Witness Name: Professor Matthew Keeling
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UK COVID-19 INQUIRY

WITNESS STATEMENT OF PROFESSOR MATTHEW JAMES KEELING OBE

I, Matthew James Keeling, will say as follows: -

1. I am a Professor at the University of Warwick, and Director of the Zeeman Institute for Systems Biology and Infectious Disease Epidemiology Research ('SBIDER'). I have worked in the field of epidemiological modelling since 1997 and have studied multiple infectious diseases: from childhood infections (such as measles) to respiratory infections including seasonal and pandemic influenza, to sexually transmitted infections (such as Human Papillomavirus ('HPV') and Monkeypox ('Mpox'), to livestock infections (such as foot-and-mouth disease). I have considerable experience in leading successful research grants, having been awarded in excess of £12M as principal investigator and £33M as co-investigator in my career. I have written or co-authored over 200 publications, mostly in infectious disease epidemiology, with an 'h-index' of 73 (meaning that I have 73 publications that have been cited 73 or more times). I have co-authored 33 peer-reviewed articles on COVID-19.

SBIDER

2. SBIDER is a University of Warwick based research centre, co-ordinating research activities but not responsible for departmental teaching nor having independent finances. SBIDER has around 25 permanent academic staff members (although we don't have official membership) from mathematics, statistics, computer science, life sciences and medicine, with similar numbers of post-doctoral researchers and PhD students. SBIDER academics work on a number of areas, from cellular dynamics to genomics, from community trials to population dynamics; in terms of infectious diseases we have a broad range of experience in understanding and predicting human, wildlife and livestock diseases, including: bubonic plague, Chagas disease, Ebola, foot and mouth disease, influenza (in humans, wild birds and poultry), leishmania, malaria,

measles, mpox, onchocerciasis, rabies, respiratory syncytial virus ('RSV'), sleeping sickness (Human African Trypanosomiasis) and Yaws.

3. The SBIDER response to COVID-19 was initially led by four Scientific Pandemic Influenza – Modelling – Operational ('SPI-M-O') members (myself, Dr Dyson, Dr Hill and Prof Tildesley), later joined by another permanent academic (Dr Thompson) and four post-doctoral researchers that were also members of SPI-M-O (Dr Guzmán Rincón, Dr Hilton, Dr Leng, Dr Moore). Members of the SBIDER team, led by Prof Nokes, provided input for the Ministry of Health in Kenya on the dynamics and control of COVID-19 – with considerable synergy between the research on the UK and Kenyan outbreaks.

SPI-M

4. Scientific Pandemic Influenza – Modelling ('SPI-M') is an advisory group that provides expert advice to the UK government based on infectious disease modelling and epidemiology. As such, I am one of many epidemiological modellers on the SPI-M group.

5. The role of SPI-M is to keep abreast of the latest insights into pandemic projections, with a strong focus on pandemic influenza given its potential to cause future outbreaks. This involves making the committee aware of the latest work in the area, including our own, and regularly updating the Modelling Summary to capture the latest insights into the likely scale of future pandemics. Although the Modelling Summary published in 2018 (**MK/1 - INQ000217235**) was primarily concerned with an outbreak of pandemic influenza (and chose parameters and assumptions accordingly) many of the insights are pertinent to the COVID-19 outbreak.

6. I joined SPI-M in early 2009, at the request of the chair at the time, Dr Peter Grove. SPI-M tended to meet 3-4 times a year, although there were weekly meetings during the height of the 2009 H1N1 (swine) flu pandemic. I generally attended all meetings whenever possible, subject to the constraints of my university position. During much of the 2009 pandemic I was acting chair of SPI-M, freeing Dr Grove to conduct essential Department for Health and Social Care ('DHSC') business.

7. The membership of SPI-M is such that it contains many of the country's leading experts in their field. SPI-M brings together the best epidemiological modellers with an interest in pandemic projection and control. All these modellers have a strong track-record of both cutting-edge modelling and bringing models to practical and challenging public

health problems. In my view the membership covers all the necessary expertise and there are no obvious omissions. It is important to note that SPI-M does not commission work from its members. Instead, members provide scientific advice on existing pieces of work. Often these have been commissioned from UK Health Security Agency ('UKHSA'), but I have not been involved in how this process operates.

8. During the COVID-19 pandemic, the SPI-M group became SPI-M-O. This also corresponded to a formal change in the reporting hierarchy; SPI-M reports directly to DHSC whereas SPI-M-O reported to the Scientific Advisory Group for Emergencies ('SAGE'). SPI-M-O meetings began on 3rd February 2020 (although there was a January meeting of SPI-M that discussed SARS-CoV-2 dynamics), and the meetings continued until 23rd March 2022. To ensure all matters were fully explored and discussed, there were frequently three SPI-M-O meetings each week with specialist membership. One to look at fine-scale spatial patterns of growth, one to examine in detail the medium-term projections ('MTPs') and *R* estimates, and a general meeting where the wider membership attended. I generally attended and participated in all three. SPI-M-O also had a much larger membership to reflect the individuals from multiple institutions working on different aspects of the pandemic. SPI-M-O helped to co-ordinate modelling and data analysis efforts across the involved institutions and provided a natural conduit for quantitative questions and answers for SAGE. Given my research area, I would have undoubtably worked on aspects of the pandemic, but SPI-M-O helped to focus these efforts to address the most pressing issues.

9. One of the massive advantages of SPI-M-O was the number of independent models and data analysis that was performed by different research groups. By having at least three groups providing input to the medium-term projections we were able to produce median lines and prediction intervals that captured statistical and model uncertainty. With multiple model results from different research groups, it becomes possible to investigate the impact of key underlying model assumptions, which provides a richer understanding of the projections. It provided policy advisors and policymakers with intervals that are more likely to capture the full range of future scenarios. At no point did I push for a particular course of action but sought to provide the best evidence to underpin policy decisions.

JUNIPER

10. As well as being a member of SPI-M, from Spring 2020 I have been co-leading with Professor Julia Gog (Cambridge) the Joint University Pandemic and Epidemiological

Research ('JUNIPER') consortium. This group of seven Universities (Bristol, Cambridge, Exeter, Lancaster, Manchester, Oxford, and Warwick) came together in the early stages of the COVID-19 pandemic, although all the involved academics already had good working relationships with each other and were members of SPI-M-O.

11. The formation of this consortium, and the funding of post-doctoral researchers, allowed us to generate a wealth of model results and analysis over very short periods of time; often a request would come on a Friday evening for results that were needed by Monday. By having multiple groups involved, JUNIPER brought an extremely broad cross-section of abilities. It also provided sufficient critical mass to address complex problems with multiple approaches, and there was the independence to internally review work before it was presented to SPI-M-O.

12. JUNIPER was independent from SPI-M-O but given the significant overlap in membership and the resources available to JUNIPER, we were naturally included in many of the SPI-M-O discussions. In general, JUNIPER attempted to respond to all SPI-M-O requests, so it was natural to liaise with the secretariate and chairs to find the most effective way to present our findings and to refine what we would investigate.

13. The early stages of modelling the pandemic were dominated by the two large London groups from Imperial College ('Imperial') and the London School of Hygiene and Tropical Medicine ('LSHTM'). These two groups were the only UK institutions with standing capacity funding to develop pandemic models. Other groups, including those in JUNIPER, were therefore a few weeks behind in the initial development of analysis and models. The formation of JUNIPER helped redress this balance with JUNIPER researchers being a similar size to (or slightly smaller than) the groups at Imperial or the LSHTM.

14. Whilst JUNIPER was formed in Spring 2020 the funding position was not resolved until November. This later more equitable distribution of funds between institutions beyond the Imperial and LSHTM groups may be an important lesson for the future. A diverse portfolio of researchers has many advantages:
    - it provides a diverse range of model formulations and analytical structures;
    - it provides access to multiple skill sets and specialisations at different institutions;
    - it provides access to specific data from different regional health trusts;
    - it allows different groups to tackle different aspects of an on-going outbreak; and

- it prevents the dominance of a single set of assumptions about the epidemiological dynamics.

15. In total, JUNIPER produced over 80 publications on COVID-19 and hundreds of reports based on projections, parameter estimates and analysis that fed into SPI-M-O and SAGE. In particular, JUNIPER provided considerable scientific input on variants (Alpha, Delta and Omicron), spatial/regional heterogeneity, the roadmap out of the January 2021 lockdown, and the impact of vaccination. I exhibited few of these papers as samples (**MK/2 - INQ000217236; MK/3 - INQ000217237; MK/4 - INQ000217238; MK/5 - INQ000217239; MK/6 - INQ000217240; MK/7 - INQ000217241**).

16. As co-lead of JUNIPER, I was responsible for helping to lead and coordinate activity within the consortium. This could include ensuring that JUNIPER as a whole could address the questions raised by SPI-M-O in a timely manner and checking that the individual members of JUNIPER were not duplicating efforts. I also helped make sure that research was given sufficient time to allow it to be written as a scientific publication and submitted for peer review, often facilitating internal review of papers before submission. I was also concerned with the general career progression of the members of JUNIPER, especially the early career researchers ('ECRs') where working on non-published reports for SPI-M-O and SAGE could have been detrimental to their career progression. Fortunately, many of our ECRs have met with considerable success in securing future funding or permanent academic positions.

Following the science

17. It is stated that the COVID-19 Inquiry has a "particular focus on the period 1 January 2020 to 26 March 2020", which is the time from the early detection of cases in China to the legal enforcement of the first lockdown. During this early period there was considerable uncertainty in the scientific advice; while the broad patterns were understood many questions remained. In contrast, at later periods there was far better data and far greater scientific consensus, hence any disparity between scientific advice and policy is a clearer departure from 'following the science'. For this reason, I will focus on the entire period of the Inquiry (1 January 2020 to 24 February 2022) in my statement.

18. The potential need for a lockdown was first raised during SPI-M-O in very early March 2020, although at the time there was still considerable uncertainty about the long-term

dynamics and public adherence. There was some discussion at the time of behavioural fatigue and suggestions that controls would not be adhered to for more than 3-4 weeks.

19. In contrast, from very early September 2020 onwards the data analysis and fitted models showed that cases, hospital admissions and deaths were exponentially increasing, and some form of additional control measure(s) were needed. The idea of a short-term lockdown to reduce cases (dubbed 'Circuit breakers') was fully discussed at SPI-M-O on 16th September 2020, yet was not implemented until 5th November 2020 – by which time cases had increased sixfold.

20. While the November 'circuit breaker' had a noticeable impact on the number of cases, hospital admission and deaths, it was appreciated within SPI-M-O that this control was only a short-term solution to reduce the immediate pressure on health care services and that longer-term measures were needed. The roll-out of the vaccine was on the horizon but was not going to offer an instant solution. The third lockdown began on 6th January 2021, and within a week daily hospital admissions in England peaked at over 4000[1].

21. Given these examples, I find the term 'following the science' to be confusing and unhelpful. Science should ideally be used to quantify the outcomes associated with any decision, including the absence of making a decision; but without an agreed set of guidelines or objectives these assessments cannot be used to inform policy. No such objectives were ever communicated during the pandemic.

22. As such it is policymakers who have to assess the epidemiological projections (and uncertainties) and balance these against similar calculations that we assumed were being performed by the Treasury; it is policymakers who need to decide the level of scientific certainty required before action is required; and it is policymakers who determine the details of any control measures.

23. Ultimately it is for the policymakers to make the decisions, taking into account a wide variety of factors of which the science is only one element. I do not think it was widely understood that this was the case. In my opinion, the use of the term 'following the science' led to the impression that the balance of evidence was weighted towards the

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[1] The COVID-19 dashboard gives a total of 4134 admissions with COVID-19 on 12th January 2021 (**MK/8 - INQ000217242, line 862**).

scientific advice that was being provided. In turn, this led to negative attention being received by members of the scientific community.

24. I would also like to add that media attention was a new, and unforeseen, aspect of the high-profile nature of the work we were doing. There were a few occasions with major pieces of scientific research where I provided media briefings via the Science Media Centre; I felt that the Science Media Centre did an excellent job in helping academics communicate with the media in a controlled environment. I feel that for such a complex topic as modelling, any communication of scientific findings (together with uncertainties and caveats) needs to be done with a great deal of preparation and forethought to ensure a thorough understanding by the public.

25. Considerable attention has focused on counterfactual scenarios, trying to address questions such as 'what if the initial lockdown had happened sooner'. While such questions are intuitively appealing, there are multiple challenges with rerunning history. Using an earlier first lockdown as an example, it is clear to me that if nothing else changed then an earlier lockdown would have saved lives. However, if the first lockdown had occurred earlier it is likely that many other aspects of control would have changed; with fewer cases in the preceding weeks, it is possible that public compliance may have been less, and with a lower epidemic peak it is likely that control measures may have been lifted earlier. This simple example highlights the difficulties with such what-if scenarios, they require the prediction of human behaviour and political responses with a level of detail that is unobtainable.

Interactions between SAGE and policy

26. SAGE is a group of scientists convened at times of national emergency to provide independent scientific advice to support the Cabinet Office in its decision-making.

27. The structure of SAGE and its subgroups generated a chain of information flow. For modelling this flow was from the individual researchers and research groups, through SPI-M-O (where the evidence was assessed by the UK's leading modelling experts), to SAGE (where the evidence was given broader scientific scrutiny) and then via the Chief Scientific Adviser ('CSA') and the Chief Medical Officer ('CMO') to the COVID-19 Task Force, the Cabinet and politicians. My experience stops at presenting work to SAGE, I never had direct contact with politicians. Hence, I have no knowledge how these models were presented to policymakers.

28. It should be noted that all models and many of the policy-facing results have been extensively and independently reviewed by the wider scientific community as part of the publication process. This independent review is in addition to the rigorous assessment and scrutiny that took place, first within group meetings, then within SPI-M-O meetings and finally within SAGE meetings. The publication process also generally involves the release of computer code, so that both the technical mechanics of generating results as well as their scientific interpretation can be validated. Model results on COVID-19 from Warwick have been published and peer-reviewed over thirty times; none of these reviews highlighted any substantial problems with our models or approach, providing a high degree of confidence in our findings. However, this external peer-review process is not rapid, often taking several months to fully review a document and is therefore not suitable for overseeing advice during the pandemic.

29. I would like to stress that members of SPI-M-O and SAGE were independent academics and hence free to investigate any and all aspects of the pandemic with the data available. Academics, including myself, often brought new and interesting model results or statistical analyses to meetings that were discussed by the whole group. Often such results led to further lines of enquiry over the following weeks. To ensure all matters were fully discussed, there were frequently three SPI-M-O meetings each week, including a general meeting where the wider membership agreed a consensus.

30. The consensus statement was put together by the two chairs of SPI-M-O with the assistance of the secretariate. I had some experience of this process, as I was occasionally the acting-chair when the main chairs were absent. The consensus sought to capture the main discussion points of each meeting, drawing the scientific debate into a concise narrative that described the current state of knowledge, our projections for the immediate future and our levels of uncertainty. This was communicated to SAGE after each meeting.

International Interactions

31. Academia is a global enterprise, with the sharing of ideas, concepts and information; this was particularly true during the pandemic. SPI-M-O was continually monitoring the international situation to understand what the UK could face in the near future. Many scientists involved in SPI-M-O were also involved in providing insights to other countries or international organisations (such as the World Health Organisation). SBIDER was particularly involved with the unfolding outbreak in Kenya and East

Africa. In particular, we were in close communication with South African and Danish researchers in November/December 2021, learning from their experiences of Omicron.

Mathematical Models

32. There is a deep misunderstanding of what mathematical models are, and their uses during the pandemic. There have often been questions about whether particular factors (indoor vs outdoor mixing, or the transmission risk in gyms compared to pubs) are included in the models, with the implicit assumption that including more factors leads to a better model. I would like to make clear that models are abstractions of reality – they are not meant to be "digital twins" (a digital twin is a simulation in which the complete behaviour of individuals is attempted to be captured).

33. The model used in Warwick has taken a simpler form, capturing average patterns of behaviour and therefore average risks across multiple age groups by matching to the available data on testing, cases, hospital admissions and deaths. This simpler form of model means that it can be more readily matched to the available data; therefore while not seeking to capture every element of population behaviour it does provide an accurate reflection of the epidemic that can be matched to the shifting dynamic patterns. The main Warwick model has been used in at least ten peer-reviewed publications, and multiple versions of the code made freely available.

34. The Warwick model focuses predominantly on the effects of age-structure, capturing the fact that younger ages tend to have less symptomatic infection and less severe disease (in general) (**MK/9 - INQ000217244, MK/10 - INQ000217248; MK/11 - INQ000217246; MK/12 - INQ000217243; MK/13 - INQ000217250; MK/14 - INQ000217251; MK/15 - INQ000217249; MK/16 - INQ000217247; MK/17 - INQ000217245**). This is by far the greatest heterogeneity; age explains more of the variation between individuals than any other factor, with the elderly being far more likely to suffer severe disease than the young. This age-structure means that school-level mixing is naturally included, as the overwhelming majority of four- to eighteen-year-olds are in education. However, other ways of partitioning the population are possible (and were considered); more nuanced models could consider comorbidities and other risks that increase vulnerability; ethnicity or social deprivation (both of which correlate with higher risk); professions such as health or social care workers who were often more exposed to infection; or settings such as particular workplaces or care homes.

35. While all of these are important heterogeneities, the data is lacking (either in terms of the underlying population or in terms of cases / hospital admissions) to support such extra structure within nationwide models. Therefore, while the impact of mixing in schools is relatively easy to include as it relates to the behaviour of all children, only a proportion of older adults are in care homes and this information (together with whether infected individuals are in care homes or not) is unavailable so cannot be built into the model structure.

36. The accuracy of models is also affected by uncertainties of which there are three main sources:

    a. The first is uncertainty in the inferred model parameters, this is incorporated into all projections by running computer simulations using different sets of estimated parameter values. For example, if we estimate *R* (the reproduction number) is between 1.0 and 1.2, then we will generate a suite of projections of future cases/hospital admissions/deaths using the estimated uncertainty in *R*.

    b. The second source of uncertainty is the effect of future events, such as changes in population behaviour, the start of a vaccination programme or the imposition of new control measures. These are changes that may be known about, but where the size of the change is difficult to estimate. For example, we may know that a vaccine is soon to be available but cannot reliably estimate how many people will wish to be vaccinated. We explore the impact of such uncertainty by considering multiple scenarios – for example, assuming vaccine uptake is 50%, 60%, 70% etc.

    c. Finally, there are unknowable uncertainties, events that cannot (easily) be anticipated and so can only be included into the model once this new part of COVID epidemiology is understood. Examples of this might include the emergence of new variants (which was largely unexpected before late 2020 and the Alpha variant) and the rapid waning of vaccine protection (which was largely unobservable in the data before mid-2021).

37. The models have been criticised for not including human behaviour, however this assumption is incorrect. The main predictive model developed in Warwick is driven by changes in human behaviour; we infer the level of precautionary behaviour on a weekly basis, whether this is driven by changes in policy or voluntary risk avoidance. As such the Warwick model has a very detailed picture of human mixing, which agrees with

other independent measures such as Google mobility data (**MK/16 - INQ000217247** figure 1).

38. What the models have not been able to achieve is predicting the response of the population to rising cases and increasing perceived risk. This is now an area of active scientific research, but throughout the pandemic there was very limited data to inform models of human behaviour.

39. The uncertainty around behaviour takes two forms, firstly understanding how rapidly people will return to their normal behaviour once mitigation measures are lifted; this was explored throughout 2021, with later Roadmap modelling documents taking account of gradual changes in behaviour (**MK/16 – INQ000217247** Secondly, understanding how the population will respond to increasing risk; this was epitomised by the modelling for the Omicron epidemic; with an absence of data, modellers made the safe assumption that population behaviour would not drastically change as highlighted in the exhibits (**MK/18 - INQ000217252; MK/19 - INQ000217253**).

40. Modellers were often asked to generate reasonable worst-case scenarios which, as the name suggests, make more pessimistic assumptions about parameter values to explore the likely extremes of behaviour, on the basis that the government needs to be able to plan for the worst. Unsurprisingly, such projections do not match the realised behaviour of the epidemic but serve as a useful planning role. Other projections do attempt to capture the most likely epidemic behaviour, examples include the regularly produced Medium Term Projections (MTPs) which project the recent dynamics out 4-6 weeks.

41. Roadmap projections were undertaken throughout 2021 to provide insights into the relaxation of mitigation measures. Subsequent analysis shows that the model projections were in good agreement with the actual number of hospital admissions and were equally likely to under-estimate or over-estimate the true number (**MK/16 – INQ000217247**. However, the models did tend to over-estimate the number of deaths; this is directly attributable to continual improvements in the treatment of COVID-19 patients, such that the ratio of deaths to hospital admissions declined throughout much of the pandemic.

Mathematical Models: Economics

42. There has been considerable discussion of the interaction between epidemiological modelling and economic modelling. It was made clear to me and other members that

the role of SPI-M-O and SAGE did not extend to considering the economic consequences of infection or control measures, as this was outside of our remit. I agree with this position; SPI-M-O's expertise lies in the mathematical modelling and analyses of epidemiological scenarios. It does not exist to model the harms to the economy, education, mental health and societal well-being. However, I would of course have been happy to collaborate with experts in these areas to understand whether our model output would be useful in quantifying these broader impacts of the pandemic.

43. Independent of SPI-M-O and SAGE, in late 2020 I worked with a large group of academics to explore the wider costs and benefits of social distancing measures over two time periods (May 2020 to January 2021, and January to October 2021) (**MK/20 – INQ000205272**). In this paper we used a willingness to pay approach, considering the economic losses the country would be willing to sacrifice to preserve one year of healthy life. This allowed us to determine the optimal strength and timing of Non-Pharmaceutical Interventions ('NPIs') that resulted in the smallest net loss - combining economic losses, health losses and deaths. Our results suggest that short-duration 'circuit-breaker type' lockdowns in August and September 2020 would have minimised the net loss over the first period (May 2020 to January 2021). Once vaccination began, a gradual reduction in NPIs during 2021 was predicted to minimise the net losses for that year, although this analysis did not include the emergence of the Delta variant. As such this highlights the potential benefits of considering health and economics in a unified framework.

Lessons learned

Informal collaboration

44. I believe that better lines of direct communication between the subgroups may be of great help in future pandemics; during this outbreak much of the information flowed through SAGE. I think more informal meetings between subgroups could be highly beneficial and provide all groups with a more holistic understanding of future outbreaks. There was a similar situation with 2022 Mpox outbreak, in which the modellers, the clinicians and the behavioural experts were somewhat siloed.

45. I would also state that continuing to have all meetings on-line is a definite improvement especially for the majority of academics that live outside London and encourages diversity. It would have been troublesome for me to generate the output that I did for

the COVID-19 pandemic if I also had to attend meetings in person with the associated travel times.

Accessibility of data

46. Models are only as good as the data that feeds into them, and we had issues with accessing the necessary data. We only had access to partial information. For example, for the majority of 2020 and 2021, the modellers were only provided with data about the first time an individual tested positive, so any subsequent positive tests were ignored. While there were good reasons for this in the early outbreak (not counting people testing multiple times in succession), later in the outbreak it could have been biasing the modelling results and prevented an analysis of reinfection.

47. Another continuing issue with the data is the disconnect between case and death data that was highly detailed, and hospital admission data that was aggregated at a relatively coarse scale. Again, we all appreciate the confidential nature of hospital data, but the differences between data sets seems excessive. In addition, there were often changes to the way that hospital data was counted, meaning that modellers were often fitting to the counting rather than the underlying processes. In the future, there is a need for a system to be put in place so that all modellers have access to the necessary data to enable more accurate modelling.

48. After the initial phase of the epidemic, the Defence Science and Technology Laboratory ('DSTL') and later UKHSA did an excellent job of bringing this data into a unified document, but the initial differences in the ways data is reported and recorded by the four nations caused difficulties throughout the pandemic.

49. As we move to a new protocol in working with large data sources, it is important that the public-health academic interface matches these innovations. Either academic institutions need to be trusted with large volumes of data, such that the power of university computer systems can be used to analyse the dynamics, or data access needs to be provided in secure environments with plenty of flexibility and processing power such that the same analyses can be performed.

Holistic approach

50. The epidemiological models and projections that fed into SPI-M-O and SAGE are only one part of a holistic decision-making process; projections of economics and social impacts are needed by policymakers to form a balanced viewed. While I fully support

the principle that SAGE is only involved in the science, from a mathematical modelling perspective the economics and other factors are required if we are to produce optimal solutions that balance epidemiological benefits against potential harms. Many on SPI-M-O would have welcomed being more joined up with the economic forecasts, but this never occurred.

51. I, like many in the epidemiological modelling community, would be very keen to work with experts from other disciplines to try to predict the social and economic aspects of controls, forming a more holistic view of control measures. Developing the methodology to understand and quantify the broader impacts of pandemics, including mental health and societal well-being, requires a wide spectrum of academic disciplines. This type of new, ground-breaking interdisciplinary work takes time and is best undertaken before a pandemic.

Funding

52. The academic community worked wonders with incredibly tight deadlines and on very limited resources. Many groups managed to secure some extra funds to support additional research staff, through research council grants (UKRI hosted specific schemes) and funds from other organisations (such as the RAMP initiative from the Royal Society) – although the time needed to apply for such funds is time taken away from active research into the pandemic.

53. In addition, many universities were responsive to demands placed on these researchers and reduced their teaching or administrative loads. However, there was little direct government funding for those performing activities for the multiple subgroups, and many academics would not have been able to provide the scientific input they did without the support from UKRI and host institutions. Moreover, we are now in the situation where major innovations that were generated during the pandemic, and which have placed the UK as a scientific world-leader, are likely to be lost without continued broad investment in the research field.

54. It is vitally important that multiple UK groups have the funding in place to maintain pandemic modelling capacity. Much of the early work was performed out of good will, with other activities being postponed and researchers working very long hours. We all felt it was important to do this given the urgency and importance of the pandemic; but the entire operation could have benefited from a minimal level of funding across multiple institutions.

55. I feel it is important to state that academics on SPI-M-O gave of their time without any financial renumeration. Personally, I worked extremely long hours and most weekends during 2020-2021 (and into 2022) on COVID-19 research, including large portions of the Christmas breaks. I did this in the belief that my model results and analysis of the epidemic would be beneficial in helping to inform policy makers. This COVID-19 research was in addition to my normal academic duties (teaching, marking etc).

Cooperation between scientists and policymakers

56. During the early epidemic period there was some degree of misunderstanding between modellers and politicians; politicians were often asking questions that were way beyond the scope of any model, while for modellers it was often difficult to clearly communicate many of the subtleties and uncertainties to policy makers. This improved considerably later in the pandemic when members of SPI-M-O (Dr Nick Davies and Dr Louise Dyson) were seconded onto the COVID-19 Task Force and when a member of the Cabinet Office (Rob Harrison) attended SPI-M-O meetings.

57. The benefit of this direct line of communication is a clear lesson for future outbreaks, and one that should be enacted as soon as possible. The best time to improve the communication between scientists and policymakers is before the next outbreak. Better communication by modellers to politicians of what models can realistically accomplish and the basics of exponential growth would ease interactions during a pandemic, while politicians could helpfully communicate their objectives in terms of the balance between public health and other concerns.

Statement of Truth

I believe that the facts stated in this witness statement are true. I understand that proceedings may be brought against anyone who makes, or causes to be made, a false statement in a document verified by a statement of truth without an honest belief of its truth.

Signed: Personal Data

Dated: 5th July 2023 Personal Data