term, perhaps until a vaccine is widely available, with a strong test, trace, isolate, support and integrate strategy—as outlined above, combined with social distancing.

Minimise outbreak risks in high vulnerability settings

Anywhere that people are brought together in close proximity creates opportunities for rapid spread of infection. When an infection gets into a facility, for example inside a prison, it often moves quickly through those present. As some of those who are thereby placed at risk move between the facility and the community in which it is situated, the facility will act as an institutional amplifier.[23] This was seen early in the course of the pandemic in cruise liners. It is especially likely where there is a group of individuals within the facility who, by virtue of their age or their pre-existing conditions, are especially vulnerable. Consequently, all of these facilities, whether they are care homes, prisons, or

migrant detention centres must be viewed as a very high priority for preventive measures. It will also be important to be vigilant as other settings not previously considered to act in this way, such as meat processing factories, are doing so.[24] In addition, although on a smaller scale, households where people are living in overcrowded conditions or houses in multiple occupancy should also be seen as high risk. The precise measures that will have to be taken will vary according to the particular setting, but it is essential that a detailed plan is prepared for each of them taking account of the specificities.

It is now clear that health and social care workers in the UK are at very high risk of infection. International comparisons demonstrate that this is not inevitable. Other countries have managed to avoid any deaths in health and care workers.

There are several issues to be considered here. First, it is essential that all deaths in health and care workers are adequately investigated. The chief coroner for England has recently issued guidance that there should be a low threshold of suspicion that a death from COVID-19 in a health worker is attributable to their employment.[25] His guidance also states that it is not the place of coroners to investigate wider policy failures, such as the widely publicised failures to procure adequate supplies of Personal Protective Equipment (PPE) of appropriate quality. However, individual coroners can issue a 'Report on Action to Prevent Future Deaths' (PFD) as set out in regulation 28 of the Coroners (Investigations) Regulations 2013 if they judge that action must be taken to prevent future deaths. This can be sent to any organisation or individual who the coroner considers has the power to take that action. The Industrial Injuries Advisory Council (IIAC), an independent scientific advisory body with the responsibility to advise and make recommendations to the Secretary of State for Work and Pensions might usefully consider making COVID-19 a 'prescribed' industrial disease for those whose work places them at risk, thereby enabling those affected to obtain compensation.

Second, adequate supply of PPE and other protective equipment is crucial. This is a widely known problem and the BBC Panorama programme exposed of the many failures leading up to and during the recent surge.[26] The government must now address those urgently and prepare for a next surge. All key workers should be protected and not just those working in the highest risk environments within hospitals. This means also protecting staff working on acute COVID wards outside of HDU/ICU , transport staff, care home workers and home visitors – for instance the Office of National Statistics published a report on 11th May 2020 highlighting the increased numbers of deaths due to COVID-19 among social care staff.[27]

Finally, care homes are a particularly challenging environment for preventing outbreaks – care homes across the world have become epicentres of not just COVID-19 transmission but high mortality as their residents are almost all high risk. In the UK, protective equipment and testing for care home staff and residents has been lacking (patients discharged from hospital to care homes were only routinely tested for COVID from mid-April[28] and routine testing for care homes was only introduced from 29 April).[29] As discussed above, current transmission and disease burden in the UK is concentrated in care homes.[12] While this new widespread testing of staff and residents is welcome and necessary, it must be combined with adequate protective equipment for all staff and financial support for care homes to employ more staff, undertake frequent deep cleans and configure their environments to be able to isolate infected residents (many residents might have end of life plans that preclude hospital admission and live with conditions such as dementia which makes isolation even more challenging). Additionally, we must recognise that care home staff are often poorly paid and vulnerable themselves: more likely to live in challenging housing situations, less able to self-isolate, more likely to be of BAME background [30] or living with underlying health conditions.

Manage the risk of exporting and importing cases from countries with high risks of transmission

The government has decided that everyone coming to the UK, except those travelling from the Republic of Ireland or transport workers such as lorry drivers, should be required to self-isolate for a

period of 14 days. We welcome this measure although it is not clear why there is a delay in implementing it. However, we note that there is a serious loophole in it. It will be perfectly possible for someone to fly from somewhere where the level of infection is extremely high, such as New York, to Dublin and then change planes to travel to London. For this, and for other reasons related to the extent of movement across the Irish border, it makes much more sense either to treat the two main islands of Britain and Ireland as separate entities for human health purposes, as is already the case for animal health, or for the UK and Republic of Ireland to agree a common approach.

Establish preventive measures in workplaces

The Prime Minister's messaging on 10 May about easing restrictions included calls for "respecting others in the workplace and the other settings that you will go to." Respecting others, whilst obviously an excellent thing to do, is another general phrase that does not communicate what either employers should be doing, or employees should be expecting and demanding. Timing of communications and the context of communications is also vital for managing transition if personal, social and economic costs are to be avoided. To encourage return to work at short-notice without a new, appropriate health and safety framework having been agreed by Parliament nor with the trades unions, endangers lives and will cause high levels of stress, and in some cases trauma and job resignations in a bid to protect vulnerable families from having the virus brought from work into the home.

Ensure communities have a voice, are informed, engaged and participatory in the transition

Engagement of key stakeholders, including devolved administrations

One of the main criticisms of the response by the UK government so far has been the highly centralised approach that it has taken, in some cases excluding the governments of the devolved administrations from key decisions. The elected administrations in Scotland, Wales and Northern Ireland have the powers to determine their own policies in many aspects of the response to the coronavirus pandemic. While the general position has been to adhere to the decisions made in Whitehall, each administration has the opportunity to determine the distinctive measures needed to safeguard the well-being of the population for which it is responsible. The pattern of infection with the virus appears to vary markedly across the UK and the devolved administrations should take the opportunity, where possible, to engage fully in the introduction of our strongly recommended approach of case finding, testing, tracing, and isolation. This should be a cornerstone of their approach. Northern Ireland is a particular case, having a land border with the Republic of Ireland. We urge the Northern Ireland Assembly Executive to seek to harmonise their policies with those of the Republic of Ireland in keeping with the commendable Memorandum of Understanding that has been agreed between the two jurisdictions in relation to the coronavirus crisis.

Representatives of local government, including most of the large metropolitan authorities, have also been largely excluded. Similarly, civil society organisations and business have complained that they have had little input into the development of policies and practices. For example, companies with a long tradition of manufacturing products, such as ventilators and PPE, often struggled to find out who to contact.

Instead, in a number of critical areas, the government has turned to outsourcing accountancy and consulting companies with no obvious technical experience in the tasks they are being asked to do. There have been particular concerns about procurement of both goods and services.

This approach, based on a vertical programme disconnected from existing structures, resembles those that have been tried and have failed over many decades in low income countries. Importantly, even in very resource poor settings, such as some African countries, it has been possible to develop effective responses using existing community-based structures, many of which have been developed

in response to Ebola and with a recognition that highly centralised programs often fail. These local initiatives succeed because they are well connected with local administrative systems and achieve a very high level of trust among the populations they serve. This is in marked contrast with the widespread scepticism that has greeted some of the responses, such as the target for numbers of tests to be conducted daily, in the UK. It will be essential going forward that all measures are closely linked to local communities.

A major problem for England has been that the Health and Social Care Act 2012 created a fragmented system and the absence of local and regional area health bodies has removed structures that could have facilitated a more effective response.

Communications and other measures to manage the transition of easing restrictions

There has been little engagement of communities throughout this process; if adherence to guidance is to be maintained throughout the complexities of transitioning, engaging and listening to a wide variety of communities is going to be essential, including neighbourhood and work communities, local authorities and trades unions (see later section).

For government communications to be effective in promoting adherence to guidance and in avoiding confusion, anxiety and distrust, they need to be clear, precise and consistent. This includes being behaviourally specific, i.e. advice as to who needs to do what in what situations, and what should not be done. Advice should be closely linked to action. Reasons for the advice should be given; explanation increases motivation to adhere and provides people with understanding that means that they can apply principles beyond the specific advice, as appropriate.

An example of unclear messaging is that given on 10 May by the Prime Minister of ‘Stay alert, control the virus, save lives’. It is not clear what people are meant to be alert for, nor indeed what they should do if they are alerted to something. Similarly, “control the virus” is an empty slogan without an indication of how to do this. “Save lives” is uncontroversial but without context in the rest of the message is likely to have little impact. The old saying “coughs and sneezes spread diseases” whilst not directly telling people to use tissues and to dispose of them immediately, does provide people with an understanding of causal mechanism which means that other messages are likely to have more impact. It also has the essential quality of being memorable – people need to be able to access advice in their head in the situations when they face choices about how to behave.

With the government's five tests not having been met, we are concerned that “stay alert, control the virus and save lives” is not a helpful message in terms of guiding behaviour. Dropping the ‘stay at home’ message in favour of generalised alertness may be taken as a green light by many to not stay at home and begin socialising with friends and engaging in other activities that increase the risk of transmission. This could potentially undermine the impressively sustained high levels of adherence to lockdown the public has achieved, even in very challenging situations. It is regrettable that the government does not appear to be taking on board behavioural science evidence and the principles of how to communicate effectively to enable, support and guide behaviour.

The decision not to involve devolved nations in this change of messaging has led to wider confusion. Scotland, Wales and Northern Ireland are sticking with 'Stay at Home, Protect the NHS, Save Lives’.

Any easing of restrictions needs to be accompanied by not only effective, targeted messages, but changes in the physical and social environment that enable the key behaviours to suppress transmission:

- maintain social distancing in all places outside the home including transport and workplaces,
- wash hands when coming into buildings or before eating and preparing food,
- cough or sneeze into tissues that are immediately disposed of and hands washed afterwards,
- disinfect surfaces and don’t touch eyes, nose or mouth (which is where the virus enters the body) without washing hands first and after.

Inequalities

One issue that the 10 May announcement has brought into sharp relief is increasing inequalities. People who can work from home, thereby avoiding potentially unsafe travel and workplaces, tend to be more middle-class than those in jobs that cannot be performed at home. The latest data from ONS reveal large occupational differences in the risk of COVID-19 deaths, with men in the lowest skilled occupations at greatest risks, and with taxi drivers and chauffeurs, bus and coach drivers, chefs, and sales and retail assistants at especially high risk.[14] Men and women working in social care, a group including care workers and home carers, also had significantly raised rates of death involving COVID-19. To prevent increasing the divide whereby poorer people expected to risk their lives to get the economy going whilst wealthier people stay in the safety of their homes, the government should continue to provide furlough for all workers who have not been guaranteed safe work and transport to work, and work much harder to achieve safety for all.

Effective clinical care for patients and staff

Lockdown is unsustainable until a vaccine is available. As we come out of it, it is possible that any combination of measures will not be enough to prevent a second surge. We need to learn now from the problems experienced in March and April (particularly those that were not anticipated). Many of these are avoidable and must be avoided in future. The worst case would be for such a surge to coincide with the winter flu season, when hospitals are often overwhelmed even in normal years. The government should use this time to prepare for such a surge, gathering together experts from across disciplines, including (but certainly not limited to) the clinical community, the social care and public health community, systems engineering, operational research, industry, supply chain specialists and local government.

Critical care capacity

The lockdown has worked well in allowing the NHS to cope within its surge capacity. This surge capacity has been staffed by those within critical care working beyond their normal, already extensive, hours and work patterns; by the redeployment of healthcare professionals from other services (for example Anaesthesia and Surgery) to critical care, and by the cancellation of NHS activity like elective surgery. Critical care staff continue to work above and beyond their normal working patterns. It will not be possible to sustain that level of activity indefinitely and any future central NHS modelling must take staff sustainability and wellbeing into account. Healthcare staff are comprehensively trained for patient safety and cannot be created overnight, however alternative models of delivery of care have been used during the pandemic and this affords us an opportunity to build resilience into future modelling. For instance, high requirements for breathing support stressed hospital supplies of oxygen that led to critical incidents, as in Northwick Park Hospital.[31] Systems engineers, mathematical modelers and clinicians can work together to design treatment pathways and oxygen supply chains to optimize the use of oxygen within hospitals and across the system.

Returning to normal NHS activity

As other activity in the NHS begins to return, this will impact the surge capacity currently possible in critical care. It is important, and the Faculty of Intensive Care Medicine and the Royal College of Anaesthetists have provided guidance to support hospitals in making the decision on why they can begin to reopen normal activity.[32] It is also important that rather than this being a top-down process, that this decision is made at the Health Board / Trust level as each hospital's number of COVID cases, pre-existing case mix and floorplan will be different. The guidance produced gives a red-amber-green (RAG) rating for hospitals to make an informed decision about this whilst protecting their staff resilience and pandemic preparedness.

Guidance from NHS England outlines a phased approach to nurse staffing.[33] In reference to the strategy document, any critical care unit that is using a phase 3 or 4 staffing model (i.e. with triple or quadruple the normal nursing numbers), or is more than double its baseline capacity, would be red. If using phase 2 and/or is at double baseline capacity the unit would be amber. If returned to pre-pandemic staffing levels or capacity, then it would be green. This is line with what the Faculty of Intensive Care Medicine (FICM) set out in a joint statement by the British Association of Critical Care Nurses.[34] Going forward, there will be reduced efficiency in the acute hospital setting, partly due to the need to separate COVID-19 and non COVID-19 patients but also because of the need to undertake social distancing between staff and between patients, particularly in the Emergency Department and Out Patient clinics. Crucially, as the Royal College of Anaesthetists has been stating in all senior NHS briefings and in media work, staff are the central resource for our patients. Their position statement on sustainable working patterns during COVID-19 pandemic, which covers senior doctors, Advanced Critical Care Practitioners and Critical Care Pharmacists, provides more information on this important area.[35]

Co-ordination between specialties

We now realise COVID-19 is a complex multi-system disease and not the classic viral pneumonia that we first suspected.[36] There is a wealth of research emerging almost every day, providing insights on the effects of the virus on the blood vessels, kidneys, nervous system, and other parts of the body. This is offering new insights into possible opportunities for prevention and treatment, from reducing the risk of infection to stabilising the lining of the blood vessels and managing the often fatal inflammatory storm. The UK's Recovery Trial, ensuring that candidate treatments are evaluated rigorously, is an exemplar of what can be done,[37] but it is difficult to avoid the conclusion that too many of the discussions are taking place in clinical silos - there are currently 35 MHRA approved COVID-19 therapeutic clinical trials in the UK. The sheer volume of evidence can seem overwhelming, and of course until it is peer reviewed it must be treated with caution. What we do need is a clear mechanism to ensure that a wide range of front line clinical and basic science expertise is brought together, for which no obvious mechanism exists.

Collateral effects on non-COVID-19, or post discharge COVID-19 patients

Collateral damage from the lockdown is being felt. Within hospitals, competing resources for, for instance, renal disease (manifest in 30% COVID cases) are problematic.[38] There are rising numbers of excess deaths from non-corona causes as people die at home instead of calling an ambulance and all routine and elective care is cancelled. Community services have been cancelled so there is little hands-on chiropody, physiotherapy, mental health services, and occupational and speech therapy - GP appointments are being replaced with telephone calls and video conferencing. These are vital services for older people for whom telephone calls are often an inadequate substitute for hands on care. Meanwhile, in many hospitals, wards are half empty and some staff are under-occupied as the COVID surge recedes. Bed occupancy has fallen, the Nightingale hospitals are empty and clinical need is rising. There is an opportunity to consider an alternative use for the Nightingale hospitals, to alleviate some of the pressure that will inevitably continue, such as regional weaning units or rehabilitation centres. Although not initially designed for this it would facilitate earlier hospital discharge, provide a bridge between secondary and primary care and liberate capacity for GPs, particularly as hospitalised COVID-19 patients are much more likely to have existing health conditions. Failing to plan for this will lead to a high number of readmissions to hospital or even severe sequelae such as significant additional morbidity or death.[39]

Mental health

Many people, especially the elderly and those in single households are essentially in solitary confinement and, as a result, at increased risk of mental anguish (not least those with depression or incipient or actual dementia). Residents in care homes are confined in their rooms, with no visits from

relatives – even when gravely ill or dying – often with minimal interactions with staff.[40] The decision to exclude relatives means that care homes have become closed institutions, increasing the risk of neglect, or even abuse.[41]

Health, social and economic protections for women, marginalised and BAME groups

Recent data have suggested increased mortality in BAME communities in UK which requires urgent exploration through robust analysis of routinely collected prospective data on COVID-19. This will not only explore risks and outcomes associated in BAME populations but for the entire population. This important information must be communicated in an accessible and culturally appropriate way. However, to get a clearer picture of ethnic and socio-economic disparities in incidence and outcome in the UK, we need detailed national data linkages with some of the best data globally.

Racial Disparities in COVID-19

The new report by ONS on coronavirus by ethnic group shows the important role of socio-economic and housing circumstances in explaining some of the racial disparities between ethnic groups in relation to COVID-19 deaths (although racial disparities still remain even after taking these factors into account). Factors include age, sex, underlying morbidity, place of residence, area clustering, socio-demographic factors, laboratory measures, and burden of undiagnosed disease to determine if the observed signal between ethnicity and COVID-19 outcomes is real or an artefact. Some of these data are already available. However, mixed methods research will be required to fully understand the complex interplay between the various biological, social, and cultural factors underlying these early findings. We welcome the recent launch call from NIHR and UKRI for research on COVID-19 and ethnicity.

Notably, the report did not discuss the important factor of racial discrimination in understanding the different experiences of poverty and deprivation between ethnic groups. An analogy that could be used here is we know that social class is a strong predictor of educational performance (like poverty is for health outcomes), but the reasons for why black and Gypsy Roma Travellers (GRT) working class children are performing poorly in education are somewhat different for why white working class children are performing poorly in education. Racial discrimination and racism (as manifested in disproportionate school exclusions of black and GRT children) is an important explanatory factor.

The equality and migrant sector, including Runnymede Trust, have repeatedly tried to illustrate how COVID-19 is not just a health crisis, but also a social and economic one – bringing into sharp relief pre-existing socio-economic and racial inequalities. These factors matter because we may all be weathering the same storm, but we're not in the same position to manage and recover from the storm.

Strengthen social security

While there is a great deal of heterogeneity among BAME groups, BAME people are much more likely to be among poorer socio-economic groups, living in poorer-conditioned, multigenerational and overcrowded housing, working in low-paid and insecure jobs and over-represented among low paid key-workers e.g. carers, transport and delivery drivers, cleaners etc. In the context of COVID-19 this raises questions about the extent to which BAME people can social distance, but also highlights the extent to which poorer BAME groups (including those in working households) rely on social security as a large part of their income and housing costs.

While the government have taken several steps to mitigate the economic impact of COVID-19, these measures have not equally benefitted all groups in the labour market (as well as those not economically active in the labour market). Many women and BAME groups at the bottom end of the socio-economic spectrum, as well as those on route to settlement (with or without leave to remain) are currently falling through the net into poverty and destitution because of barriers to social security.

Of those groups who are able to access benefits, including Universal Credit, there are still major financial barriers which are pushing people 'just about managing' into poverty. The current level of Universal Credit is too low and does not take account of changes in social circumstances due to COVID-19. Families with children at home as a result of school closures and childcare facilities being closed will face increased food and utility costs. Child benefits, therefore, need to be increased to £50 per child per week to cover gaps in free school meals and to cover extra costs of children being at home full time. In addition, benefit caps, under-occupancy benefits and the two-child limit in Universal credit (which means that families with three or more children, born after April 2017, do not receive support for these children) all need to be lifted. And housing allowances must reflect local rents, particularly in cities where the cost of housing is pushing families into poverty and destitution.

There is also a five week wait for Universal Credit, which is currently covered by 'advanced payments' in the form of loans. The food bank, Trussell Trust have argued that this is creating more debt for families, and Women's Budget Group and Fawcett Society have recommended that this form of advanced payment should be converted to 'non-repayable grants'.

There are also concerns about the level of Statutory Sickness Pay in the context of COVID-19. Currently, is too low (£95.85 per week) and is not enough to live on for working families. Low levels of statutory sick pay, and restricted eligibility increase the risk that people who are ill, or around those who have been ill, are spreading coronavirus. Around one in five workers are not eligible because of low or intermittent pay/zero-hours contracts.

No Recourse to Public Funds

There are additional concerns about the government's No Recourse to Public Funds (NRPF) condition imposed on migrants with limited leave. Under the NRPF condition migrant workers with limited leave cannot access public funds including Universal Credit, Child Benefit or Housing Benefit. Yet many of these working migrant groups are in low paid work, including low paid care work – which on its own is rarely sufficient for food and housing costs. With children now at home, this increases the risk of food poverty and challenges the extent to which such families can social distance if they are forced to work because of risks of poverty.

Engagement with Civil Society

Finally, the government needs to work closer with civil society organisations representing vulnerable and BAME groups to ensure that their measures are sufficiently protecting and shielding these groups from COVID-19. One area where the government has increasingly been listening to civil society organisations are the domestic abuse charities, which have rightly highlighted concerns about the increase in domestic abuse since the lockdown (the National Domestic Abuse Helpline reported a 25% increase in calls and online requests for help since March 2020). The government needs to mirror this listening and engagement approach with all frontline civil society organisations representing vulnerable groups from all walks of life.

What is needed for the future?

A safe vaccine with near 100% efficacy for long term protection and high global uptake provides an ideal route out. However, it would be foolish to base all plans on that. It is likely that the virus will persist in the UK for at least a year, and, in the absence of the optimal vaccine, will possibly become endemic within the population. In this scenario the country will be subject to recurrent local outbreaks requiring rapid intervention. It follows that exit from the current lockdown must encompass a strategy of searching for the virus wherever it appears, understanding and intervening in transmission networks, as well as protecting those with disease. This requires a virus control system which has long term sustainability. It must be built into an enhanced public health protection system, taking advantage of the primary and secondary health care system, but also incorporating locality-based integration (integrated Care Systems) including local government and social care, and crucially with community participation.

In order to guide future infrastructure requirements, it is important to appreciate how the UK have come to a situation where "lack of testing and infection control capacity", has been used to justify the suboptimal UK government response to the pandemic.

There is an urgent need to rebuild an integrated public health infrastructure of the form required to deliver optimal protection of the people of Britain and Northern Ireland. This needs to assimilate the highest quality diagnostics, data collection, management analysis and sharing, and innovative social and behavioural science, as a critical component of our protection from this and future pandemics.

Appendix

The utility of R for policy and strategy planning

The basic or initial reproduction number R_0, is an important epidemiological parameter that quantifies the number of secondary infections from initial (index) cases of an infected individual. At early stages in the outbreak it is a useful summary to communicate the likely infectiousness and to explore possible trajectories of infection. However, the reproduction number is not a biological measure—it incorporates many factors; e.g., the number of contacts an individual makes. To understand the utility of this, now, well-known metric, in terms of forward planning by governments and individuals, one must consider whether the value can be estimated in real-time and if not, what is the lag.

Currently, even highly robust and technically sophisticated techniques can only estimate changes in R (the effective reproduction number) with a lag of several days, using retrospective data. It has been used, for example, by the Imperial College London group (Report 13) to investigate the consequences of social distancing and lockdown measures (and their accumulated effects).[42] And even here, robust R estimates were reported by taking into account data from many countries. In short, a real-time metric may be of greater utility for social distancing advice and policy planning.

Technically, Report 13 used (hierarchical) Bayesian Regression to infer R using known times of change in numbers of contact; i.e. date stamped lockdowns on bars and gyms, etc.—with estimated infections, using known deaths and an assumed infection fatality ratio. This is state of the art regression yet as the authors explain, it is retrospective, looking after a change in policy has been rolled out.

A generative model (that does not rely on regression methods) may be necessary to infer current infection rates. The Dynamic Causal Model for COVID-19[43] provides such estimates real time infection rate estimates, which formally incorporate behavioural adjustments in the community. These kind of 'here and now 'estimates may become increasingly important to plan surveillance strategies, for example, 'How many tests should I carry out in my area tomorrow in order to identify the requisite percentage of new cases?'.

In terms of forward planning one can envisage a 'traffic light 'scheme.[44]; much like the weather forecast or flood warnings (after the news, for example)—where the public are alerted to current levels of infection in their area: will tomorrow be Green, Amber or Red? If infections are high in Leeds for example then more social distancing (and testing) may be necessary, while Dorset may be 'Green ' on Tuesday and require less.

Modelling approaches

If we focus on models that are fit to data, there are two key aspects that need to be considered. First, the nature of the model and its parameters. Second, the mathematical procedures used to recover or estimate the model's parameters. In terms of the form of the model, most models assume one can be in a particular state or another (e.g., am I infected or not?). The model parameters then control how quickly one moves from one state to another (e.g., the rate at which people become infected). A key question is what states are included in the model. In short, which states matter?

Current models range from simple models with a handful of states (for example, I can either be susceptible to infection, exposed to infection, infected, or recovered). At the other end of the scale, one can have fine-grained models that include where I am; e.g., whether I am at home, work, a care home or hospital. The choice of states is in part determined by the kind of data available. There will always be an optimum number of states for any given data. The objective is to find the model who states have the greatest evidence (technically, the model under which the data are the most likely). This is important because it means that there is no true model—there is only the best model, or

explanation, for the data at hand, which may be more or less complex. This speaks to the second aspect of modelling; namely, how one fits models to data and assesses their evidence.

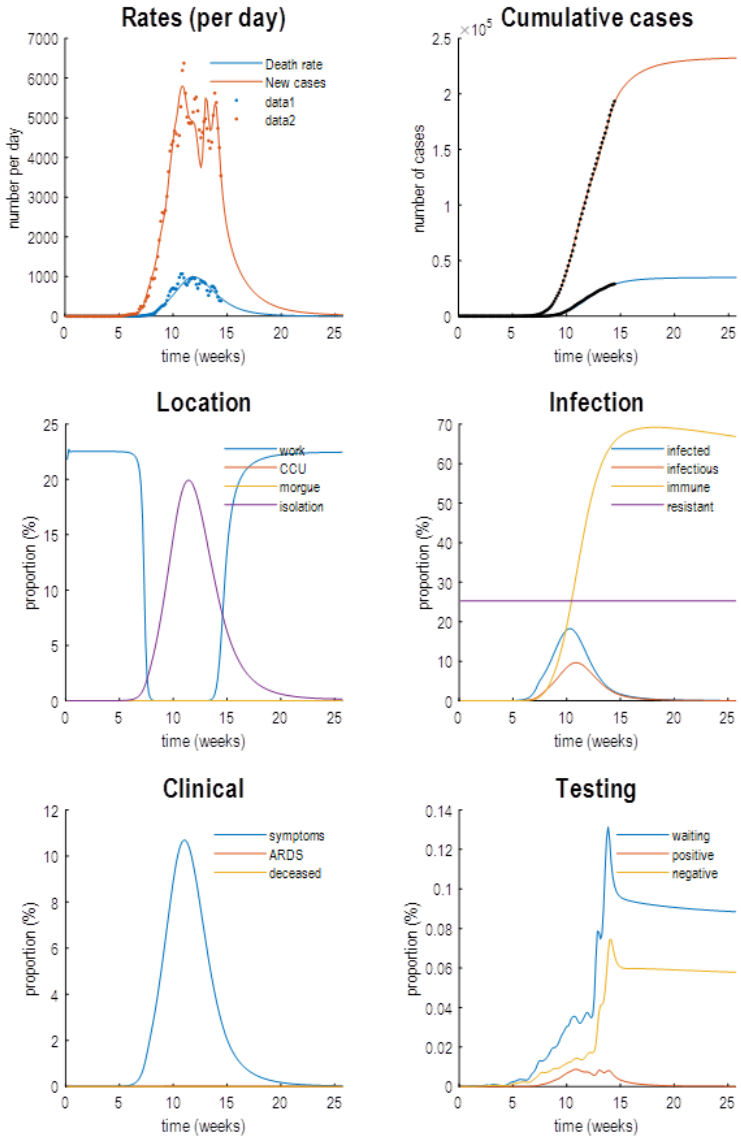
Broadly speaking there are two ways to fit models to data. One can simulate large numbers of trajectories of what might happen in the future and pick those simulations that, in some sense, are close to the observed data. These are known as sampling approaches and are used widely in weather forecasting. These procedures dominate most epidemiological modelling. However, there is a more efficient way of fitting models, where one replaces millions of samples with a single probability distribution over the unobserved (latent) states causing observable outcomes. These techniques arose in physics and are known as mean field approximations and variational procedures. The advantage of variational procedures is that they match faster than sampling-based approaches (e.g., simulating an outbreak in minutes as opposed to hours)[45-47]. This efficiency is important, because it means that one can fit lots of competing models to the same data and evaluate their evidence. This is known as Bayesian model comparison. Model comparison is a key part of optimising the model of any timeseries data. In neurobiology, this is known as dynamic causal modelling[48].

Dynamic causal modelling may have a potentially important role to play because it enables one to test different hypotheses about (i.e., models of) the pandemic and our responses to it. For example, one can evaluate the evidence for models of social distancing predicated on the prevalence of infection vs. The numbers of new cases vs. the R ratio. Note that with dynamic causal models of this sort, everything that matters can be built into the model—including social distancing responses. In contradistinction to conventional epidemiological modelling, this means that one can predict not only the morbidity but also our responses in the future. In other words, our response to the pandemic becomes part of the epidemiological process. This ability to model responses is potentially important when comparing data from different countries. For example, one can ask whether the efficacy of the German response to COVID-19 is mediated by enhanced testing or a greater emphasis on primary health care (e.g., surveillance of symptoms in the community). In short, the ability to model 'everything that matters 'in a comprehensive and efficient way may become increasingly important as we face choices about the deployment of resources—and start to consider other costs beyond the mortality rate of COVID-19 per se.

Based upon the data so far, dynamic causal modelling of the pandemic has provided slightly different predictions from conventional epidemiological models. For example, they predict (or predicted) that the Nightingale hospitals would not be required. They predict (or predicted) lockdown will start to be relaxed in the UK on 8 May. Perhaps more importantly, dynamic causal modelling suggests a decentralised regional response mode (as opposed to a centralised, federal mode) is not only a better explanation for what is happening in the United States – it will also save lives[18].

Figure 3 is based upon current new cases and death rates. It shows the kind of predictions that can be made, in terms of the latent (underlying) causes of mortality. The dots represent the data up until the present day, while the curves project into the future. These simulations suggest that things may not be quite as bad as they could be. Indeed, we are already witnessing the (start of) soft relaxation of social distancing—as predicted by the model (and witnessed by the streets of London).

Figure 3 *Illustrative predictions of the course of the epidemic*



This figure summarises the kind of estimates furnished by modern-day (variational) approaches to timeseries analysis. These approaches inherit from statistical physics and the characterisation of population dynamics in neuroscience. The basic idea is to model the underlying causes that generate data by building a generative or forward model—and then estimating the causes from the observed consequences, using variational procedures such as dynamic causal modelling. In this example (taken from Testing and Tracking in the UK: a dynamic causal modelling study: in preparation), data on daily cases and deaths (the dots in the upper panels) have been used to infer the underlying causes (in the lower panels). These courses can be multifactorial in nature. Here, the pandemic has been modelled in terms of four attributes of people in the United Kingdom; namely, where they are (*location*), their infection status (*infection*), their clinical status (*symptoms*) and their testing status (*testing*). The solid lines represent the most likely trajectory of these causes or attributes over six months. Note that having a generative model underneath the data allows one to estimate the past and the future. For example, installing social distancing responses into the model allows one to predict when social distancing will be relaxed. Here, social distancing is manifest in terms of the probability of leaving home to go to work (blue line in the *location* panel), which—according to the model—should have been partially relaxed at the time of writing. This kind of model may be particularly useful because it provides instantaneous (real-time) estimates of the prevalence of infection and quantities like the reproduction rate. In short, in contrast to curve fitting, dynamic causal modelling estimates the

causes of morbidity and mortality by leveraging our knowledge about all the factors that matter in a quantitative way. For technical details and a full description of this figure format please see[18].

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