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Science advice in a crisis

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About this report

At the start of the coronavirus pandemic ministers insisted they were "following the science", and science advice has remained at the heart of government's response. But in a crisis, using advice well to inform decisions, and communicating those decisions to the public, is hard. Drawing on the UK's experience of past crises, this report examines the way the government has used science advice in the coronavirus pandemic and outlines how it could do so better in future.

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Science advice has been at the centre of most of the major decisions the UK government has taken throughout the coronavirus pandemic. Scientific advisers inside and outside government have been put under intense pressure and public scrutiny. They have had many successes, not least in the sheer volume and speed of high-quality analysis they have produced, drawing together the work of hundreds of people.

But the crisis has exposed flaws in how ministers understand and use science advice to inform their decisions. The public's understanding of the rationale behind these decisions has also at times been undermined by a lack of transparency and muddled communication.

Given the central role of scientific advice in the crisis, it is important to look at what has and has not worked, and how it can be improved to better inform the government's approach. This is not just relevant to the coming months, as tiers are negotiated and vaccines rolled out, but also in preparation for future crises.

This report is informed by interviews with key players in the current crisis and past crises, including senior officials, government chief scientific advisers, SAGE members, external scientists and experts on the use of science advice around the world. We draw on case studies of key decisions, including the decisions to lock down in March and November, the changes to contact tracing, the closure of schools, the two-metre rule and the wearing of face masks.

There will be time for a far more comprehensive evaluation once the crisis is over, not least in a public inquiry, but we hope that our findings, given in brief here, offer some useful reflections on how to use science advice well in the current crisis and future crises.

The role of science advice in the UK government

The UK's science advice structures are widely regarded as excellent. The UK was among the first countries in the world to appoint a chief scientific adviser and chief medical officer; it pioneered the way many countries now identify and prepare for risks; it developed the Scientific Advisory Group for Emergencies (SAGE) – an expert group with flexible membership that provides a consensus view to policy makers, mobilised nine times since 2009; and it has wider scientific expertise and numerous expert advisory committees across government departments and agencies.

Previous governments adapted these structures in response to past crises, including the outbreak of bovine spongiform encephalopathy (BSE, or 'mad cow disease') in the 1990s, the foot and mouth disease (FMD) outbreak in 2001 and the H1N1 'swine flu' pandemic in 2009. Each of these crises, though much smaller in scale than the current one posed by the Covid-19 coronavirus, demonstrated the difficulty of using scientific advice well in an emergency.

But many of the problems identified by inquiries into those crises have returned: the blurring of policy decisions and expert advice; the need for politicians to interrogate advice, and for advisers to understand the policies they are informing; the risks of relying on uncertain modelling and of 'groupthink'; and a lack of transparency in explaining how evidence and advice are used.

The difficulties faced by decision makers during the coronavirus pandemic have been far greater than in any recent crisis. Ministers have had to make unprecedented interventions in people's lives and faced extraordinarily difficult trade-offs. They have done this while operating under huge uncertainty.

No system would have been flawless in responding to such an emergency. It is easy to criticise decisions with the benefit of hindsight, while decision makers (and those advising them) had to respond very fast. Nevertheless, our research has identified some clear problems: while there are improvements those providing scientific advice should reflect on, the biggest concerns are the way the government used this advice and the way it communicated it.

How science advice was used by decision makers

In the initial months, ministers put too much weight on SAGE – relying on it to fill the gap in government strategy and decision making that it was not its role to fill. At times the prime minister and ministers waited until the scientific evidence was overwhelming rather than using it alongside other inputs to make their own judgements. This was captured in the government's rhetoric, which wrongly suggested that science could simply be "followed" – and appears to have been a big factor behind the costly delay to the first lockdown. The reluctance to make judgements on a precautionary basis was also visible elsewhere, such as the delayed mandating of the use of face masks.

Decision making at the centre of government was too often chaotic and ministers failed to clearly communicate their priorities to science advisers. This was most acute in the initial months but a lack of clarity about objectives persisted through the release of the first lockdown to recent decisions over the second lockdown and regional tiers. At times the process of commissioning advice – COBR* asking questions for SAGE to answer – did not work well, with advisers' ability to provide useful answers hampered by poorly formulated questions (though this improved as the crisis went on).

* COBR, which stands for the Cabinet Office Briefing Rooms, is the meeting of ministers and officials that provides high-level co-ordination and decision making in national emergencies. See: www.instituteforgovernment.org.uk/explainers/cobr-cobra

The work of departments was at times fragmented, most damagingly during the lifting of the first lockdown between May and August. An example was the Treasury designing policies – such as the Eat Out to Help Out scheme – without consulting the government's leading epidemiologists. Reports have since found the scheme was associated with increases in transmission of coronavirus.

How science advice has been provided, and the role of SAGE

Scientific advisers have broadly responded well to the pressures they have faced. Sir Patrick Vallance, the government chief scientific adviser (GCSA), and Chris Whitty, the chief medical officer (CMO) for England, adapted SAGE, which they co-chair, in response to the scale of the crisis. Often its interventions have proved critical.

But the crisis also threw up some issues with the way advice is generated, several stemming from the fact that, as an ad hoc group, SAGE was not designed to take on such a prolonged role. It has now met more than 70 times; in most previous crises it has met on no more than five occasions. Typically, after the initial weeks of a crisis, the lead department and agencies take over for the ongoing response. In a public health crisis, this would be the Department of Health and Public Health England (PHE) (and the public health agencies in the devolved governments). But this did not happen. Instead, No.10 opted to retain greater control at the centre and keep SAGE running even after COBR stopped meeting.

SAGE and its secretariat have coped with a punishing workload. In late summer, some of its external members were still working pro bono and said they lacked pastoral support and clarity about their roles. As in past crises, scientists have been put under sustained, and unfamiliar, media scrutiny. Extra support has been put in place in recent months, but more should now be done to better equip SAGE for future crises.

Scientific advisers have struggled to access data essential to their modelling, including health data, in part because government departments and public agencies were unwilling to share it, and had concerns over the legality of sharing data with external organisations. This was most difficult early in the crisis but has continued. The creation of the Joint Biosecurity Centre (JBC) in May, with additional analytical resources and access to data, helped. But these problems reflect deeper issues with data access and sharing in government.*

Vallance and Whitty have managed a difficult balancing act. They have publicly made clear where their advice suggested stronger action was needed, while also maintaining a close relationship with the prime minister and other ministers. Some interviewees questioned whether they and other SAGE members been forced to "self-censor" their private advice to ministers, based on what they thought ministers' would support. This has come up in past crises and will no doubt feature in the public inquiry into the government's handling of coronavirus. But accusations that Vallance and Whitty have been "captured" are wide of the mark.

* While there have been some improvements, data sharing between organisations remains patchy. There is a lack of clear responsibility for improvement: the post of chief data officer has been vacant for four years. The Institute for Government set out how to improve the use of data in policy making in a previous report, www.instituteforgovernment.org.uk/publications/policy-making-digital-world

The GCSA and CMO should reflect, however, on the criticism that there could have been more challenge built into the scientific advice process. While they clearly thought hard about how to do this, scientists inside and outside government argued that SAGE has still been dominated by too narrow a group of medical scientists and modellers at the expense of others such as external public health experts. The same criticism was made after the swine flu crisis.

Transparency and communication of science advice

The communication of scientific advice and evidence is crucial in a public health crisis. Compliance relies on the public trusting the government's overall handling of the crisis, understanding specific measures they are supposed to follow and having confidence in the rationale for them. But here the government has fallen short.

A lack of transparency about SAGE's membership and advice in the first four months created suspicion about the government's approach that it has struggled to shake off, even after much greater publication and openness. Lack of access to evidence also undermined the implementation of specific policies: for instance, making it harder for parents and teachers to have confidence in the government's plan to reopen schools.

In May, SAGE published a backlog of minutes from its first 34 meetings and it has published minutes fairly regularly since. This is welcome and has raised the quality of public debate. But the prominence of SAGE evidence without clear discussion of the other evidence (such as economic advice) has created a perception of conflict between ministers and scientific advice: for example, over the timing of a second lockdown.

The government's communication of the risk around key activities has also often been confusing. Ministers have switched back and forth between alarm and reassurance, while failing to drive home key messages, such as the risk of gathering in indoor and poorly ventilated settings.

Trust in the government's handling of the crisis – and its authority in communicating rules – was also harmed by its response to the scandal over Dominic Cummings, the prime minister's chief adviser at the time, who broke lockdown rules by taking a trip in April from London to Barnard Castle in the north-east of England. That damage was ultimately a matter of political judgement and leadership. But scientific advisers arguably should have been more consistent in distancing themselves from the breach of rules in order to preserve the consistency of public health messaging.

The government has also frequently released details about major changes such as national lockdowns through off-the-record briefings, creating uncertainty and adding to public anxiety. At times there has been a lack of clarity about who was responsible for communicating the overall strategy.

Recommendations in brief

Recommendations for the current crisis

We offer three main recommendations for the current crisis. First, the government must integrate scientific advice better with other forms of advice, particularly with the economic advice given to the chancellor. In the coming months, as vaccines are rolled out but cases remain high, the government cannot afford to repeat the muddled thinking behind the accelerated lifting of the first lockdown.

There have been calls to appoint economists to SAGE, but this would not solve the problem of how best to integrate different forms of advice. It is ultimately for the Cabinet Office – not an external advisory committee – to bring different strands of analysis together into coherent advice. Officials and scientific advisers told us this was not happening effectively, though there have been exceptions such as the revision of the safe distancing guidance from two metres to 'one metre plus'.

- **The Cabinet Office should ensure the Covid-19 cabinet committees use a clear decision framework that integrates scientific, economic and other advice, and have enough capacity in place to support this.**

Second, the government needs to improve the way it sets out the trade-offs it is facing. It finally published analysis of health, economic and social effects of Covid-19 in late November, but the document was widely criticised for rehashing existing analysis and failing to engage with the costs of implementing different restrictions, or not doing so. Better explanation is needed not least because it may find itself acting contrary to the view emerging from SAGE again in the coming months.

- **The government should improve the way it sets out the basis of its decisions, including by publishing further economic analysis.**

Third, the government must improve its communication – which will be especially important as it seeks to build confidence in the vaccine roll-out. The appointment of a new press secretary and director of communications provides an opportunity to refresh its approach. New measures should not be leaked chaotically but announced (and debated) in parliament. Joint press conferences may sometimes work, but always appearing alongside ministers has made it harder for scientists to explain their advice and the evidence on health risks.

- **The government should ensure any new public health measures are announced and explained in parliament.**

- **The government should be clearer about the purpose of press briefings and allow scientist-led briefings more often.**

Recommendations for future crises

The crisis has shown the relationship between ministers and scientific advisers to be crucial, but difficult to get right. Ministers and officials need to develop a "scientific mindset", as Vallance has put it, if they are to ask the right questions and understand scientific advice.[1] Ministers and the GCSA also need to consider how to manage such prolonged crises in future and how to incorporate more internal challenge.

- **The prime minister and secretaries of state should prioritise developing strong working relationships with their scientific advisers, including through inductions and planning exercises.**

- **The government should strengthen science capability across the civil service, including by ensuring departmental chief scientific advisers have sufficient clout and resources.**

- **Ministers should set out clear expectations about the role the new National Institute for Health Protection (NIHP), which will replace PHE, will play in future public health crises and ensure it is given the ability to do so.**

- **The government should apply the technique of 'red teaming' – groups that are tasked with finding a weakness in a proposal or system – more consistently, particularly in complex future crises.**

1. Introduction

On 16 March, in the first of what would become daily press conferences, Boris Johnson advised the public to avoid all unnecessary social contact and travel, and to work from home if possible. He insisted the government's decisions would be "led by science" and was flanked by two relatively unknown figures at the time, Sir Patrick Vallance, the government chief scientific adviser (GCSA), and Professor Chris Whitty, the chief medical officer (CMO) for England. Both have since become household names. Like their predecessors in previous crises, the pair have played a central role in informing the government's response.

But using science advice well in a crisis is hard. It relies on ministers and officials knowing what questions to ask, how to comprehend and challenge advice, and how to balance it alongside other inputs to form judgements. It relies on the GCSA and CMO (and others depending on the type of crisis) being able to marshal a range of expertise and often uncertain evidence. They must understand ministers' objectives such that they can distil expertise into useful advice. And it relies on both ministers and scientific advisers being able to communicate the evidence and rationale behind measures to the public, particularly in a crisis where success is determined by public adherence to measures.

The UK has a well-developed system for using scientific advice during emergencies

The UK has been a pioneer in the use of science advice in government – and in crises. In 1855, it became the first country in the world to create the post of chief medical officer – the 'nation's doctor' responsible for advising on epidemics and disease prevention and acting as an interface between the government and medical and clinical professionals. In 1964, it became only the second to formally appoint a government chief scientific adviser (GCSA). The GCSA is the prime minister's top adviser on scientific issues and oversees the network of scientific advisers and science and engineering officials in government.

The GCSA is responsible for co-ordinating scientific advice in an emergency, and typically draws together a committee of expert advisers to support this. In 2009, this was formalised through the creation of the Scientific Advisory Group for Emergencies (SAGE) – an expert group activated at the start of a major crisis that integrates independent scientific research and analysis from across government and academia. Its membership changes depending on the nature of the emergency. The GCSA appoints SAGE members, though the Government Office for Science keeps lists for different types of crisis. During a public health emergency, SAGE is co-chaired by the GCSA and CMO.

SAGE's role is to provide a consensus view to ministers to support the government's response to an emergency. Committee members can express different opinions to the media in a personal capacity, but the purpose of SAGE is to distil a wide range of evidence and expertise into a single view. SAGE responds to requests for advice on specific questions from the Civil Contingencies Committee (COBR), which is chaired by the prime minister or a senior minister and directs the government's response to the emergency.

Government departments and public bodies also receive a wide range of scientific advice – and this continues to play an important role in a crisis in informing decision making across government. Many have their own scientific advisory committees – there are more than 70 across government.[1] Almost all departments have appointed a chief scientific adviser. Agencies such as (the soon to be replaced) Public Health England (PHE) also have deep scientific and technical expertise that is important in a public health crisis.

Past crises have exposed the difficulties with using science advice well

The UK has experienced three major disease outbreaks in the past 30 years: bovine spongiform encephalopathy (BSE, or 'mad cow disease') in the 1990s; foot and mouth disease (FMD) in 2001; and H1N1 or 'swine flu' in 2009. UK ministers have also called on scientific advisers to inform their responses to epidemics abroad, such as Zika and Ebola, and other types of crisis, such as the disruption caused by the Icelandic volcanic ash cloud in 2010 or winter flooding in 2013 (see Figure 1).

Scientific advice played a prominent role in all of these crises. In several cases, there have been lasting controversies over how it was communicated to the public and used to make decisions. During the 1990s, ministers repeatedly reassured the public that British beef was safe to eat, despite uncertain evidence; agriculture minister John Gummer was famously pictured eating a burger with his daughter. It was not until March 1996 that the government reversed its position and acknowledged a link between BSE in cattle and a neurological disease (vCJD) in humans. Some 178 deaths have been attributed to vCJD in the UK since.

In the summer of 1996, the crisis appeared very troubling. The EU imposed a ban on British beef (which would not be lifted until 2006). Around 4.4 million cattle were slaughtered in the UK. And the media, suspecting a cover up, blew the level of risk to humans out of proportion.* John Major, Conservative prime minister at the time, said he was "scared stiff" that he was presiding over the collapse of a £20 billion industry and had never worried so much about an issue since entering the House.[2]

The outbreak of FMD in 2001 was one of the largest foot-and-mouth epidemics in history. It was brought under control through a controversial policy of mass "contiguous culling", which meant killing not only infected cattle but cattle in adjacent fields and areas, opposed by many vets and farmers at the time. In total, more than

* For example, the *Daily Mirror* ran with the headline: 'WE'VE ALREADY EATEN 1,000,000 MAD COWS: "BORROWED TIME" FEAR', Turner A, *The Classless Society: Britain in the 1990s*, Aurum, 2013.

six million cattle were slaughtered, leaving an indelible mark on farming communities and the countryside economy. The overall cost of the crisis was estimated at £8bn.

Subsequent research found that cattle were infectious only when they had symptoms and suggested such pre-emptive culling should not be used in future.[3] However, scientists involved have argued that given the size of the outbreak – it had spread to up to 50 farms by the time the government intervened – and the lack of surveillance and data on transmission at the time, a more targeted approach would not have worked.[4]

The 2009 swine flu crisis ultimately had a much less dramatic impact than BSE or FMD, but initial warnings suggested it would be more damaging. The first cases of the virus were detected in Mexico and the US in April 2009 and community transmission was recorded in the UK at the start of May. In July, the then CMO, Professor Sir Liam Donaldson, released models for the potential impact of the pandemic. Under the best scenario, 5% of the population would become infected with an estimated 3,100 deaths. The 'reasonable worst-case scenario' – which was widely reported – assumed 50% of the population would be infected, with a death toll of up to 65,000. In the event, the pandemic turned out to be far less damaging than feared, with a total of 457 deaths by March 2010.[5]

The subsequent inquiries launched into these crises show many of the difficulties the government have struggled with during the Covid-19 pandemic are not new. Reviewing them, we identified five persistent criticisms.

- **The relationship between ministers and scientific advisers is essential, but has proved difficult to get right.** While the UK system uses committees of advisers (as favoured by most EU countries), it also gives the GCSA and CMO a central role as conduits of expertise into policy making. This pair therefore have a tricky balance to strike between being independent experts and trusted advisers, and their relationship with the prime minister has a major bearing on the handling of crises. David King, GCSA between 2000 and 2007, gained the trust of Tony Blair, and was even able to publicly contradict ministers. He took a prominent role in the FMD crisis, leading the government towards the controversial policy of mass culling. By contrast, William Stewart, GCSA during the earlier BSE crisis, was side-lined.[6] Most other EU countries rely more on committees than individuals.[7]

- **Ministers and officials have often not found it easy to understand and interrogate scientific advice.** For example, until 1996 ministers often claimed the argument that BSE would have no implications for human health was "a matter of scientific certainty", when in fact the report they cited was explicitly uncertain and based on limited data. The subsequent Phillips inquiry into the crisis stated that the government needed to retain expertise to ensure scientific advice was properly understood. Uncertainty around modelling has proved especially difficult for ministers. The independent Hine report into the swine flu pandemic found that insufficient data in the early stages of the pandemic meant that the modelling figures had wide confidence intervals and this was not fully appreciated by ministers or officials.[8] It recommended that they should receive training on how to interpret it.

- **Ministers have sought to blur the line between policy decisions and scientific advice – and GCSAs, CMOs and others have struggled to protect their independence.** There is inevitably some crossover: use of evidence is not free from biases and political values, and the line between scientific and policy advice is often finely drawn. However, the Phillips inquiry found ministers had a tendency to want to obscure the distinction between advice and policy decisions and that government departments often asked expert committees to assist with policy decisions that should have been reserved for government, rather than having those discussions with officials.[9] The inquiry acknowledged an inherent tension but recommended consideration should be given to how to keep scientific advice and policy decisions separate. In his book on the role of scientific advisers in government, Professor Roger Pielke Jr, an American political scientist, noted how difficult it is for individual scientific advisers to carve out a neutral role as "honest brokers".[10]

- **The GCSAs and CMOs have often struggled to design enough challenge into the committees they run and processes they oversee – and have been vulnerable to 'groupthink' in several past crises.** The absence of a medical epidemiologist and human public health expert on the BSE advisory group established in 1990 was seen as a major omission given rising concerns that BSE was transmissible to humans.[11] A report by MPs in 2011 similarly questioned whether there was adequate challenge within SAGE during the swine flu crisis.[12] The Hine review argued that scientific advice in that crisis was too dominated by a narrow group of medical scientists and modellers – and the GCSA should have exposed modelling to scrutiny by experts from other areas, such as public health.

- **Governments have often struggled with when and how to make science advice public – as well as how to communicate it in a way that builds trust, adequately reflects uncertainty and avoids creating panic.** Previous inquiries have wrestled with the question of the appropriate time to release minutes and papers produced by SAGE, and criticised excessive secrecy.[13] During the BSE crisis, scientific advisers described the media pressure as "immense" and noted they received no training on how to manage it.[14] In the swine flu pandemic, Donaldson failed to adequately explain to the media that the 'reasonable worst-case scenario' of 65,000 deaths was not the government's core forecast.

The coronavirus pandemic has been on a different scale but has echoes of past crises

The current crisis has been on a different scale to these previous crises in terms of the difficulties facing the government and those advising it. It has been much more severe in terms of the impact on life (causing more than 65,000 deaths in the UK and more than 1.63 million worldwide as of 16 December)* and livelihoods (it has spurred the deepest recession in the UK since the Great Frost of 1709).[15] It has also been more broad-based and prolonged, with every part of the country, every sector of the economy and every area of government affected for many months. It has been characterised by extreme uncertainty: almost nobody had heard of the

* See 'COVID-19 Dashboard by the Centre for Systems Science and Engineering at Johns Hopkins University', www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6

pathogen SARS-CoV-2 in January and scientists have rushed to understand its basic characteristics: how it spread, who was susceptible, its effects, how it could be treated, whether patients gained immunity. And it has been truly international, with scientists around the world collaborating, the media informing the public of events unfolding abroad and ministers forced to explain when approaches and outcomes differed.

Although the scale and severity of the crisis are different, the use of scientific advice in the response has exhibited all five problems described above. This is because these problems arise from the inherent tensions and difficulties in how scientific knowledge and expertise is incorporated into political decision making in highly pressurised situations.

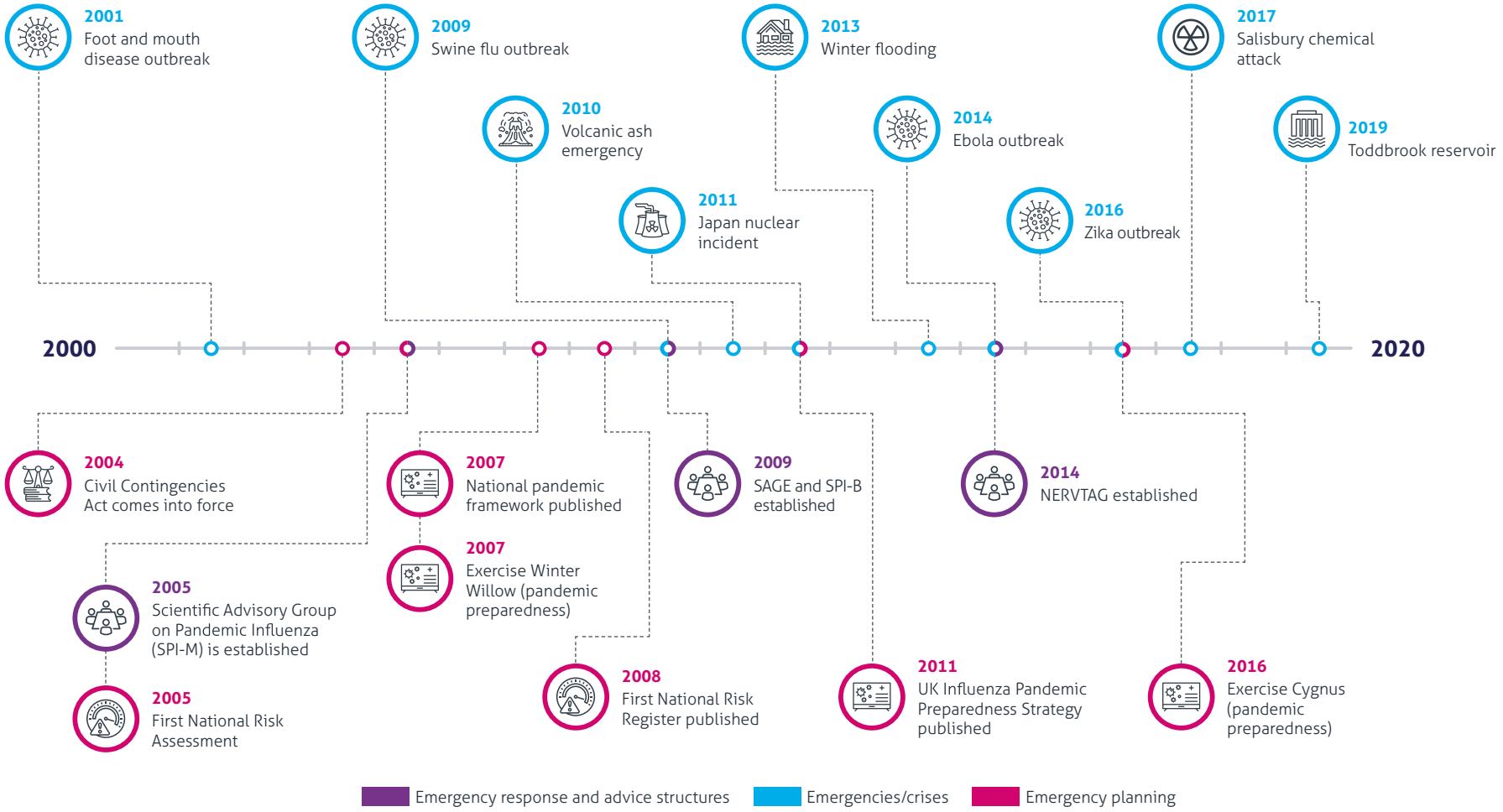
The crisis has also highlighted the importance of another aspect of the UK's approach: the way it prepares for future risks. The UK pioneered the use of national risk assessments, to which the GCSA and CMO contribute, and publishes a version of the assessment as a public register. A different type of virus – pandemic influenza – had been ranked highest in terms of likelihood and severity of impact several years in a row, and the UK had prepared extensively for how it would respond to such an event. Novel respiratory viruses were ranked lower, deemed as both less likely to occur and with lower impact, based in part on the UK's assessment of the relatively small impact of the 2002–04 SARS epidemic on western countries.[16]

SARS-CoV-2 turned out to be a different type of threat to those the UK had prepared for, largely because it is more transmissible than pandemic influenza or previous coronaviruses, such as SARS or MERS.[17] This meant it could not be contained in the same way. Unlike a flu pandemic, there was also no prior vaccine to work from and testing processes had to be developed from scratch.

This frustrated the UK's immediate response. With plans oriented towards an outbreak of a less contagious influenza rather than a virus such as Covid-19, the Department for Education did not have a detailed plan for how it would close schools while the government struggled to respond to the level of demand for personal protective equipment (PPE), which was 15 times higher than that modelled for pandemic influenza. Even the relatively low likelihood attached to a novel respiratory virus was not adequately carried into operational plans.

Risk planning had an impact on readiness and the initial response across government and the wider public sector. It also influenced scientists' thinking as they began to try to understand the virus in the initial months. In the next chapters, we examine how ministers and those advising them responded.

Figure 1 **Timeline of selected emergencies and changes to emergency planning**



Source: Institute for Government analysis.

2. How science advice has been used in decision making

The value of science advice in a crisis depends on the quality of the decision making it informs. Ministers and officials need to balance scientific advice alongside other inputs, ask the right questions and understand how to interrogate advice received. In turn, science advisers need to understand ministerial priorities to make their advice relevant and useful. This dynamic has not always been achieved in the current crisis.

Ministers' insistence that they were "following the science" was inaccurate and damaging

In the early months of the crisis, the prime minister and other cabinet members regularly said they were "following" or "led by the science". The phrase was offered so frequently in daily briefings and media interviews that it became a mantra. It may have been an attempt to give greater authority to public health measures. But the phrase was inaccurate – and in fact damaging – because it implied a role that scientific advice could and should not play.

The phrase blurred the line between the scientific advice and policy decisions. Politicians make judgements by weighing up a range of factors – the social, economic and other impacts of a proposal; operational considerations; their values and political programme; and the attitudes of their parliamentary party, the media and the public.[1] Scientific advisers cannot make policy judgements for politicians to simply "follow".

The difference between being *led* by and *informed* by the science may seem subtle, but it is important. It is also not new. Ministers should have appreciated the distinction given the UK's experience of previous crises: the BSE inquiry noted that "the attraction" for ministers of obscuring the distinction between scientific advice and policy choices was harmful.[2]

Politicians outside Westminster took a different approach. Nicola Sturgeon, first minister of Scotland, said that science advice "informs our decisions" while stressing "the uncertainties and complexities of the decisions ahead".[3] Angela Merkel, the German chancellor, said that information from scientific experts informed decisions made by the authorities.[4] Jacinda Ardern, the prime minister of New Zealand, explained her decision to lock down as a choice made by the cabinet, drawing on medical data and modelling.[5]

The UK government's decision to frame science advice the way it did undercut both the importance of ministerial judgement and the accountability of ministers for those decisions. It also undermined the protective space in which scientists advising the government could operate. It made it difficult to explain occasions UK ministers came to different decisions from those in the devolved administrations and other countries.

And it made it harder for scientific advisers, pressed at daily briefings, to clearly set out their expert view of the evidence. Their appearances alongside politicians made them appear accountable for policy choices. Many scientists, including members of the Scientific Advisory Group for Emergencies (SAGE), went as far as to say they felt they were being set up as scapegoats, with politicians "hiding behind a cloak of science".

The specific phrase "*the* science" also implied there was a single, fixed scientific view of the pandemic. But this was a crisis caused by a novel pathogen, about which scientists had, for many months, limited understanding. In many areas – the extent of asymptomatic transmission, the efficacy of face masks – scientific understanding was uncertain and changed rapidly. And, as one interviewee said, it misrepresented the nature of science: far from establishing one unchanging truth, acknowledging uncertainty is "at the heart of what it means to be scientific".

UK ministers eventually began to drop the phrase in May and June. But by then the line had already been blurred – and would remain so. As well as obscuring the role of ministers, it also created a perception of SAGE that was at odds with what the body was designed to do. This planted the seed for tensions between science and other forms of advice that have affected subsequent decisions as the crisis has progressed.

Ministers' lack of clarity about strategy delayed decisions and made it harder for scientific advisers to provide useful advice

The use of scientific advice throughout the crisis has been undermined by major problems in how the government made decisions.

One SAGE member described a "void of decision making" at the centre. In the early stages of the crisis, the prime minister missed several key COBR meetings. While COBR meetings are often chaired by other ministers, Boris Johnson's absences raised legitimate questions about whether the prime minister was sufficiently alert to the scale of the threat.[6] Less than three weeks later, he and several senior ministers and advisers fell ill with the virus. But even after a recovered Johnson took greater charge, a lack of clarity over decision making continued.

The government shifted between several different forums of decision making: first COBR, then a smaller C-19 group centred around the prime minister and key ministers, then two cabinet sub-committees dealing with strategy and operations respectively. There may have been good reasons why the models needed to change as the crisis developed, but the shifts made decision making opaque and confusing for senior officials working in government, let alone external advisers working on SAGE. There was also a divide between No.10 and the Cabinet Office, which added to the chaotic

nature of decision making at the centre. At times it was very unclear, outside the inner circle, just who would be involved, how decisions were taken and on what basis.

Delaying the decision to lock down in March laid bare these problems – and led to tragic consequences. An Institute for Government report that examined that decision found that "science was seen as a source of 'answers' to the questions with which the government was grappling, rather than an input into wider policy discussions".

Scientific advisers, including Whitty and Vallance, have argued that politicians implemented SAGE's advice on the first lockdown in reasonable time.[7,*] However, at the root of the issue is not timing per se but how government uses advice. In countries that locked down faster – and suffered proportionately fewer fatalities than the UK – politicians often made a judgement or decision on a *precautionary* basis. In the UK, ministers were unwilling to take action until scientists thought the evidence was "overwhelming".[8] Waiting for evidence to cross that bar proved costly. With the benefit of hindsight, and evidence they did not have at the time, several SAGE members have conceded that with cases in mid-March doubling every three to four days, many lives would have been saved if the UK should have locked down just a week earlier.[9,**]

There was ongoing confusion in the scientific community over the government's objectives. The basic strategy – suppression of the virus – was known. But beyond that, we were told, scientists asked to advise the government often had little idea of what politicians' objectives were and what actions they were prepared to consider taking to achieve them, or over what timeframe. This persisted after the first lockdown. On 11 May, the government published *Our Plan to Rebuild*, its strategy for exiting the lockdown,[10] but as our colleague Gemma Tetlow argued, this left glaring questions about the government's objectives and reasoning unanswered, including how it would balance different trade-offs and what informed its plans for phasing out restrictions.[11,***]

SAGE members told us that in the autumn they were still unclear about the government's thinking, despite the new Covid cabinet committees having been created in June with the aim of clarifying decision making. One interviewee described the conversation between ministers and SAGE as circular: "Ministers said: 'What should we do?' and scientists said: 'Well, what do you want to achieve?'" Some back and forth is necessary to refine questions, but scientists said ministers' objectives remained unclear throughout the crisis.

This had a lasting effect on how effectively science advice was used. One SAGE member described it as the biggest obstacle he had faced in advising the government.

* Two days after lockdown, Vallance said: "I think the government has listened to SAGE's advice very carefully and followed it." Whitty agreed that ministers followed SAGE advice "with a delay of no more than you would reasonably expect".

** Neil Ferguson, an Imperial College modeller and member of SAGE, told MPs: "Had we introduced lockdown a week earlier we'd have reduced the final death toll by at least half." Others have argued that a policy of "shielding" would have caused less harm but it is highly doubtful whether such a policy would have worked.

*** It also failed to explain the reasoning or evidence behind specific measures, such as encouraging people to travel to their workplace if it was open but keeping schools closed.

The lack of strategy meant the government struggled to commission advice effectively

There were also problems with how ministers and officials commissioned science advice. SAGE is meant to be a "crisp mechanism for filtering and answering questions", one scientist told us. But particularly in the initial months of the crisis, the questions that came to it were often poorly formulated. With limited understanding of ministers' thinking, scientists often struggled to answer them. This undermined the ability of scientific expertise to feed into political decisions.

A SAGE member, with experience of playing a leading role in past crises, explained how commissioning (the process by which policy makers request scientific advice) should work. The COBR secretariat should work with ministers and departments to refine a question – "how toxic is Novichok?" in the case of the Salisbury poisoning – on which scientists can assess evidence and agree a consensus view. An official explained that to be a good "policy customer", departments needed to give SAGE "clarity on what they're trying to achieve".

But officials and SAGE members said that the questions submitted to it during the earlier stages of the coronavirus crisis, particularly in March and April, were not always well phrased and objectives were often unclear. Ministerial discussions and policy decisions were described as a "black box", and scientists we spoke to said they had little clarity about how their advice was used.

The government failed to consult with SAGE on the potential impact of some key policies it was contemplating. Theresa Marteau, a member of SPI-B, the SAGE sub-group for behavioural advice, cited the example of the government's advice on self-isolation for those suspected of being infected.[12] She said that had they been consulted, behavioural scientists on SPI-B would have advised that the level of financial support was too low to encourage adherence, and that the use of fines could discourage people from engaging with the track and trace system. This may show the benefit of hindsight – but has proved the case.

The government was also slow to seek advice from SAGE on issues where it was evident some time in advance that difficult policy decisions would have to be made. It should have been clear from March, for example, that managing the return of students to universities in the new academic year would be a challenge. But SAGE was not commissioned to look at this until it was almost too late to inform policy. Members told us that, since they were not asked for advice on some key issues, they started to set some of their own research questions based on what they thought would be useful to policy makers.

The closures of schools, ultimately announced on 18 March, was a prime example of where it was difficult for SAGE to provide useful advice and modelling without a sense of what ministers wanted to prioritise and what options they would consider – who would be sent home, for how long and so on. Even when it came to schools reopening in June, communication between SAGE and the Department for Education (DfE) was

limited, which made it difficult for policy officials and scientists to quickly test options and scenarios. This was partly, though, because decisions were made rapidly by the prime minister and education secretary, outside of normal departmental processes.

Part of the role of the GCSA, CMO, and departmental CSAs is to act as conduits between policy discussions and expert committees. The critique from the scientists we spoke to about the way advice was commissioned suggests that at times this was impeded.

But interviewees suggested that this may also reflect the breakdown of cross-department co-ordination and the traditional role of the policy making official at the centre – of bringing different strands of thinking together effectively to help ministers make decisions. The Civil Contingencies Secretariat (CCS), a Cabinet Office unit that prepares for emergencies and has extensive experience of refining questions for scientists, was shunted aside by No.10 in the initial months.

Another key difference to previous crises was that multiple departments needed advice – from the Treasury to the DfE – and many had limited experience of working with scientific advisers in the past.

By May, SAGE was complaining of being overloaded by requests for advice coming in from across government, including many questions that did not appear essential.[13] There was confusion as officials and ministers contacted SAGE members directly, after which departments were instructed to channel all requests for advice centrally. SAGE members and officials involved at the centre said this led to an improvement, though members still reported issues with the framing of questions, restricting the use of their responses to officials. It is difficult to include everyone at the right stage when decisions are being made in rapid, and often ad hoc, way. But scientific advisers could have provided more value had communication between politicians and scientists been better.

Decision making – and scientific, economic and other advice that informs it – has been fragmented

Another problem with government decision making during the crisis is that it has not been joined up. This is a perennial criticism of Whitehall, but has proved especially damaging in a pandemic in which mitigating a public health threat has required policies with huge economic and social impacts.*

A lack of joined-up thinking was most apparent as the UK exited the first lockdown over the summer. From May, the government encouraged people to return to offices and even travel abroad, while the Treasury, in particular, launched policies designed to encourage them to venture out and spend. These policies reflected changing political priorities – particularly of more "hawkish" cabinet members anxious to get the economy moving. But they were also based on an optimistic – rather than a scientific – assessment of the progression of the coronavirus at the time: as Rishi Sunak, the

* For example, academics have been examining questions such as how behaviour responds to the progression of the pandemic and how risk of infection affects incentives to work and consume. Yates T, 'We need a new UK Centre for Epidemiology and Economics', blog, 10 July 2020, retrieved 8 December 2020, www.longandvariable.wordpress.com/2020/07/10/we-need-a-new-uk-centre-for-epidemiology-and-economics

chancellor, put it in the Commons on 5 November, the Treasury was confident that "we could stay ahead of the virus".[14]

This view was not shared by the leading epidemiologists advising government. SAGE members saw policies that incentivised people to gather in risky indoor settings and travel abroad, potentially re-seeding the virus on their return, as epidemiologically illiterate – and were consistent in advising to this effect. While the exact effects of the Eat Out to Help Out scheme, which tempted people into pubs and restaurants with government-subsidised half-priced meals, is still debated, a recent study from the University of Warwick suggested it caused a "significant" rise in infections.[15] John Edmunds, a core SAGE member, told an Institute for Government event that SAGE was not consulted on the policy.[16]

More broadly, we were told in September that Treasury ministers and officials had not developed close relationships with SAGE scientists.

This lack of integration was not helped by the fact that economic and epidemiological modelling is largely done separately currently. For example, the Imperial College model does not include economic inputs (meaning that it did not take account of how people would respond to emerging health risks) – while modelling by the Treasury, the Bank of England and the Office for Budget Responsibility does not incorporate epidemiological analysis. Combining the two in any meaningful sense would undoubtedly present challenges, and Whitty rejected the suggestion that it could easily be done through SAGE.[17] However, much more could be done to ensure they do not happen in isolation, and those producing respective models could share their working and assumptions more collaboratively. Meanwhile, several academics have argued that given time, modelling could be brought together if the government funded economists and epidemiologists to collaborate.[18]

Several people – including the former prime minister Theresa May – have suggested that another way to resolve this lack of integration would be to add more economic and business expertise to SAGE. But this would not solve the problem of departments like the Treasury and the Department of Health and Social Care (DHSC) not talking enough to each other. It should be the role of the Cabinet Office – not an external scientific advisory committee – to bring together different strands of advice to inform discussions in the Covid-19 cabinet committees on strategy and operations. But SAGE members and government officials we spoke to in the summer and autumn thought this was not happening effectively.

The government did show itself able to integrate different forms of advice, for example when deciding to change the minimum distancing guidance from two metres to 'one metre plus' in June. Other countries, such as Spain and Germany, had adopted more lenient rules of one metre or 1.5 metres distancing from the start, in line with WHO guidance. But in April and May, SAGE recommended retaining the two-metre rule. In June, a joint review was conducted the GCSA, the CMO, Simon Case, then Downing Street permanent secretary (now cabinet secretary), and Clare Lombardelli, the Treasury's chief economic adviser. It noted the severe economic costs of two-metre

distancing and concluded that the minimum safe social distance could be reduced to one metre with other mitigations such as face masks. In this case, ministers understood the limits of SAGE and political pressure pushed them to combine analysis to provide stronger grounds for a policy change.

But our interviewees saw this as an exception. An immediate priority for the current crisis should be to break down departmental silos.

Ministers and officials not properly challenging scientific advice caused problems

Politicians cannot take scientific advice as gospel. Ministers and officials need to understand and challenge scientific advice in order to combine it effectively with other sources of advice to inform decisions. Some ministers are capable of doing this well. But in the current crisis, they have too often appeared "passive recipients" of scientific expertise, as historian Lawrence Freedman put it.[19]

There are several reasons why a lack of political challenge caused problems. First, scientists may have limited understanding of the wider factors that inform decision making, such as operational capacity. It is up to politicians and officials to bring together the different forms of advice and information they receive and scrutinise them. An example in the current crisis was testing and the evolution of contact tracing.

Jeremy Hunt, former health secretary and chair of the Health and Social Care Select Committee, has questioned why the government did not do everything possible to raise capacity earlier to support contact tracing. He claimed testing capacity was raised to 100,000 tests a day in April (albeit with some dubious counting) and asked why that did not happen in January or February.[20] Investigative journalist Chris Cook has argued that the fact that the government did not focus on raising capacity before March was influenced by assumptions made in the flu strategy, including that its approach would quickly move beyond contact tracing.*

There were operational problems. DHSC ultimately held responsibility for the build-up of testing capacity, working with PHE and others, although Institute for Government research found responsibilities and lines of accountability were unclear.[21] The department struggled to raise capacity quickly for various reasons, including fragmentation and lack of co-ordination in the NHS, problems with IT systems and problems securing the supplies needed for tests.

SAGE's advice was affected by these operational problems. With limited test and trace resources available, and the pandemic having grown beyond the 'contain' phase, the focus was on how to use resources pragmatically. SAGE's minutes focus on protecting ICU capacity.[22] But SAGE was consistent in advising the government to raise testing capacity.[23]

* As Chris Cook has written, under the flu strategy there would be a drive to monitor and study the "first few hundred" cases, but officials assumed containment strategies would quickly become ineffective due to the volume of cases entering the country. Officials said it was "hard to break away from a plan that was very well conceived". Cook C, 'The wrong kind of pandemic', Tortoise Media, 6 October 2020, retrieved 8 December 2020, www.tortoisemedia.com/2020/10/06/the-wrong-kind-of-pandemic

Ministers and officials should have had a clear view of how the scientific advice intersected with operational issues. But it appears they accepted the advice too readily without interrogating it. A senior official told Tortoise Media: "The PM didn't push back [on the advice on contact tracing], at least not very much. Boris was content to go along with the advice."[24]

The second reason why a lack of political challenge is problematic is that scientific advisers often make assumptions about political influences on decision making, particularly when the interface between scientific and policy discussions is working poorly. Some interviewees said they thought that SAGE, and even on occasion the GCSA and CMO, engaged in "self-censoring", based on what they thought would be acceptable to politicians. We do not know how Vallance and Whitty presented arguments to ministers behind the scenes, and both would doubtless refute such claims. But SAGE members have said, for example, that the delay in recommending the first lockdown was influenced by scientists believing it would be politically unpalatable. Ministers need to ensure that scientists feel able to offer candid advice – and they need to interrogate what they hear to ensure they understand the assumptions that underpin their advice.

Third, ministers need to understand scientific modelling and the level of risk and certainty that scientists attach to projections. Modelling has dominated scientific advice to ministers in past public health crises, such as swine flu, as has again in the current crisis. It has probably been too dominant, as we will argue later. Nevertheless, ministers and officials need a strong understanding of what models are showing if they are to use them well to inform decisions, and this again did not appear to be the case.

Interviewees described how challenging scientific advisers can be difficult because they are often "highly confident" and ministers and officials can feel stupid for asking obvious questions. A former permanent secretary said: "Ministers don't find it easy to follow what scientists saying... so they often think it's better to hide lack of knowledge." Another described ministers "glazing over" when presented with scientific evidence.

Officials and special advisers around ministers, who are aware of how they operate and understand their decision making style, should help to facilitate good two-way conversations between ministers and scientific advisers. There was a furore over the revelation that Dominic Cummings and Ben Warner, another key No.10 adviser, attended SAGE meetings. But it was sensible. Officials and special advisers should help ministers to understand the scientific discussion and work out what questions to ask.

In recent months, ministers have shown a willingness to reject scientific advice. Most controversially this was apparent with regards to SAGE's call on 21 September for a second national 'circuit breaker' lockdown. Their calls for action went unheeded for six weeks. The regional tiered approach proved inadequate, as scientists warned it would (though ministers would no doubt claim they faced uncertainty over whether it would work). Ultimately, ministers and officials need to find a balance – interrogating and weighing scientific advice alongside other inputs to form decisions.

Recommendations for the current crisis

The government has faced severe difficulties in the coronavirus crisis. But the approach taken by ministers and officials to science advice unnecessarily impaired the response. Some problems are deep-rooted and will take time to address, such as weaknesses in scientific capability in Whitehall. But there are also immediate fixes that would improve the use of scientific advice in the current crisis.

1. The government should develop a clear framework for integrating different forms of advice

The Cabinet Office should adopt a clear framework for decision making that brings together different forms of advice. Gus O'Donnell, a former cabinet secretary, has outlined how this could work – not just incorporating science and economics, but also a broader view of wellbeing and population health.[25] This would not remove difficult trade-offs, but it would help ministers to have a more informed discussion about how to manage them. Ministers cannot be expected to effectively reconcile differences if the advice they receive varies hugely in its analysis of the virus.

It is unclear whether the secretariat currently supporting the Covid cabinet committees has sufficient capacity and capability to support such a holistic approach to decision making. Most interviewees thought not. The Cabinet Office may need to bring in extra analytical expertise to support this. It should draw on other models that have effectively distilled a wide range of advice into a coherent view: Nick MacPherson, former Treasury permanent secretary, argued at an Institute for Government event that the National Security Council was one such model.[26]

As well as improving the way advice is integrated in discussions at the centre, departments should also open themselves up to scrutiny from those with different perspectives. It was a serious failure that Eat Out to Help Out was designed without input from the government's leading epidemiologists. Given the central role of economic measures to the success of the government's public health strategy, it is also regrettable that senior Treasury ministers and officials and scientific advisers do not appear to have developed close relationships.

The government may also benefit from developing more capacity outside of Whitehall to tackle more challenging tasks, such as integrating economic and epidemiological modelling. Tony Yates, a former Bank of England official, has suggested that a new Centre for Economics and Epidemiology, with a modest budget, could perform this role in the mould of the Office for Budget Responsibility. It may be unrealistic to expect government ministers and departments to hand over extensive influence to an external

body. But it would be sensible for the government and research funders to support work in academia to help bring the disciplines together ahead of future crises.*

- **The Covid cabinet committees should use a clear decision framework that integrates scientific, economic and other forms of advice. The Cabinet Office should ensure it has sufficient capability and capacity to support this.**

- **UK Research and Innovation should fund interdisciplinary programmes to bring together epidemiology, economics and other disciplines.**

2. Ministers and scientific advisers should draw a clear distinction between scientific advice and policy decisions

Rather than insisting that they are "following the science", ministers ought to make clear from the beginning of any crisis that they are informed by the best scientific advice, but also other advice. They should be honest with the public that their job is to make judgements. Departments should also ensure the distinction remains clear internally by making sure it remains the job of policy officials to provide policy advice.

There have been ongoing examples of ministers blurring the lines. For example, when Boris Johnson was repeatedly pressed in late September and early October about whether scientific advisers thought the regional tiered approach was working, he obfuscated, insisting his "advice" suggested it was. When the scientific advice was subsequently published, and contradicted his assertion,** this created unnecessary confusion. Johnson missed an opportunity to build confidence by explaining to the public the rationale for his decisions.

Ministers should be upfront and not use scientific advice in a misleading way to defend their choices. They should explain their judgements and persuade the public and MPs of the rationale for them, rather than deferring to their advisers to justify decisions.

There also needs to be "clear blue water" in departments between scientific advice and policy decisions to avoid scientific advice being "co-opted" by policy, as one official put it to us. The Department for Environment, Food and Rural Affairs (Defra) achieved this during the foot and mouth crisis by having a chief veterinary officer (a scientific adviser) and a separate director of animal health policy (a policy official). They worked closely together but their roles and responsibilities in a crisis were clearly defined, which helped to maintain a sharp distinction between scientific and policy

* Yates points to several economists who have started to explore how behaviour responds to the progress of the epidemic during Covid-19, Yates T, 'We need a new UK Centre for Epidemiology and Economics', blog, 10 July 2020, retrieved 8 December 2020, www.longandvariable.wordpress.com/2020/07/10/we-need-a-new-uk-centre-for-epidemiology-and-economics; Gus O'Donnell has argued for modelling that factors in impacts on wellbeing and the economy to inform decisions about lockdowns, O'Donnell G, 'The Covid Tragedy: Following the science or the sciences', speech at the Institute for Fiscal Studies, 24 September 2020; Ian Mulheirn, a former Treasury economist and executive director of the Tony Blair Institute, has produced a rough "Total Cost of Covid model" in an attempt to get people to assess how they trade off the costs, Mulheirn I, 'An interactive Total Covid Cost model', blog, 18 October 2020, retrieved 8 December 2020, www.medium.com/@ian.mulheirn/an-interactive-total-covid-cost-model-7ee5c965386e

** Scientific advisers made their views clear – that incidence was rising in tiers 1 and 2, and they were unsure that tier 3 was bringing transmission under control quickly enough.

discussions.[27] Some of this distinction could be achieved quickly through changes to ways of working, though departments may also need to look at planning to create new roles (as Defra did for FMD) in future crises.

- **Ministers should be upfront about the distinction between scientific advice and policy decisions and be open about where evidence is uncertain.**

- **Departments should ensure they maintain a sharp distinction between expert advice and policy discussions. They should plan the roles and responsibilities of scientific advisers and policy officials involved in emergency response.**

Recommendations for future crises

1. Ministers and scientific advisers should develop trusting personal relationships

The coronavirus crisis has shown that the relationship between senior politicians (the prime minister and secretaries of state of key departments) and scientific advisers is a crucial one. But even in normal times, it is not an easy relationship to get right; in the throes of a crisis, it is doubly hard. Both sides should invest in developing these relationships in "peacetime", and the process for doing this should be incorporated into induction processes.

A former cabinet secretary explained: "If you have to give science advice in a crisis for the first time you're lost. The time to educate politicians about science is before a crisis comes up. You need to get politicians used to issues and context and build up personal relationships beforehand." He noted that the timing of the current crisis, just three months into a new administration, was very difficult.

Prime ministers set the tone for relationships with the GCSA. They should ensure that they build an open and trusting relationship, which enables the GCSA to raise issues of concern. The most effective operators – going back to Solly Zuckerman, who first held the post under Harold Wilson in the 1960s – all had the trust of the PM. Interviewees told us that David Cameron made himself available to GCSAs and built a rapport with them quickly. But such open dialogue, in which politicians feel able to challenge and scrutinise scientists, has not been the case for all PM–GCSA relationships.

Scientific advisers, for their part, need to think carefully about how to approach the relationship, based on their judgement of a prime minister's personality. There is a difficult balance between being close to decision making and retaining independence. Predecessors such as John Beddington and David King were seen as more in the "independent challenger" mould. Some interviewees thought the shift towards "trusted confidant" started under Mark Walport, Vallance's predecessor. The best approach will depend on the personalities of the PM and GCSA, but the quality of the relationship is critical.

All of the above is even more true at the departmental level. Departments such as health and social care, education, transport and the Treasury have found themselves deeply involved in a fast-moving public health crisis and needing to respond to uncertain scientific evidence. But as previous Institute for Government research showed, the relationship between secretaries of state and departmental chief scientific advisers is often even less well established.[28]

- **The prime minister and secretaries of state should develop strong working relationships with their scientific advisers. The prime minister, GCSA and cabinet secretary should ensure this forms a routine part of ministerial inductions and planning exercises.**

2. Ministers and officials should improve their understanding of scientific issues and concepts

Several current and former officials and scientific advisers suggested the problems described above were partly caused by a lack of scientific understanding in government. Ministers and officials do not need to absorb huge amounts of scientific knowledge: that is what scientists do. The point is to understand enough about scientific and technical concepts to be able to use scientific advisers well – and interrogate the advice they offer. Vallance has argued that ministers need to develop a "scientific mindset".[29]

The current crisis has also highlighted the importance of mathematical skills: for example, to understand the implications of advice based on modelling. The government should accelerate its plans to raise technical literacy, with a focus on the skills and concepts ministers and officials need to understand scientific advice well.

The weakness of science capability among ministers is an old complaint. Margaret Thatcher is the only prime minister to come from a scientific background.* Few of the current cabinet do – and this is fairly typical.** The civil service is similar: though there are notable exceptions, many policy officials still have limited understanding of scientific concepts.[30] One civil servant said "officials' understanding of science was a problem" when it came to asking the right questions and interpreting scientific evidence and advice.

Recent governments have made some progress. Almost every department has appointed a chief scientific adviser. More than 100 policy and analytical officials have taken part in fellowships offered by the University of Cambridge's Centre for Science and Policy (CSaP) over the past decade.

* Harold Wilson worked as a statistician during the Second World War but did not have any scientific training.

** A 2017 Nesta study found that the coalition cabinet had only three members with a science, technology, engineering or maths (STEM) background. And the problem goes deeper than the government frontbench: the same study found that only 9% of candidates running for the 2017 election had a background in STEM, despite the fact that these subjects accounted for over 40% of graduates. Bego K, Pilkington J, Goujon C, 'Only 9% of GE2017 contenders have a STEM degree: why this is a problem', blog, Nesta, 22 May 2017, retrieved 8 December 2020, www.nesta.org.uk/blog/only-9-of-ge2017-contenders-have-a-stem-degree-why-this-is-a-problem

But these efforts have not gone nearly far enough. The science capability review, led by Vallance and published in November 2019, found that skills and experience remained patchy across government.[31] While departmental CSAs have been appointed, some still have marginal roles, while in several departments they are 'double-hatting' policy or analytical officials, which raises questions about how much time they can devote to the job.[32] Efforts to raise scientific skills among policy officials have reached only a small group of senior officials.

The fragmented nature of advice from different disciplines – particularly science and social sciences, including economics – that has caused problems in the current crisis is also an old problem. It was criticised by a Lords committee in 2012, and highlighted as an area that needed improvement by Beddington, when he left his term as GCSA the same year.[33] But progress has stalled.

When it was elected, the government expressed a desire to improve scientific and technical skills, including around data and modelling. The experience of the pandemic should strengthen its resolve. It should now provide the resources needed to implement the recommendations of the science capability review – in particular, focusing on the 'science system' needed in each department and strengthening leadership.

Ministers also ought to be provided with professional development to improve their scientific and technical understanding – particularly in key departments of state. The government has shown willingness to do this in other areas, such as project management.[34] But generally, ministers undertake little professional development. The civil service should work with academic institutions to develop a programme. If it is serious about the need to raise ministers' technical skills, No.10 should encourage them to attend.

- **The government should strengthen science capability across the civil service by providing chief scientific advisers in each department with the clout and resources to implement the recommendations of the 2019 science capability review. CSAs should sit on departmental boards.**

- **The civil service should work with academic institutions to create professional development programmes for ministers focusing on scientific and technical skills and developing a 'scientific mindset' needed for decision making. Ministers of key departments should be expected to attend.**

3. How science advice has been provided and the role of SAGE

SAGE was mobilised rapidly at the start of the coronavirus crisis. Under substantial pressure, scientific advisers have since provided a huge volume of high-quality advice. Senior members have managed a difficult balance as independent experts and trusted advisers well, and been highly influential on decision making. However, as in past crises, SAGE discussions have been dominated by a fairly narrow group of medical scientists and modellers, while the body itself has suffered from not being designed to operate continuously in a prolonged crisis. A broader range of expertise may have helped to challenge its thinking.

The strengths of the UK model were evident in SAGE's initial mobilisation – and scientific advisers have provided a huge volume of high-quality advice

SAGE met twice in January and a further nine times in February. The UK's existing structures meant the GCSA and CMO could call on scientists familiar with SAGE and its ways of working. But the UK's model is also nimble, and they were able to adapt and rapidly expand capacity in response to the nature of the crisis.

Vallance and Whitty quickly assembled a group of eminent experts from key disciplines – particularly epidemiology, virology and behavioural science. The UK had strong expertise in these areas, including research groups based at Imperial College London, the London School of Hygiene and Tropical Medicine (LSHTM) and Warwick University. Several had experience of working on the responses to foot and mouth, swine flu and Ebola, which some said helped them to work more effectively together, and challenge one another more freely.

The strengths of the SAGE structure, though, went beyond the main committee. Vallance and Whitty were able to call on specialist groups of experts on modelling (SPI-M) and emerging infectious diseases (NERVTAG) – committees established in the past two decades to advise the health department. Vallance and Whitty quickly made them formal sub-groups of SAGE. They also added a committee to focus on social and behavioural interventions, the Scientific Pandemic Influenza Group on Behaviours (SPI-B), which had also been used during the swine flu pandemic in 2009.

Given the scale and nature of the coronavirus crisis, bringing these three committees under SAGE early on was sensible. It increased the body's expertise and capacity for specialist analysis, and avoided disruption in combining these groups later (as had happened during the FMD crisis, when King established the Foot and Mouth Disease Committee some 35 days into the crisis to address problems he was experiencing in accessing expertise and modelling).

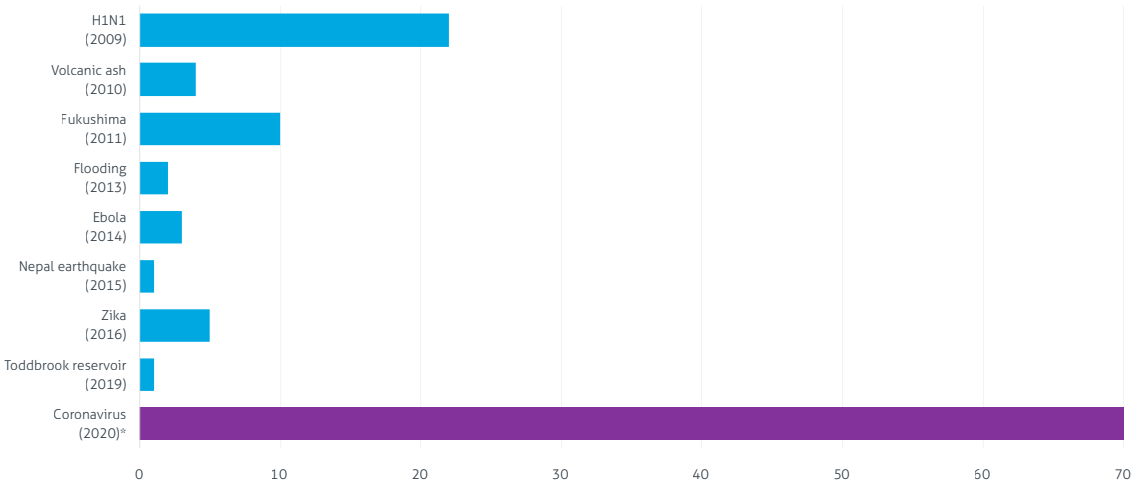
Scientific advisers on these committees and beyond have provided a huge volume of high-quality advice over the course of the crisis, with many scientists inside and outside government working tirelessly to produce timely assessments of the latest evidence. SAGE and its sub-committees produced more than 360 working papers between January and December – more than one a day – and its sub-committees many more. SAGE's model for rapidly integrating a huge volume of work proved effective, though was achieved through some effort, with members reporting that they had consistently worked evenings and weekends for months.

The Government Office for Science quickly scaled up the SAGE secretariat – the group of civil servants that supports the GCSA and SAGE members. In January, it had seven staff; by the end of February, it had more than 100, working a 24-hour shift pattern. The secretariat adapted well to the huge volume of work and requests, though SAGE members reported some inevitable problems given the fast-moving crisis, such as briefing agendas sent out at very short notice.

As an ad hoc committee, SAGE was not designed for a semi-permanent role

Despite these efforts, SAGE was not designed for the semi-permanent role it has had during the Covid crisis. In all previous crises since it was established (with the exception of swine flu and the Fukushima nuclear disaster) it met no more than five times: as of the end of November 2020, it had met 70 times.*

Figure 2 **Number of SAGE meetings by emergency**



Source: Institute for Government analysis of gov.uk and nationalarchives.gov.uk.

Many interviewees, including several SAGE members and departmental CSAs with experience of previous crises, expressed surprise that ministers and the GCSA had kept SAGE activated for so long. As one said: "The 'E' part [emergencies] is quite important: not semi-permanent. There is a mismatch between the nature of the committee and the nature of the beast."

* The number of meetings held over the Salisbury chemical attack has not been made public.

The continued reliance on SAGE created problems. At the end of the summer its external members were still working pro bono, even as supporting SAGE has taken over much of their working lives. Some who work primarily on epidemiological modelling point out they would have been doing this work anyway in the midst of a pandemic. Others told us they were often under pressure to find cover for their teaching and research responsibilities. Members also complained that they were given little pastoral support, even as they came under sustained scrutiny. The minutes of a meeting held in June record a conversation about the lack of resources to support the resilience of SAGE members "who will continue to work under intense pressure on the Covid-19 response for many more months".[1]

The Government Office for Science has managed to mitigate these problems. The government agreed to provide funding to back-fill SAGE academics' teaching commitments. In the summer it implemented a support package for SAGE members, including advice on wellbeing and media handling.

There was also a lack of definition of roles within SAGE. Several external members complained that they lacked a specification setting out what was expected of them, or guidance on how they should be navigating their roles. This is particularly important for core SAGE members. One said they had to "make up" their role on the hoof, with little guidance about who they should be talking to. The lack of definition also created problems with communications. While SAGE provides a consensus view, there was confusion when SAGE members appeared in the media. As one scientist said: "There is no binding definition of what it means to be a SAGE member," which has led to "ill- or indiscipline".

In previous crises, governments have tended to shift the ongoing crisis response more quickly to a lead department, which has more resources and a greater ability to connect across Whitehall. SAGE usually acts as a rapid response function and meets only when COBR meets. In a public health crisis, that would usually mean transferring ongoing management (and expert advisory mechanisms) to DHSC, PHE (and the equivalent agencies in the devolved governments) and other specialist bodies. While these organisations have played a prominent role in the current crisis, they have done so in conjunction with SAGE.

Some thought SAGE should have stopped meeting when COBR did in the current crisis, as happens normally. They argued this would have aligned expert advice with the part of government with deepest expertise and capability and created clearer lines of communication and avoided crossed wires between advice coming through SAGE and advice coming through departments.

Some interviewees had the impression that one reason why SAGE continued was because senior figures in No.10 had become very critical of PHE early on in the crisis – ultimately leading to the decision to replace it. Instead they retained greater control from the centre, and kept SAGE running. However, PHE has continued to provide important technical and scientific advice to ministers alongside SAGE and its work is incorporated into SAGE. While the desire to keep a close grip on handling the crisis

may have formed part of thinking, it seems more plausible that it was SAGE's own prominence and transparent advice that kept it going. It had come to be seen as the source of scientific advice to the government – even though it was not the only one. Disbanding it and moving external advice into a different system would have led to accusations the government was suppressing the very advice it had lauded so much in the early stages of the crisis.

Ministers and scientific advisers should reflect, though, on how long to retain emergency advisory structures in different types of future crises – including those lasting many months. It is vital that there are clear expectations about the role the new National Institute for Health Protection (NIHP), which will replace PHE, will play in future emergencies.

Some of SAGE's sub-committees were not consistently used well

While the decision to appoint sub-committees was sensible, their work does not appear to have been incorporated consistently into SAGE's advice. This reflects the difficulty of integrating a broad range of expertise very quickly in a crisis, but it points to lessons for future crises.

SPI-B and NERVTAG sometimes decided on their own work, but more often they were commissioned by SAGE members. However, sub-committees often felt the questions that came down were poorly formulated or irrelevant, which made it more difficult to provide useful input. "What we are asked about are often not the issues of the day," one sub-committee member said.

Some sub-committees also had little sense of whether their work was having any impact. They were largely made up of academics and lacked feedback loops into decision making. SPI-M addressed this by appointing a departmental CSA as its co-chair, which helped to provide a direct interface to Whitehall, but others reported receiving little feedback on how their work was being used, which prevented them from refining their approach. In some cases, sub-committees conducted detailed analysis which was then barely discussed by SAGE itself.

Work was also not always joined up between sub-committees. Andrew Hayward, a member of SPI-B, has said that his committee did not know what questions were being asked of other specialist committees, or the broad direction of policy.[2] Another sub-committee member said: "We are all in silos and don't know what people are doing."

Scientific advisers initiated some reforms to tackle these problems. For example, after wider government confusion over schools reopening, some core SAGE members set up an expert sub-group that brought together modellers and behavioural experts to look at the issue. This followed the realisation that the interaction between the two disciplines "had to happen earlier" in the process. Working together, the sub-group members were able to discuss and refine their respective assumptions before presenting to SAGE. But this was the exception not the rule. These efforts were also helped by a Royal Society initiative to bring together academics from different disciplines to advise on schools reopening.

Integrating large volumes of evidence to formulate advice quickly in a crisis is always difficult. However, sub-committees play an important role in giving SAGE depth and analytical capacity: there is a strong case in such a broad-based crisis for using them to ensure a wide range of disciplines are contributing to advice.

SAGE discussions would have benefited from greater challenge to its thinking

A major criticism of SAGE levelled by MPs and external scientists has been that it lacked sufficient internal challenge. Vallance appointed a range of internal and external experts to the committee, with an average of around 30 experts attending most meetings from mid-March (and often a large number of observers on top of that). The Government Office for Science launched wider initiatives to incorporate a range of expertise and challenge. However, some interviewees argued the actual discussion was still largely dominated by a small core group of medical scientists and modellers, and several members felt it had too few "dissenting voices" from other disciplines, particularly external public health experts, to scrutinise its thinking.

SAGE's lack of external expertise in public health arguably impeded it in understanding and articulating to ministers how local public health systems respond to epidemics. Anthony Costello, a former director of maternal, child and adolescent health at the World Health Organization, said that while implementation was not SAGE's responsibility, it needed to better understand the implications of what it was recommending on the ground.[3]

Others have argued that SAGE did not take as broad a view of the impacts of restrictions on population health and wellbeing as it might have.[4] UK public health academics were involved in expert advisory committees in other countries, such as Ireland, while the expert committee advising US president-elect Joe Biden's transition team features prominent public health experts.[5]

PHE officials regularly attended and contributed to SAGE, but interviewees did not feel that they (or other public health experts) were prominent in the discussions, compared with the core group of epidemiologists and modellers. Several argued that it would have been valuable to also have external public health experts – in the same way government had other scientists from outside – to bring additional experience and expertise, and an ability to provide challenge.

Not everyone agreed about the need for more public health expertise, however, with some arguing SAGE should stick to "pure science". A senior academic felt appointing public health experts or social scientists to SAGE risked "moving into policy and operations". It is true that SAGE cannot (and should not attempt to) cover everything. Different strands of expertise need to be integrated at the higher level of policy formation, as we have argued in relation to economics. But particularly given SAGE's prolonged role in the response to such a wide-ranging crisis, in our view broader public health expertise would have been helpful.

The public health issue is connected to a broader criticism that SAGE discussions lacked dissenting voices. Vallance has firmly rejected this, telling a select committee: "If you thought SAGE and the way SAGE works was a cosy consensus of agreeing scientists, you would be very mistaken" – and noting that the internal disagreements that did take place were rarely recorded in SAGE minutes.[6,*] SAGE and its sub-groups do draw in academics from a wide range of disciplines, and it has established processes to encourage challenge, particularly in areas such as modelling (as we outline below). The Government Office for Science has undertaken initiatives to bring in a diverse range of disciplines, including by working with the Royal Society to establish two interdisciplinary groups looking at lessons from international responses to Covid-19 and broader perspectives on modelling.[7]

These efforts have undoubtedly strengthened scientific advice. Nevertheless, most SAGE members we spoke to still felt dissenting voices were not prominent. The critique partly stems from the fact that an unusually high proportion – more than half of SAGE members – were civil servants. This included a large number of departmental CSAs; officials from public bodies, including PHE and the Office for National Statistics (ONS); and officials from the devolved administrations.

While these attendees can offer their scientific view, they face conflicted loyalties and are not necessarily able to ask difficult questions in the way external members could (although some noted departmental CSAs from outside government were often good at challenging). A report by the Science and Technology Committee in 2011, reviewing SAGE's performance in several crises, had already expressed concerns that the presence of a large number of government officials on SAGE would limit its challenge function.[8]

The external members on SAGE were also arguably not sufficiently challenging or diverse in their expertise. Many came from a similar biomedical background, had sat on existing committees, such as NERVTAG, and had close connections. One member felt the committee did not have effective "plants" (people brought in to provide constructive criticism).

One interviewee, with experience of chairing scientific advisory committees during crises, described how he went about picking members to avoid groupthink. "You look down your list and you need to pick people who are not closely bound up through personal interactions like co-working or supervisor relationships," he said. "You need pokers and irritants who can say 'you are all barking up the wrong tree'."

Very diverse committees are naturally at risk of failing to agree on anything. But particularly given inquiries into previous crises had repeatedly criticised a failure to design in sufficient challenge, it would have been sensible to incorporate more dissenting voices.

* A previous Science and Technology Committee inquiry recommended that disagreements should be recorded in SAGE minutes (which before the Covid crisis were published post-fact). But this recommendation has not been taken up. House of Commons Science and Technology Committee, *Scientific advice and evidence in emergencies: Third Report of Session 2010-11 (HC 498)*, The Stationery Office, 2011.

Modelling has been produced robustly, if not always presented clearly

Modelling often takes on an important role in public health crises, as scientists use different scenarios about the potential transmission of a disease to help inform politicians' choices. It is an important and valuable tool – but a difficult one to use well. Models are uncertain and only as good as the data and assumptions they rely on. Past crises have shown decision makers need to understand their limitations. This crisis has again pointed to issues with how models have been produced and used.

The standards that government departments – and expert advisory groups – are expected to follow when producing models were set out in the 2013 Macpherson review, which was set up due to concerns about the quality of modelling across government.[9] It said all business-critical models should have their inputs, methodology and outputs quality-assured to ensure their robustness. It noted that the robustness of plans for modelling pandemic flu depended on several processes including academic peer review, external publication, internal professional standards and parallel modelling processes.

Much of this best practice appears to have been followed in the current crisis. SAGE has used SPI-M to draw together the work of several teams, including at Imperial, LSHTM and Warwick and Cambridge – taking advantage of the UK's leading expertise in epidemiological modelling. SPI-M combines a wide variety of independent models, data sources and methods of parameter estimation to ensure robustness: for example, its estimates of the R-number in early December were based on a statistical combination of 16 models.

There have been some questions raised about how modelling has been presented. In November, the UK Statistics Authority wrote to the government to call for more transparency over how scenarios were being produced and what data they were using. This came after Vallance presented a particularly alarming chart that showed several scenarios including one projecting 4,000 deaths a day by December. This turned out to be an out-of-date scenario.[10]

There has also been confusion over the government's reasonable worst-case (RWC) scenario. Johnson cited the fact that the virus was spreading faster than modelling in the RWC as rationale for locking down again in November, albeit weeks after SAGE had advised to do so. But the latest officially published RWC at the time was from May, while a version from July had been leaked to the press. Journalists questioned whether the data exceeded these scenarios, but the claim was not fully explained.[11]

Scientists are working under extreme pressure to produce rapid modelling and advice, and the UK's modelling processes are robust. However, more could be done in future crises to ensure that the code underpinning models can be quickly shared, and the source of models is explained clearly. The RWC is a Cabinet Office – not a SAGE – document and ministers may worry that if it were published more routinely it would be treated as a prediction and cause panic. However, given important decisions were being framed around it, more transparency would arguably have benefited public understanding.

Ministers and civil servants must also understand modelling's constraints. As the Hine inquiry into the swine flu pandemic noted, the mathematical nature of modelling can create an impression of scientific robustness in the minds of ministers. But when reliable data is unavailable, as was the case at the start of both the swine flu and coronavirus pandemics, the models are subject to high levels of uncertainty. Mike Tildesley, a modeller at the University of Warwick, noted that:

> **"In the early stages of the pandemic a lot of the modelling groups associated with SPI-M, my understanding is, had a real challenge with accessing data. These models, we have to remember, are only as good as the data that go into them."**[12]

SAGE regularly emphasised the high levels of uncertainty attached to its modelling projections. But it is not clear that this uncertainty was appreciated by ministers, who relied on models in early March to provide an indication of the ideal timing to impose lockdown measures. Some economists have criticised the attempt to "fine tune" the path of the virus in the initial months of the crisis, without taking enough account of the limitations of the data and uncertainty over behavioural responses to measures.[13] A report on the use of modelling by Defra commissioned in 2003 noted that models must be used with care as a decision support tool, and advised that ministers "must not rely on the model to make a decision for them but be prepared to use it as part of a process in which other factors, such as the 'riskiness' of a policy, are weighed."[14]

Recommendations for future crises

Ministers and the GCSA should consider how SAGE can operate more smoothly in future crises

While SAGE members have responded well to the challenges of 2020, the Covid crisis has thrown up several issues. It would not make sense to address these in the midst of the current crisis, particularly given that the vaccine roll-out indicates there is a clear end point and making changes to how advice is provided at this stage could be disruptive. However, ministers and scientific advisers should evaluate how it could work better in future crises.

First, the government should assess how to ensure scientific advice can work better in such a prolonged crisis. The government should examine its protocols for convening SAGE, communicating its role at the start of a crisis, and how to move to the next stage of a response once COBR stops meeting. As it establishes the new NIHP, it should set out clear expectations about what role the new agency is expected to play in future public health crises of similar duration. Ministers will need to understand this role and ensure the agency has the resources it needs and their trust and support.

The government should commit to continuing to provide funding to cover SAGE academics' teaching commitments. The cost of this would be negligible and, as this report has shown, these academics help inform decisions that have huge implications for the economy and, most importantly, people's lives. The Government Office for Science should keep in place support packages it has developed for SAGE members in future crises.

It should also consider providing training and induction for potential future SAGE members in advance of crises. It is hard to prepare academics for being thrust into the midst of a crisis, and SAGE's flexible membership has made it difficult to create an institutional culture and share lessons about how to manage this. The Government Office for Science could provide potential future members with induction and training, including peer support.

Second, ministers and scientists need to reflect on broader issues with how science advice has been brought together and fed into policy making. Where possible, it might be helpful for sub-committees to be co-chaired by a departmental chief scientific adviser – as SPI-M has been – to ensure they are well connected to the decision makers.

Problems with the commissioning process – and how ministerial objectives have been communicated down to expert groups – also deserve reflection. These may have stemmed from a lack of clarity about what ministers wanted to achieve, and from the crisis requiring departments with little experience of seeking scientific advice having to do so. But the problems also suggest scientific advisers and the Civil Contingencies Secretariat need to look at how to improve the flow of information between policy and scientific discussions and ensure there is a better feedback loop.

- **The Government Office for Science should ensure SAGE members are able, if required, to focus on advising the government full-time in future crises. The government should commit to continuing to provide funding to cover SAGE academics' teaching commitments in future crises. The Government Office for Science should keep in place support packages it has developed for SAGE members in future crises.**

- **The government should set out clear expectations about what role the new National Institute for Health Protection (NIHP), which will replace PHE, will be expected to play in future public health crises.**

- **The Cabinet Office minister and the Civil Contingencies Secretariat should review:**

    - **how scientific advice should best feed into future crises after COBR stops meeting**

    - **how departments and devolved governments commissioned advice and what could be done to improve commissioning in future.**

The Government Office for Science and the GCSA should consider how to ensure there is sufficient challenge in science advice systems

Those overseeing scientific advisory systems need to design in as much challenge as possible. Inquiries into previous crises have identified the risk of groupthink and "accepted views" not being challenged; the lesson should be learned this time.

In future crises, particularly in complex public health crises such as the current one, the GCSA and the Government Office for Science should examine how to make discussions on SAGE more diverse – and ensure it has vocal external members from a broader range of disciplines. He or she should create a public health sub-group – similar to that on modelling or behaviour – chaired by an external public health expert, who would attend SAGE.

The public inquiry should also consider the appointment process. There is a natural risk for the chair to appoint scientific experts with whom they are familiar. That is arguably a particular risk if the crisis happens to relate to their area of expertise. Up until the swine flu epidemic, advisory committees in crises had an "independent co-chair" – an appointee from outside government – to help maintain challenge. This was changed over fears that the CMO was not given a prominent enough role in that crisis. While it makes sense for the CMO to play a prominent role in a public health crisis – particularly when they have experience responding to pandemics, as Whitty does – future inquiries should examine what the right balance should be.

The government and the Civil Contingencies Secretariat should also go further. It is not only that there needs to be more challenge within SAGE. Senior ministers have also complained of having no way of testing the policy decisions they are making on the basis of the different forms of analysis they receive. There ought to be systems within government that allow ministers and officials to more easily test their thinking.

Ministers should apply the approach of 'red-teaming' – creating an independent team within government, with access to internal analysis, to interrogate advice and decision making – more consistently. While the UK government has experimented with this, it has not used it much or always given 'red teams' the resources and time they would need to be effective. The Behavioural Insights Team (BIT) and the Institute for Government have previously recommended that this approach should be used more.[15]

The Independent SAGE committee, a group of external academics critical of the government's approach, chaired by King, has in a way acted a 'red team' on the government's policy decisions (although many scientists inside and outside government understandably felt giving it that name was damaging, and it should have been upfront about its role). However, it would be far more beneficial to have an internal 'red team', with access to data, which scientific advisers and decision makers trust.

- **The GCSA should incorporate a broader range of external expertise into the SAGE process in future crises and ensure there is sufficient challenge. He or she should consider establishing a public health sub-group in future public health crises.**

- **The government should apply the technique of 'red teaming' more consistently, particularly in complex future crises. To be effective, a red team should be staffed by experienced former officials and scientific advisers, given access to internal data and information and hosted in the Cabinet Office, with a remit to challenge strategy and thinking across the government's response.**

4. Transparency and communication

In a public health crisis, the public need to understand the rationale behind measures and have confidence in the government's approach. This requires transparency in the use of scientific advice and evidence. Scientific advice also needs to be well-communicated to the public, and ministers need to explain its limitations and how it is balanced against other forms of advice.

The government has struggled with this during the current crisis. Initially, it was not transparent at all. However, since May matters have improved, with for example the publication of SAGE minutes. But other types of analysis have not been published, which has created the impression of conflict between ministers and scientific advisers. The government's communication of the risks associated with specific behaviours and its overall strategy has been inconsistent and confusing.

The government's initial approach was marked by a lack of transparency

SAGE's membership was initially kept private, and the government published it only in May. Vallance told MPs that this was to avoid members being unduly influenced and for security reasons.[1] This rationale had been used occasionally in previous crises: for example, during the Icelandic volcanic eruption in 2010 there were concerns members would be lobbied by the airline industry. However, not all crises require such measures. During the BSE crisis, membership of expert scientific advisory committees was made public at the start.

The decision not to reveal the SAGE membership in 2020 added unnecessarily to wider concerns about transparency and fuelled suspicions about 'political interference'. The government was stating that it was "following the science", and asking the public to accept unprecedented interventions in their freedoms, without ever making clear who the source of this 'science' was. Scientists working on SAGE who we spoke to saw no overwhelming reason for the secrecy and felt it created unnecessary distrust and undermined the authority of their advice. While there does not need to be total openness, as ministers and advisers need a safe space for discussions, the public need enough information to understand the basis of decisions.

Not being transparent was a political decision and SAGE members pushed for transparency earlier. When the government released SAGE's membership it also initially published the entire list of everyone who had ever attended SAGE, rather than a list of the core membership, which would have been more useful.

The government was also initially reluctant to publish SAGE minutes (which summarise its discussions and recommendations to ministers) and evidence (either papers presented at SAGE or SAGE's summary of the evidence base on specific questions). It did not publish any minutes or evidence until the end of May, some months into the pandemic, when it was under pressure over SAGE's membership and after leading scientists published letters in *The Times* and *The Lancet* criticising the lack of transparency.[2]

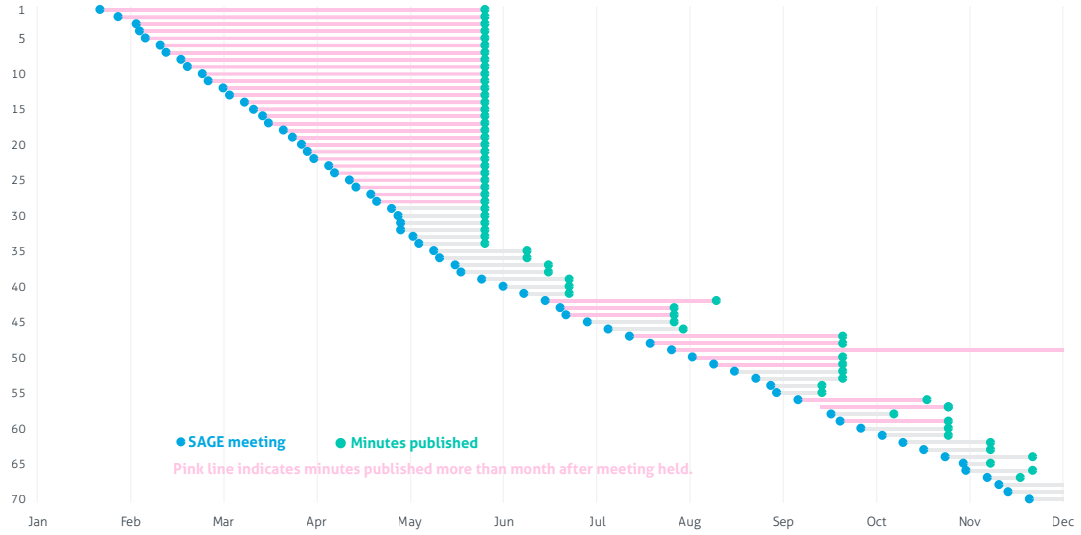
The debate over whether to publish minutes and papers during a crisis is more difficult than the debate over membership. Again it is about balance. It is important to allow SAGE to complete its core role – advising government on difficult decisions – while also providing transparency and public understanding of how it is fulfilling that role.

SAGE needs to be able to have difficult conversations and provide rapid advice; Whitty has, for example, expressed reluctance to publish advice that had not been peer reviewed.[3] Publishing SAGE's judgements before they have been acted on by policy makers also risks creating confusion, as delivery bodies or the public try to anticipate decisions. In previous crises SAGE minutes have been published when the crisis was over, with any redactions required for national security or other reasons.

But that approach was ill-fitted to such a severe and prolonged crisis. The government should have recognised earlier that it would need to open the basis of its decisions to scrutiny, even if that scrutiny was uncomfortable and made the job of politicians harder.

On 29 May, the Government Office for Science said that in view of the "high level of public interest", it would publish all past minutes and supporting documents, and that all future minutes and supporting documentation would be published within one month of the meeting, and earlier where possible.[4] Around three quarters of its minutes have been published within this target. This effort to be transparent – which has involved officials gaining permission from decision makers who the advice informs – has been commendable, and has substantially contributed to the public and political debate around decision making.

Figure 3 **Date of SAGE meetings and when minutes were published**



Source: Institute for Government analysis of gov.uk.

Further problems have been caused by the government's repeated reluctance to set out broader evidence and reasoning for its decisions. This was shown most clearly in the debacle over schools reopening in June. DfE announced a plan on 11 May to begin a phased reopening of schools from 1 June but the government did not publish any evidence, or underlying scientific advice, supporting its plan, instead insisting it would reopen schools if certain (vaguely worded) tests were met.

This was fatal to efforts to secure buy-in. Teachers and parents feared, arguably correctly, that the government was refusing to publish the evidence because it did not support proceeding on such a rapid timetable.* Their concerns were added to by testimony given by DfE's chief scientific adviser, Osama Rahman, who told MPs that reopening schools could "bring together hundreds of vectors" that would fuel the spread of the virus.[5] Independent SAGE also warned publicly that the timetable was unsafe. Paul Whiteman, the general secretary of the National Association of Head Teachers, told MPs: "There is a void of trust out there at the moment... if we are going to fill that void, we need to understand the underpinning science."[6]

The government did organise meetings between teaching unions and senior scientists in mid-May. But these failed to resolve the dispute. Teachers and parents could have had more confidence if the government's evidence had been open to scrutiny. The phased plan was ultimately scrapped, with some primary years returning but most secondary schools remaining closed to all but children of key workers and vulnerable students.

One interviewee highlighted a similar debate going on in Denmark at the same time but with a key difference: the process began with the country's infectious diseases

* The minutes of SAGE meetings, published much later, suggested these fears were well-placed. SAGE had confidence that the severity of and susceptibility to the disease was lower in children than adults, but noted uncertainties over risks to teachers, support staff and parents. Some interviewees suggested SAGE members also had reservations about the speed of the government's timetable.

agency, SSI, publishing a report modelling the likely effect of reopening.[7] Acrimony was avoided as teachers' unions accepted the modelling and used it as the basis for discussing safety guidelines.[8]

Opaque evidence has not been confined to SAGE: it has been a feature across government policy during the crisis. Sense about Science, a think tank, undertook a review of the transparency of evidence across coronavirus policies – supported by the Institute for Government.[9] The review found that most departments had failed to cite the evidence underlying policy decisions, from public health measures to economic policy decisions.

Scientific evidence and advice is now more transparent, but this has raised questions about what the publication policy for other evidence should be

The transparency of scientific advice and evidence provided to the government has now improved. But other forms of advice are not made public and, as the crisis has worn on, there has been increasing controversy when government has not followed the advice clearly given by scientists. It will not be possible to publish all evidence, and many decisions are not made on evidence alone. But more transparency about how other forms of analysis would help the government to avoid presenting decisions as being either scientific or not.

Scientific advice is now on a very public pedestal. This has exacerbated a view of the government "battling" its scientific advisers when it chooses not to follow their advice.[10] In early October, SAGE published minutes that showed that ministers had rejected its advice, given three weeks before on 21 September, to implement a two-week circuit breaker to curb an "exponential" rise in cases. The minutes made clear that SAGE believed the measures the government implemented at the time (the 'rule of six' and the 10pm curfew in pubs and bars) and four weeks later (a plan for a regional approach, based on three 'tiers') would be insufficient to get 'R' below one.

However, while the government appeared to reject the idea of a second lockdown because it believed the harm it would cause to the economy would be too great, it did not set out the *economic* analysis underpinning this choice. This was an omission. What economic analysis there was appears to have been caught up in political debates over different restrictions. The Treasury initially briefed, on 24 October when the government still opposed a second lockdown, that it would publish analysis of the costs of lockdown and regional tiers.[11] But throughout November, after the government had been forced into a U-turn and implement a lockdown, the chancellor and Treasury officials insisted that in fact no such analysis existed.

While it may have been politically difficult to publish information about the costs of lockdown, which many Conservative MPs opposed, after belatedly implementing one, the government would have been better off setting out at least some economic analysis from the start to inform the public, MPs and others about the trade-offs it was making. Nick Macpherson, permanent secretary to the Treasury from 2005–2016, told an Institute for Government event on 6 November that "a more confident government would be publishing impact assessments".[12]

In late November, the government eventually published analysis of the costs of the regional tiered approach. This was welcome, but rather than a one-off, to bring restive MPs on board, it should become an ongoing part of the government's approach. The point of transparency in a crisis is to help the public and others to understand the decisions ministers make, and particularly in such a broad-based crisis publishing only scientific advice is not enough to do that.

Ministers complained that SAGE released its 21 September minutes immediately after the prime minister's announcement of the new regional tiered approach, making it a bombshell news story that dominated the headlines. Number 10 also appeared to brief against SAGE, saying it had leaked its support of a circuit breaker even before discussing it with ministers.[13] SAGE members in turn rejected this, saying ministers had agreed to make SAGE's view on a second lockdown public promptly, only to stall.

In future crises the government and its scientists should aim to have a more settled approach to transparency.

Communication of key measures, risk and uncertainty has too often been poor

The way science advice has been used in key decisions has been made worse by government's communication of them. Messages have been muddled, policies announced through unofficial channels, and there has been a lack of clear and consistent communication of risk. These problems were related to, and again made worse by, a lack of transparency.

One of the key issues has been the communication of risk – particularly the overall level of threat and the danger associated with specific actions. As one SAGE member told us: "Generally, communication of risk has been absent: the comms has lurched from 'we're all going to die' to 'it will all be fine'." This was apparent in the initial months: for example, Andrew Hayward, a member of SPI-B, contrasted the serious warnings being made by NERVTAG in late February with the continued public reassurances made by politicians.[14]

It was also evident in the abrupt change from the government's 'stay at home' message through spring and early summer to it strongly encouraging people to travel to work and eat out in restaurants in August – only to once more reintroduce restrictions and ask people to work from home in September. These contradictory policies illustrated a lack of joined-up thinking between scientific and other forms of advice, as we set out above. But they also showed a failure to learn from past crises, about consistent communication of levels of risk to the public. Some messages have landed – for instance, on social distancing – but a member of SPI-B told us that others, such as the relative risk of meeting in poorly ventilated indoor settings, have been lost.

The government has also often failed to use proper channels of communication. It succeeded in establishing a 'battle rhythm' of communications in the daily press conferences.[15] But it repeatedly chose to issue off-the-record briefings to favoured journalists, leaking out potential measures before they were announced, causing the public confusion and anxiety.[16]

This was particularly acute in the initial months given there was little transparency around science advice, but even new restrictions introduced in October were publicised through off-the-record briefings.

A lack of consistency from ministers and, above all, the prime minister has made it harder for scientific advisers to communicate risk. While Vallance and Whitty have stuck to a cautious, evidence-based line in press conferences, they have often been portrayed in the media as unduly negative, particularly as ministers unveiled policies encouraging people to return to normal.

Ministers have, at other times, failed to communicate a change in approach when scientific understanding has changed. Covid-19 has been particularly difficult because of the uncertainty around the evidence, especially in the early stages of the crisis. But while the government's advisers have tried to talk about uncertainty, ministers' failure to talk about the limits of science advice has made it harder for the government to adapt messaging when uncertain evidence has changed.

A good example of this was the about-turn on face masks. UK scientists have tended to set a high bar on evidence – rather than adopt a more 'precautionary approach'. Scientific advisers in the UK were initially unwilling to recommend masks until there was stronger evidence (echoing their hesitance in supporting a full lockdown).

The UK government initially advised the public not to wear a face mask, claiming it did not stop the spread of the virus and could even make it less likely that people would practise more effective behaviours, such as hand washing and social distancing. Following a review in mid-April, SAGE concluded that the positive effect of wearing a mask was likely to be small but not zero. And there is now far greater evidence suggesting masks have a more significant effect.[17] But ministers were slow to communicate this new assessment of risk to the public. It was not until 11 May, almost a month later, that it changed its guidance and recommended the use of face coverings in enclosed public spaces, including public transport and shops. Face masks were made compulsory on public transport in England from 15 June, and in shops and supermarkets from 24 July.

Other governments took a different approach, either recommending face masks earlier on a 'precautionary basis' or changing their policies quicker after evidence changed. For example, several east Asian countries with experience of SARS – and in which there is more of a cultural norm around mask wearing – made it obligatory from the start of the crisis, as did Czechia.[18]

While concerns about adherence may have justified initially not taking a precautionary approach, ministers also proved reluctant to change tack and contradict earlier messaging. The messaging might always have been difficult – face masks have proved to be highly controversial in other countries and become a politicised issue, particularly in the US. However, the government should again reflect on whether better communication of the uncertainty throughout would have made such decisions easier to sell.

Communication of the government's overall approach and the science behind it has also been inconsistent

The government also struggled to clearly communicate its overall strategy – and the science underpinning it. This may have been, particularly in the initial months, because there was no clear strategy to communicate, which was partly a consequence of not having planned for such a pandemic. But muddled communications appear to have also been caused by a lack of clarity about who was responsible for setting out the government's approach, and what evidence strategies were based on.

The fact that 'herd immunity' came, even briefly, to be seen as the government's strategy illustrated a disorganised approach to communication. The concept has been controversial throughout the pandemic in several countries – and continues to be a subject of debate. In the UK the confusion as to whether this was, in fact, government strategy stemmed from interviews in which government advisers appeared to suggest that one way to manage the epidemic would be to cocoon the vulnerable and for the rest of the population to develop herd immunity.*

While in retrospect it does not appear to have been the intention, journalists took these comments to mean that the UK was aiming to naturally reach herd immunity before a vaccine became available – a highly unorthodox strategy. Vallance and the other SAGE members all later clarified that this was not what they meant; Vallance later apologised for the confusion, saying: "Herd immunity was never the UK's strategy." The SAGE minutes accord with this: the concept of herd immunity was barely discussed.

But, as Lawrence Freedman said, as an approach to communication it was a disaster: "It appeared that the government was preparing to let the disease rip through the community as part of a cold-blooded experiment in disease management."[19] The episode resulted in lasting confusion about the government's approach – but also reflected a lack of clarity about who was responsible for communication.

The GCSA and CMO are the only individuals authorised to speak publicly on behalf of SAGE. But members are entitled to offer their 'personal views' to the media and there has been an overwhelming demand for commentary from experts, including SAGE members. In practice, many scientists labelled 'SAGE member' have appeared in the media throughout the crisis, often with no caveats applied – and with the government insisting it was "following the science", there was confusion at times about whether certain SAGE members were setting out their own views or the government's approach.

* David Halpern said on 12 March: "There's going to be a point... where you'll want to cocoon, to protect those at-risk groups so that they don't catch the disease. By the time they come out of their cocooning herd immunity has been achieved in the rest of the population," Easton M, 'Coronavirus: Care home residents could be "cocooned"', BBC News, 11 March 2020, retrieved 8 December 2020, www.bbc.co.uk/news/uk-51828000; Graham Medley said on 13 March: "We are going to have to generate what we call 'herd immunity' [...] a situation where the majority of the population are immune to the infection. And the only way of developing that, in the absence of a vaccine, is for the majority of the population to become infected," 'Coronavirus: can herd immunity protect the population?', *Newsnight*, 13 March 2020, retrieved 8 December 2020, www.bbc.co.uk/programmes/p086hjgc; Vallance told Sky News that around 60% of the population would need to become infected for the country to gain herd immunity and referred to "herd immunity" several times in press conferences, 'UK needs to get Covid-19 for herd immunity', 13 March 2020, retrieved 8 December 2020, www.youtube.com/watch?v=2XRc389TvG8

Another example of confused communication centred around the concept of "behavioural fatigue". This was cited repeatedly by government sources in early March as a reason for delaying the introduction of the lockdown.[20,*] Yet it was unclear on what analysis this was based. It was never discussed on the SPI-B – the group set up to provide behavioural expertise – and one SPI-B member told us it would not have been endorsed if it had been. On 16 March, a week before lockdown was introduced, a group of 600 behavioural scientists from around the UK published an open letter, which said: "There is no sound evidence base to suggest that behavioural fatigue would undermine early interventions based on social distancing, and especially not in a case like the one we currently face."[21]

Government ministers and officials subsequently dropped the phrase, and a senior behavioural expert on SAGE questioned about it later reported that he did not know where it came from.[22] While ensuring adherence with measures has proved a challenge as the crisis has worn as – particularly as public trust has fallen – there was little scientific evidence underpinning the early focus on it.

These examples suggest that there was early on a lack of the discipline needed internally – among senior ministers, scientists and officials – to draw in and scrutinise evidence, ensure it was robust, and then decide how the strategy and the evidence behind it would be communicated.

However, arguably the most damaging episode to the government's communications effort was the scandal over Dominic Cummings' trip from London to Barnard Castle in the north-east of England, during the height of the lockdown. Several studies showed this led to a significant drop in public trust in government, while many interviewees suggested such high-profile rule-breaking undermined commitment to adherence.[23] While the other examples we have discussed point to disorganisation, the Cummings episode showed a more simple failure of leadership from the prime minister.

* Whitty referred to the risk people would get "fatigued" at a press conference on 9 March, and said this was based on both "behavioural science" and "common sense". Whitehall sources briefed that Whitty was the main advocate of this view, based on his own personal medical experience, 'Fifth coronavirus death as UK "very close" to telling even those with minor symptoms to stay at home', ITV News, 9 March 2020, retrieved 8 December 2020, www.itv.com/news/2020-03-09/prime-minister-boris-johnson-coronavirus-covid-19; Conn D, Lawrence F, Lewis P and others, 'Revealed: the inside story of the UK's Covid-19 crisis', *The Guardian*, 29 April 2020, retrieved 8 December 2020, www.theguardian.com/world/2020/apr/29/revealed-the-inside-story-of-uk-covid-19-coronavirus-crisis

Recommendations for the current crisis

1. The government should improve the transparency of its science and other advice

The government ought to see transparency as a proactive way to build trust and confidence in its approach. It should also make other advice beyond science more transparent, to help the public understand what is informing decision making.

It is welcome that SAGE now publishes its minutes and this has hugely benefited debates over government decision making. When SAGE does not meet its publication policy, the GCSA should explain why, so that the reason can be scrutinised. It should also publish the evidence that underpins its advice more routinely. SAGE members need to ensure their discussions are secure. The government, for its part, should do more to prevent scientific advisers becoming politicised and subjected to media and political attacks. Scientific advisers also need reassurance that their findings will not be held back because they are politically uncomfortable.

The Treasury, working with other departments, should publish government analysis on the costs – to the economy, health and wellbeing – of implementing public health restrictions, and the potential impacts of not doing so. It published some analysis on 30 November, but this only reproduced existing OBR forecasts and did not properly engage with the question of what impacts different approaches to restrictions would have on the economy and the progression of the virus. The document said: "Due to the unprecedented nature of the virus and the restrictions... it is not possible to assess the balance of these effects."[24]

It is reasonable for the government to say that, given such uncertainty, producing a precise cost benefit analysis of specific restrictions (as many Conservative backbenchers have called for) is not possible. Nor would attempting to do so necessarily be a sensible approach to decision making. However, what the Treasury has released offers an extremely limited view of thinking inside government and how ministers are approaching trade-offs. As Mel Stride, Conservative chair of the Treasury Select Committee, said, the analysis offered little beyond what information had been published already and failed to engage with the impact of different tiers.[25]

More broadly, the government should publish the evidence underlying policy decisions and its broader strategy much more routinely. A forthcoming transparency review we have conducted jointly with Sense about Science, which will be published in 2021, found many departments failing to set out clear evidence behind policy decisions. Such transparency is vital if parliament and the public are to scrutinise government decision making.

The public inquiry should consider how transparency and publication processes should work in future crises. The current crisis has clearly put strain on the relationship between government and its scientific advisers. Given the high stakes involved, there needs to be a clear, agreed process for when and how different forms of advice are published.

- **The government should improve the way it communicates the basis of its decisions to give parliamentarians and the public more confidence in them. While it will inevitably be uncertain, the Treasury should set out economic analysis of the costs and wellbeing impacts of implementing public health restrictions, and the potential impacts of not doing so, to support this.**

- **Departments should publish the evidence underlying policy decisions more routinely.**

2. The government must clarify its communication of risk and strategy

The government still faces several critical months in which its ability to communicate messages clearly to the public will be hugely important. It needs to ensure adherence to measures to prevent the virus from getting out of control in what looks to be a long winter. The phased roll-out of the vaccine will also need to be supported by a major communications effort.

In January, the government will seek to refresh its approach to communications, with a new press secretary, Allegra Stratton, fronting televised briefings. It should use this as an opportunity to professionalise its communication of public health restrictions – avoiding the off-the-record briefings and leaks that have added to public anxiety.

Joint press conferences made sense initially, but they have not always helped scientific advisers answer questions directly, or focus on explaining risks or complex rationale behind advice (such as reasonable worst case scenarios) in detail. A former GCSA told us that being able to communicate directly with the public in a crisis was critical.

- **The government should ensure any new public health measures are announced and explained in parliament.**

- **The government should be clearer about the purpose of press briefings and choose the line-up of ministers and scientists best suited to achieve it. It should allow scientist-led briefings more often to enable scientific advisers to communicate directly with the public.**

Conclusion

Coronavirus has been a crisis on a scale not seen in over a century – and of a completely different order to any that scientific advisers have responded to since the roles were created in the years after the Second World War. The UK's advisers adapted and provided high-quality advice across a huge range of areas, coping with massive strain. But ministers, officials and scientific advisers should be frank in examining where the system has not worked as well as it should have.

They should make several changes to improve the use of scientific advice in the remainder of the current crisis. While the news of vaccine approval is extremely positive, there are hard yards of roll-out ahead – and it would be a mistake to think that the difficult part of the crisis is already over. The government will continue to need to balance extremely difficult trade-offs.

It needs a much clearer approach to managing those trade-offs than seen in 2020, in which its approach has been too fragmented, leading to incoherence. The Cabinet Office needs to bring together different forms of analysis to inform ministerial discussions.

All of this must be communicated far better – both in terms of the measures the government expects people to comply with, and the rationale behind its overall approach. Too often it has sought to brush off scrutiny without explaining decisions convincingly. The Treasury should publish fuller economic analysis. But ultimately it is up to ministers to do a better job of bringing colleagues in parliament, and the public, on board. Scientists should also be given more space to communicate directly to the public.

We also recommend longer-term improvements that should be made before future crises. The government should strengthen the role of science in the civil service by making departmental CSAs more powerful; it should ensure ministers and officials have the 'scientific mindset' needed to use advice well; and it should prioritise building stronger relationships between scientific advisers and ministers. Scientific advisers ought to reflect, too, on the composition of committees and how to ensure their thinking is sufficiently challenged.

It is telling that many of our recommendations – and the problems identified – echo those offered by inquiries into past crises, but not acted upon. It is easy for the politician caught in the midst of a crisis to say they will do everything possible to commit the attention and resources required to make sure we are better prepared

next time; it has proved much harder for politicians to continue to prioritise those reforms when the demands of the everyday business of government, and competing pressures on spending, return.

But the current crisis should give this and future governments the resolve to focus on how they will respond to future emergencies – which will surely come – and in which science advice will again have a critical role.

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