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Email: jrg20@c `Irrelevant & Sensitive`
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By email to: solicitors@covid19.public-inquiry.uk

7th October 2022

Dear Tim Suter,

I am writing in response to your request for evidence under Rule 9 of the Inquiry Rules 2006, for Module 2 of the UK COVID-19 Public Inquiry, reference M2/SAGE/01/JG, dated 2nd September 2922.

I appreciated your patience while I was on leave until 26th September 2022. Subsequent pages contain responses to your questionnaire, as far as I am able in the time available. If anything is unclear or more detail is required, I would be happy to assist.

Yours sincerely,

Personal Data

Prof. Julia Gog OBE
David N. Moore Fellow in Mathematics, Queens' College
Professor of Mathematical Biology, DAMTP, University of Cambridge

Response to request for evidence, reference: M2/SAGE/01/JG
From Prof. Julia Gog, October 2022

Question 1 (overview of qualifications etc)

Qualifications:
BA Hons in Mathematics, Class I in all parts, University of Cambridge 1997
Certificate of Advanced Study in Mathematics (Part III), Distinction, University of Cambridge 1998
Ph.D. "The Dynamics of Multiple Strains of an Infectious Disease", University of Cambridge 2002

Career history:
2002-2004   Research Fellow, Queens' College, Cambridge
2004-2012   Royal Society University Research Fellow:
       2004-2006 held in Department of Zoology, University of Cambridge
       2006-2012 held in Department of Applied Mathematics and Theoretical Physics (DAMTP),
University of Cambridge
2004-   Official/Professorial Fellow, Queens' College, Cambridge
2006-2013   University Lectureship, DAMTP , University of Cambridge
2013-2017   Reader in Mathematical Biology, DAMTP, University of Cambridge
2018-   Professor of Mathematical Biology, DAMTP, University of Cambridge

Professional Expertise:
I am a mathematician, with 25 years of experience of research in infectious disease dynamics. My research specialism is the spatial spread and evolution of influenza, and more recently, COVID-19.

Selected publications (prior to COVID-19, as those are covered in my answer to question 5):

Gog, J. R., & Grenfell, B. T. (2002). Dynamics and selection of many-strain pathogens. *Proceedings of the National Academy of Sciences*, *99*(26), 17209-17214.

Grenfell, B. T., Pybus, O. G., Gog, J. R., Wood, J. L., Daly, J. M., Mumford, J. A., & Holmes, E. C. (2004). Unifying the epidemiological and evolutionary dynamics of pathogens. *Science*, *303*(5656), 327-332.

Gog, J. R., Afonso, E. D. S., Dalton, R. M., Leclercq, I., Tiley, L., Elton, D., ... & Digard, P. (2007). Codon conservation in the influenza A virus genome defines RNA packaging signals. *Nucleic acids research*, *35*(6), 1897-1907.

Kissler, S. M., Gog, J. R., Viboud, C., Charu, V., Bjørnstad, O. N., Simonsen, L., & Grenfell, B. T. (2019). Geographic transmission hubs of the 2009 influenza pandemic in the United States. *Epidemics*, *26*, 86-94.

Kissler, S. M., Viboud, C., Grenfell, B. T., & Gog, J. R. (2020). Symbolic transfer entropy reveals the age structure of pandemic influenza transmission from high-volume influenza-like illness data. *Journal of the Royal Society Interface*, *17*(164), 20190628.

For further academic papers, please see [Google Scholar](#)

Question 2 and 3 (SAGE and subgroup participation)

SPI-M-O: I was a member of SPI-M since 2018, and hence was automatically on SPI-M-O as it moved to operational mode in response to COVID-19 in January 2020. I was involved throughout the COVID-19 emergency, except for occasional days of leave. I took part as a member of SPI-M-O, contributing on a wide range of topics. I also acted as chair of SPI-M-O on occasions when one of the usual chairs was absent (see below for dates).

One of my regular contributions to the SPI-M-O main meetings was as chair of the Spatial Heterogeneities sub-group (see below), where I presented a summary of each of our sub-group meeting to the corresponding full SPI-M-O main meeting.

SPI-M-O attendance (as confirmed by SPI-M-O secretariat):
- I attended 94 of the 104 main SPI-M-O meetings. First meeting: 27th January 2020, last meeting 23rd March 2022.
- The ten meetings I did NOT attend were: 26/2/20, 16/3/20, 17/3/20, 29/3/20, 12/8/20, 16/9/20, 23/9/20, 7/4/21, 22/9/21, 15/12/21.
- I acted as chair for 13 meetings: 22/7/20, 2/9/20, 30/9/20, 25/11/20, 2/12/20, 24/3/21, 26/5/21, 14/7/21, 28/7/21, 25/8/21, 8/9/21, 13/10/21, 9/3/22.

SAGE: I was first invited to be a participant of SAGE in early March 2020. The first formal meeting invitation I had was received on 10th March 2020 for a SAGE meeting planned for 12th March, but in the event it was delayed to 13th March, and this was the first meeting of SAGE that I attended.

Throughout, my participation in SAGE was associated with my membership of SPI-M-O. I was a participant for about a third of the meetings: this was largely in sporadic blocks, plus a few isolated meetings. In some meetings I contributed papers that I had been involved in preparing (as set out in further detail at question 4), in some I responded as acting chair of SPI-M-O, in others I contributed only occasionally on specific points where my expertise was applicable; for example, to ask questions in response to presented work.

SAGE attendance (working by meeting numbers): I participated in 35 of the 106 SAGE main meetings, the first one being SAGE 15 on 13th March 2020, the last being SAGE 105 on 10th February 2022. The full list of SAGE meetings attended:15, 22, 25-28, 30-31, 38, 46-48, 54-55, 60, 65, 70-80, 87, 89-92, 94, 96, 105.

SPI-M-O Spatial Heterogeneities: this was a subgroup of SPI-M-O focussed on fine scale heterogeneities. Here, multiple researchers from SPI-M-O presented their findings based on using a broad set of different approaches on a range of recent data. This was a part of trying to interpret the latest signals of COVID-19 dynamics, for example identifying geographic hotspots or outliers, and particularly anything which warranted further consideration as a pattern consistent with the establishment of a new variant. My role was to chair these meetings, and to then bring a summary to the corresponding main SPI-M-O meeting (usually the next day). Sometimes I produced figures to summarise data (for example based on the COVID-19 dashboard downloads of cases plotted by age and region). This group ran from February 2021 to March 2022 and there was usually one meeting the day before every SPI-M-O main meeting (so approximately every Tuesday for 13 months). I attended and chaired nearly all of these meetings.

Task and finish group on children (SAGE subgroups): (Unsure of official name of group) There were various phases of a subgroup on the role of children with respect to COVID-19. My recollection is that the first version of this group was formed in early April 2020 by request of SAGE and initially was mostly

comprised of participants drawn from SPI-M-O. By late April, the group had evolved into a rather different SAGE subgroup with participation from Department for Education and SPI-B (behavioural science group) as well as SPI-M-O.

My contribution was as lead on the modelling side for this subgroup in its earliest incarnation, and I was co- or deputy chair when the group broadened out. I am unsure of the precise dates for this subgroup: it was certainly active from April-July 2020, and again in Autumn 2020, and January-February 2021. Throughout, this was a subgroup which was reporting findings to SPI-M-O and/or SAGE.

Other subgroups: The other main subgroup of SPI-M-O that I attended was Medium Term Projections. My recollection is that I attended this on about half of these meetings (across the full period of SPI-M-O), usually to make sure I was up to speed before SPI-M-O meetings, particularly when I was acting as SPI-M-O chair, but also at key times when the dynamics of COVID-19 was changing rapidly, such as around the appearance of new variants. I did not myself contribute any projections to these meetings. I was mainly an observer, but would ask the occasional question or make a comment.

There were other more transient subgroups of SPI-M-O, but I do not have systematic records of these and I am unsure which were officially subgroups, or which were additional SPI-M-O meetings of a subset of participants when something required extra time beyond the main meeting. My recollection is that in 2020 there was a subgroup on BSI (Behavioural and Social Interventions, essentially an earlier term for what later became known as NPI: non-pharmaceutical interventions). In 2021 there were additional meetings to look in detail at the work relating to the "roadmap" for lifting interventions – I attended as a general member of SPI-M-O to help offer scrutiny of the modelling work.

Variant Technical Group: though not a subgroup of SPI-M-O or SAGE, I include this as I joined around May 2021 as a representative of SPI-M-O and attended most meetings until present (I estimate around 12 meetings up to and including February 2022). VTG is convened by UKHSA (previously PHE), to consider variants of COVID-19. I was invited to join due to my expertise on emerging variants and work from SPI-M-O, particularly to communicate work from SPI-M-O teams on the delta variant at the time. I also attended at least one joint meeting of SPI-M-O and NERVTAG in response to the emergence of omicron.

Question 4 (Documents contributed to SAGE and subgroups)

Papers to SPI-M-O main meeting: I regularly contributed a summary from the Spatial Heterogeneities subgroup to the main SPI-M-O meeting. This included a summary that I wrote based on the discussions and consensus from the subgroup meeting. My other contributions of papers to SPI-M-O have been on a range of topics, and I list below all that I can readily find on which I am an author (usually with several others) with date of the SPI-M-O.

Meeting	Paper title
24/02/2020	Transmission-reducing interventions: prediction of reduction in overall attack rate and peak incidence from simple models
02/03/2020	Some outputs from a UK spatial model
11/03/2020	Some results from BBC project on contact rates by context and age
20/04/2020	Effectiveness of isolation, testing, contact tracing and physical distancing on reducing transmission of COVID-19 in different settings
27/05/2020	Differences in R estimates
22/07/2020	Note on false positives and negatives
09/09/2020	COVID-19 and seasonal influenza: speculation on interactions
11/11/2020	Effect of tiers: current summary
22/12/2020	Notes on the new variant
13/01/2021	COVID-19 and Universities: Report from the Higher Education working group at the Isaac Newton Institute
10/02/2021	Minimising case numbers is essential to reduce the risk of vaccine escape
10/02/2021	Impact of partial school openings
17/03/2021	Response to SPI-M ask for 17th March from JUNIPER
24/03/2021	Variants and vaccinations
21/04/2021	Exploring the impact of reopening secondary schools and the effect of mass testing
21/04/2021	Higher Education - return of Face to Face Teaching, Lateral Flow Testing and potential impact on the Road Map
05/05/2021	Options 1, 2 and 3 - reaction from JUNIPER
12/05/2021	Briefing note: Potential community transmission of B.1.617.2 inferred by S-gene positivity
26/05/2021	Investigating the age distribution of S-gene positive cases in England
02/06/2021	Estimates of R advantage at fine spatial scale
02/06/2021	Comparing temporal trends in the demographics of S+ and S- COVID cases
16/06/2021	Advantage estimation for England
23/06/2021	Shifting age distributions
30/06/2021	Transitioning from non-pharmaceutical interventions to vaccination to control COVID-19 transmission
06/10/2021	Estimated vaccination coverage among first year students across a selection of English HE providers in Autumn 2021
01/12/2021	S-gene target failure and epidemiological patterns
08/12/2021	Briefing note: Early S-gene trends in England: Omicron surveillance.
15/12/2021	Briefing note: Early S-gene trends in England: Omicron surveillance
22/12/2021	Short-term Projections based on Early Omicron Variant Dynamics in England
06/01/2022	What does a shorter GT mean?
16/02/2022	Endemicity and transients from variants: insights from toy models

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Papers to SAGE main meeting: Where my contribution is on behalf of a SAGE subgroup I have not listed the documents individually below, but to summarise here: I have contributed directly towards some of the SPI-M-O consensus statements and other papers summarising evidence from SPI-M-O, particularly when I was covering as chair. I also contributed as part of the SAGE subgroup on children (see above). I was also part of the Variant Technical Group convened by UKHSA that contributed technical briefings that went to SAGE. There were also two papers that went to SAGE from the SPI-M-O Spatial Heterogeneities subgroup (to SAGE 87 and 91).

This list below are remaining individual papers where I am contributing as an author or co-author. In each case, the linked webpage gives a brief summary.

Paper title and date	SAGE meeting	URL
Transmission-reducing interventions: prediction of reduction in overall attack rate and peak incidence from simple models, 24 February 2020	10	Link
Using BBC Pandemic data to model the impact of isolation, testing, contact tracing and physical distancing on reducing transmission of Covid-19 in different settings, 16 April 2020	26	Link
Effectiveness of isolation, testing, contact tracing and physical distancing on reducing transmission of COVID-19 in different settings: Draft for SPI-M, 20 April 2020	27	Link
University of Cambridge: Estimating R for intermittent interventions, 29 April 2020	31	Link
Isaac Newton Institute: Contact tracing, 9 June 2020	41	Link
Juniper consortium: Notes on the new SARS-CoV-2 variant, 22 December 2020	74	Link
Isaac Newton Institute: COVID-19 and universities, 13 January 2021	76	Link
Juniper consortium: Impact of partial school openings, 10 February 2021	80	Link
JUNIPER: Potential community transmission of B.1.617.2 inferred by S-gene positivity - briefing note, 11 May 2021	89	Link
JUNIPER: Comparing temporal trends in the demographics of S+ and S- COVID cases, 3 June 2021	91	Link
JUNIPER: Estimates of R advantage at fine spatial scale, 2 June 2021	91	Link
JUNIPER: Transitioning from non-pharmaceutical interventions to vaccination to control COVID-19 transmission, 7 July 2021	93	Link
International vaccination: Potential impact on viral evolution and UK public health, 21 July 2021	94	Link

Question 5 (Contributions relating to COVID-19)

(i)   Academic papers including preprints:

I'm including here all articles on which I am a co-author which relate to COVID-19.

Gog, J. R. (2020). How you can help with COVID-19 modelling. *Nature Reviews Physics*, 2(6), 274-275.
https://doi.org/10.1038/s42254-020-0175-7

Thompson, R. N., Hollingsworth, T. D., Isham, V., Arribas-Bel, D., Ashby, B., Britton, T., ... & Restif, O. (2020). Key questions for modelling COVID-19 exit strategies. *Proceedings of the Royal Society B*, 287(1932), 20201405.
https://doi.org/10.1098/rspb.2020.1405

Gog, J. R., & Hollingsworth, T. D. (2021). Epidemic interventions: insights from classic results. *Philosophical Transactions of the Royal Society B*, 376(1829), 20200263.
https://doi.org/10.1098/rstb.2020.0263

Kucharski, A. J., Klepac, P., Conlan, A. J., Kissler, S. M., Tang, M. L., Fry, H., ... & Simons, D. (2020). Effectiveness of isolation, testing, contact tracing, and physical distancing on reducing transmission of SARS-CoV-2 in different settings: a mathematical modelling study. *The Lancet Infectious Diseases*, 20(10), 1151-1160.
https://doi.org/10.1016/S1473-3099(20)30457-6

Thompson, R. N., Hill, E. M., & Gog, J. R. (2021). SARS-CoV-2 incidence and vaccine escape. *The Lancet Infectious Diseases*, 21(7), 913-914.
https://doi.org/10.1016/S1473-3099(21)00202-4

Lucas, T. C., Davis, E. L., Ayabina, D., Borlase, A., Crellen, T., Pi, L., ... & Déirdre Hollingsworth, T. (2021). Engagement and adherence trade-offs for SARS-CoV-2 contact tracing. *Philosophical Transactions of the Royal Society B*, 376(1829), 20200270.
https://doi.org/10.1098/rstb.2020.0270

Enright, J., Hill, E. M., Stage, H. B., Bolton, K. J., Nixon, E. J., Fairbanks, E. L., ... & Tildesley, M. J. (2021). SARS-CoV-2 infection in UK university students: lessons from September–December 2020 and modelling insights for future student return. *Royal Society Open Science*, 8(8), 210310.
https://doi.org/10.1098/rsos.210310

Challen, R., Dyson, L., Overton, C. E., Guzman-Rincon, L. M., Hill, E. M., Stage, H. B., ... & Danon, L. (2021). Early epidemiological signatures of novel SARS-CoV-2 variants: establishment of B. 1.617. 2 in England. *MedRxiv.*
https://doi.org/10.1101/2021.06.05.21258365

Eames, K. T., Tang, M. L., Hill, E. M., Tildesley, M. J., Read, J. M., Keeling, M. J., & Gog, J. R. (2021). Coughs, Colds and "Freshers' Flu" Survey in the University of Cambridge, 2007-2008. *medRxiv.*
https://doi.org/10.1101/2021.03.31.21251220

Gog, J. R., Hill, E. M., Danon, L., & Thompson, R. N. (2021). Vaccine escape in a heterogeneous population: insights for SARS-CoV-2 from a simple model. *Royal Society Open Science*, 8(7), 210530.
https://doi.org/10.1098/rsos.210530

Keeling, M. J., Brooks-Pollock, E., Challen, R. J., Danon, L., Dyson, L., Gog, J. R., ... & Tildesley, M. (2021). Short-term Projections based on Early Omicron Variant Dynamics in England. *medRxiv.*
https://doi.org/10.1101/2021.12.30.21268307

Saad-Roy, C. M., Levin, S. A., Gog, J. R., Farrar, J., Wagner, C. E., Metcalf, C. J. E., & Grenfell, B. T. (2021). Vaccine breakthrough and the invasion dynamics of SARS-CoV-2 variants. *medRxiv*. https://doi.org/10.1101/2021.12.13.21267725

Vegvari, C., Abbott, S., Ball, F., Brooks-Pollock, E., Challen, R., Collyer, B. S., ... & Trapman, P. (2022). Commentary on the use of the reproduction number R during the COVID-19 pandemic. *Statistical Methods in Medical Research*, *31*(9), 1675-1685. https://doi.org/10.1177/09622802211037079

(ii) Articles for public communication of science:

These articles are communicating some element of the science or mathematics of COVID-19, for a general audience. These were either written in collaboration with the Plus magazine editors, or my contributions were substantial quotes, and are all available from https://plus.maths.org/:

How can maths fight a pandemic. March 2020.
https://plus.maths.org/content/how-can-maths-fight-pandemic

The problem with combining R ratios, May 2020
https://plus.maths.org/content/problem-combining-r-rates

The growth rate of COVID-19, June 2020
https://plus.maths.org/content/epidemic-growth-rate

R's not all you need. February 2021
https://plus.maths.org/content/R-not-all

Understanding the generation time for COVID-19, December 2021
https://plus.maths.org/content/understanding-generation-time-covid-19

Why the generation time of COVID-19 is important, December 2021
https://plus.maths.org/content/why-generation-time-covid-19-important

(iii) Interviews for media:

I am including as much as I can recall or easily find record of media interviews – I did not keep a detailed list during this busy period. Throughout all interviews I sought to focus on the science of COVID-19 rather than specifically commenting on the UK government's response.

Interviews for podcasts:
BBC Inside Science – June 2020, August 2020
BBC More or Less – August 2020, July 2021
BBC Science in Action – July 2021
David Runciman – July 2021
Plus magazine: On the mathematical frontline – July 2021
CSaP – June 2020, March 2022
Isaac Newton Institute - November 2020
Jack Blanchard – November 2021

Interviews for national newspapers/magazines:
Financial times – June 2020
Wired Magazine – June 2020
New York Times – June 2020
Guardian – November 2020
New Scientist – February 2021
NRC (The Netherlands) – January 2022

Local BBC regional TV news: Look East (West). I made short interview appearances approximately 12 times between August 2020 – February 2022

(iv)   Public lectures:

Again these are focussed on the science communication, and somewhat on how the science was done, rather than by way of giving commentary on the UK's response.

Gresham College – London Mathematical Society annual lecture, May 2020
https://www.gresham.ac.uk/watch-now/maths-covid

Rosalind Franklin Lecture – Royal Society, October 2021
https://royalsociety.org/science-events-and-lectures/2021/10/rosalind-franklin-lecture-2020/

Royal Institution, co-lecturer – December 2021
https://www.rigb.org/explore-science/explore/video/going-viral-how-covid-changed-science-forever-perfect-storm-2021

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Question 6 (Views on whether the work of the above groups etc in responding to the Covid19 pandemic met with success in its aims)

You have asked for my views here, but it is unclear what level of detail of response would be most helpful at this stage. I hope it will be helpful if I outline a few key themes that were visible from my perspective:

(i) *The diversity of expertise in SPI-M-O and the consensus approach*: within a matter of weeks, SPI-M-O incorporated representation from many research groups across the UK, comprising a range of experts in disease modelling. These modellers bring a wide spectrum of different technical expertise, background knowledge and specialist approaches. This gave a broad repertoire of possible approaches to questions, and also the option of multiple distinct approaches to be used in parallel, and a diversity of thought.

The chairs of SPI-M-O understood that bringing a multiplicity of approaches enables more robustness of science done under the extreme pressures of very little time and limited data. For some work there could be formal statistical ensemble approaches, but for most of the more complex narrative questions, discussion in meetings sought to find consensus. In SPI-M-O this meant both seeking commonality of results and conclusions (same qualitative answer from separate methods and different data streams gives confidence that the output is not in error or sensitive to small changes in data or technique), but also real curiosity, interest, and openness when there were differences. Sometimes these differences told us something important (for example if the differences in results could be pinned down to different data streams e.g. admissions vs cases, then knowing that the signal from these is inconsistent can tell us something about the epidemiological patterns). Combining the diversity of contributors and a forum where there is encouragement to take different approaches and willingness to explore outputs together to understand similarities and differences was a very powerful way of working under great uncertainty and extreme time pressure.

Throughout, there was a very positive and supportive culture and environment in both SPI-M-O and SAGE where I felt confident that I could raise a point of challenge or disagree even with very senior scientists, and that this would be treated with respect and even welcomed. This is remarkable looking back, considering all the pressures those groups were under, and credit for this is due to our chairs: Graham Medley and Angela McLean for SPI-M-O and Patrick Vallance and Chris Whitty for SAGE.

(ii) *The engagement between SAGE and subgroups and academic researchers*: the strength of engagement between science advice for government and academic researchers was very different in the UK to what I have heard of science input for government in other countries. There were both extensive structures in place interlinked with government, via SAGE and SPI-M, but also these groups were networked extensively to the wider research community in the UK within academia. This is in contrast to patterns in other countries with purely government research groups contributing science advice for policy, and/or substantial expertise in university groups but with little or no path to contribute to their government's national response.

As well as the overall and longstanding structure of scientific advice embedded within the UK government, from my view of this period I would highlight one point as key: the secretariats were highly effective in interfacing with university academics with little or no previous experience of government. The SPI-M-O secretariat had a strong understanding of

the science and what we could and could not contribute. During these months and years of working closely together, their knowledge grew further of how to ensure we were able to bring our research expertise to bear on points which had value within government. I also encountered great expertise in Go-Science more broadly and civil servants in a range of departments (DHSC, DfE, and FCDO). Independent scientists simply could not have played a role of any significant value without this science expertise embedded in government capable of acting as an interface to academe.

There was an overwhelming will to contribute to efforts in response to the COVID-19 emergency from the wider academic research community, far beyond those formally contributing to SAGE or SPI-M-O and beyond those with specific experience in infectious diseases. There were times when we could bring specific themes to academic networks, and then bring valuable findings back to SPI-M/SAGE. This was done for example under the auspices of research hubs such as the Isaac Newton Institute, or via informal collaboration networks. The Royal Society's RAMP programme also harnessed this generosity of time and energy from the broader research community to bolster modelling efforts, for example in 2020 by coordinating extra volunteer researchers to aid the groups that were contributing to SPI-M-O, and also by running a Rapid Review Group as a form of organised peer review that we could use for mathematical modelling papers before submitting them to SPI-M-O or SAGE, to name but two of the initiatives of RAMP to bring in contributions from researchers with expertise adjacent to modelling of infectious disease.

(iii)   *The level of commitment and way of working from volunteer researchers contributing to SPI-M-O and SAGE:* I felt directly some of the demands and pressures of contributing to SPI-M-O and SAGE, but I also saw up close the depth and longevity of response from my colleagues to this emergency. Very many scientists put in phenomenal amounts of time and care, working closely together on very tough problems under very difficult situations and pressures beyond anything we had experienced before. This was not just for few intense weeks, but in the end, this dedication was for years.

My view is that the core reason that our commitment remained solid was that we felt that we were able to contribute something. I could see that work from SPI-M-O was reaching SAGE and hence to the CSA and CMO and other senior scientists embedded in government. We felt confident that there was a route for our contributions to reach policy makers. Even though we know the difference most of us individually would make to the advice given was likely extremely small, we remained firm in our sense of responsibility to do all we could while knew there was a chance it could help against the harms from this horrific pandemic.

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Question 7 (Views on lessons than can be learned from the UK's response to the pandemic, in particular relating to the work of the above-named groups)

Again, it is unclear what level of detail of response would be most helpful at this stage. So I will again focus on a few key headings:

(i)   *Data provision*: this was a recurring problem over the full period here. There were numerous delays and limitations of what was supplied to modelling groups, including data that existed that would had the potential to change our real-time understanding of the unfolding pandemic. Access to data was a factor that was identified before 2020 as clearly important for science and modelling in particular to make the most useful and accurate contributions. There is much to be learnt about what happened in practice in terms of data flows to SPI-M-O groups during the COVID-19 emergency: there are systems that can be developed and in place ahead of pandemics and other emergencies.

My view of this was largely through SPI-M-O and the Spatial Heterogeneities subgroup. A specific example: while SPI-M-O researchers had access to counts of *positive* tests stratified by spatial location, age and socio-economic factors for England, they did not have the same for *negative* tests. In brief: without the information of counts of tests taken, it becomes impossible to disentangle whether an increase in positive tests in some component of the population is due to an underlying increase in prevalence, or if it is due to changes in testing (either provision of testing or behaviour in seeking tests). There was no obvious fundamental ethical barrier to withhold data on negative tests and not the positive tests. Repeated requests highlighting the need for these were never quite refused, nor resolved. I cannot recall if this ever was fixed, but certainly during the critical period of the establishment of the omicron variant in December 2021, it was missing. This is just one example of a data problem that limited our contribution.

I was never in a position to see exactly where the crux of the problem of data flows was: my communication on this largely went through the SPI-M-O secretariat and SAGE who clearly understood the issues. I am concerned this remains unresolved for future emergencies.

(ii)   *Pressure on volunteer academics*: a flip side of the success in terms of the commitment of volunteer researchers was the extreme and prolonged pressure on individuals. This was through many sources including the sheer hours and difficulty of the research itself, the time pressures routinely requiring working through the weekend, long days and often working into the night. This emergency brought with it some factors which are specific to an infectious disease, such as the dreadful reality of living through this pandemic at the same time, including we and loved ones facing COVID-19. We felt the pressure of the importance of the work, and wish to do as good a job as we could, but also the stress from the unfamiliarity of working in a new and changing organisation with a wide range of colleagues that we did not work with before.

My experience of the public and media pressure was initially mild as I did not seek to reach out to the media as a COVID-19 expert, but that changed in May 2020 when I was named as a SAGE participant at a time when the media had extreme interest in identifying and pursuing SAGE scientists. The deluge of high profile media requests was not something I was at all prepared for. Nor had I before been in a position where I was subject to being sent abuse by people who clearly regarded scientists as "fair game". This was not something I and others were brought into gradually through career progression, but a very sudden change due to our roles on SAGE and subgroups.

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On top of this, we remained *volunteer* academics, and many of us had university positions, and after the initial phase of the emergency, we had to double up our SPI-M-O/SAGE work with some aspect of our "day job". For example I wrote and delivered a full third year undergraduate lecture course in Autumn 2021, alongside working extremely long hours for SPI-M-O and SAGE. On top of this, I've spent extensive time writing applications and seeking research funding to support our work on COVID-19 (see below regarding the consortium).

The pressures on individuals as well as harming our wellbeing in the short and long term also potentially limited our capacity to respond as time went on. Some of the pressures, including some described above, was clearly specific to circumstances of the COVID-19 pandemic, but some appear likely to be repeated for other independent scientists working for any emergency government scientific advice.

Addressing the question of support available: I was personally supported by University of Cambridge and Queens' College for media advice, welfare support and also some reduction in my normal duties, but I am aware I am in the minority for being offered as much support as I was. Some support (including offer of counselling, and session on security) was eventually offered to us through Go-Science, but this came rather belatedly (and I am unsure of the scope of it as I did not take much of it up).

I feel strongly that support should be in place for any independent scientist actively working for government emergency science advice for policy. The routes to gain access to this should be available early, and this support should include welfare support (e.g. access to appropriate counselling), and also advice on handling communications and media.

COVID-19 was unusual in having a very large group of scientists working as volunteers for such a prolonged period, but it is not unimaginable that this could happen again for some emergency. There was some attempt to reach back to our universities, partly by letters of thanks to highlight that we were playing a role, and eventually offers of payments to our departments to cover someone else to cover some aspect of our duties. This helped, but the payments came very late in the process and did not come anywhere close to a level where we could be replaced at a suitable level for an academic term, say. Universities are extremely stretched in staff capacity for running core teaching activities: goodwill was not enough. Perhaps there could be a system where if government called upon non-government scientists for a *prolonged* period, there would be a way for the university to be compensated to properly release them from their university post (perhaps as if on sabbatical) if it is clear the need will go on for more than a few weeks.

(iii) *Scientific capacity:* the early days of the COVID-19 pandemic made it abundantly clear to us that we were limited in our response by simply there not being enough of us researchers to pursue all the lines of work that were brought to us by SPI-M-O. We are a relatively small academic field, and simply ran out of people who had the research expertise to do this work. Apart from the two large London groups (Imperial and LSHTM), most of the research groups involved were small and did not have spare capacity to easily mobilise an emergency response. However, as noted in question 6, this emergency has demonstrated the high value of multiplicity of approach.

There were some improvements over time in terms of capacity, such as the RAMP volunteers (mentioned in question 6) and emergency additional funding available from UKRI for an application deadline in August 2020. We applied for this to work as a consortium

across 16 co-investigators, with funding for many much-needed postdocs, and were granted, and funding was in place on 19th November 2020. While already over 9 months after the start of the emergency, this funding enabled us to increase our capacity and to work across multiple research groups: once at full capacity (say Christmas 2020 when most posts were filled) I believe our consortium then produced the majority of contributions from non-government researchers to SPI-M.

It was entirely foreseeable that expert research capacity would be needed in a human pandemic emergency that affected the UK. However, scientific capacity in universities is shaped by funding sources (such as via UKRI) that are for purely research priorities, not capacity for emergency scientific response. I hope this inquiry will consider this funding model, and make a finding (and if felt appropriate, recommend how) there should be a route to ensure that UK has appropriate research capacity to respond to scientific emergencies, particularly in areas that have high likelihood and impact as identified by the national risk register.

Question 8 (Documentation held)

In brief, I have electronically:

(i)   Emails regarding SPI-M-O and SAGE – these are the administration associated with several hundred meetings (including subgroup meetings). Some are email threads between SPI-M-O participants when we were asked to confirm something by email. Many are routine notifications that the day's data is now available. Some are emails between collaborators on contributed papers containing comments or edits on versions of the paper in development, including being sent iterates of the SPI-M-O consensus statement for my input.

(ii)   My own storage of papers circulated for meetings.

(iii)   For some papers that I was a co-author of, earlier file versions as the paper was developed.

(iv)   My own mathematical and computational work, including code to produce figures that I contributed to papers or the Spatial Heterogeneities work.

I will ensure the documentation I hold is retained as requested.