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UK COVID-19 INQUIRY

THIRD 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 over 32,000 citations. I have (co-)authored over 40 peer-reviewed articles on COVID-19.

<u>APPOINTMENTS</u>

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 (and 16 associate members) 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, cattle, 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 members of Scientific Pandemic Influenza – Modelling – Operational ('SPI-M-O'): myself, Dr Dyson, Dr Hill and Prof Tildesley. We were 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 of the Department of Health and Social Care ('DHSC') that provides expert advice 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.

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 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.

8. 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', or previously Public Health England 'PHE') and/or the Department of Health and Social Case ('DHSC'), but I have not been involved in how this process operates.

9. 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 than SPI-M 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.

10. One of the massive advantages of SPI-M-O was the number of independent models and data analyses that was were 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.

JCVI

11. I joined the Joint Committee on Vaccination and Immunisation ('JCVI') on 20th May 2010, although I had been a member of its Influenza subcommittee since 2008. I applied for my position on JCVI as a member with experience in infectious disease modelling. I remained a member until May 2022. Over the period 2009-2020, the main JCVI committee met three times a year, with other subcommittees meeting as necessary. I generally attended all three meetings each year. The JCVI's remit is "To advise UK health departments on immunisations for the prevention of infections and/or disease following due consideration of the evidence on the burden of disease, on vaccine safety and efficacy and on the impact and cost effectiveness of immunisation strategies. To consider and identify factors for the successful and effective implementation of immunisation strategies. To identify important knowledge gaps relating to immunisations or immunisation programmes where further research and/or surveillance should be considered."

12. In JCVI, my role as a committee member is to provide scientific opinion and advice on the information presented to the committee. This information could range from publications on clinical trials, to reports from vaccine manufacturers, to full health-economic assessments of new vaccine programmes. As the sole epidemiological modeller on the panel, I tended to focus my attention on the more quantitative studies, providing feed-back on statistical analysis and model projections.

SAGE

13. In the early stages of the pandemic, I was invited to be a temporary member of SAGE. I declined as I felt I did not have capacity to be a member of SAGE as well as generate the model projections and be a member of SPI-M and JCVI. I did, however, attend SAGE on 14 occasions, and was a member of three SAGE Task-and-Finish groups.

JUNIPER

14. 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.

15. The formation of this consortium, and the funding of post-doctoral researchers, allowed us to generate a wealth of model results and analyses on extremely short timescales; 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.

16. 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.

17. 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 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.

18. 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.

19. In total, JUNIPER produced over 100 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.

20. As co-lead of JUNIPER, I was responsible for helping to shape and coordinate activity within the consortium. This could include ensuring that JUNIPER 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 ensure that researchers were given sufficient time to allow their work 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.

21. The JUNIPER consortium has now been superseded by the JUNIPER partnership – which is focused on building national capacity in epidemiological modelling for policy across all UK universities (not just those in the initial consortium).

Test, Trace and Isolate (TTI): Background Information

22. It is worth noting some important nomenclature and concepts surrounding the broad area of testing, tracing and isolating:

    a. *Isolation* refers to the separation of individuals that are known to be infected (and infectious) from the rest of the population. It is a highly effective means of control and does not rely on the development of specific pharmaceutical measures. In contrast, *quarantine* refers to the separation of individuals presumed to be at risk of being infected (e.g. close contacts of identified cases) from the rest of the population. (Thus, cases are asked to isolate, while household members are asked to quarantine.)

    b. Testing took two main forms during the COVID-19 pandemic: PCR and LFT. Tests are generally classified by their sensitivity (ability to detect infection) and specificity (ability to identify the absence of infection). Both tests had extremely high specificity, so false positives (when the test reads positive, but the individual is not infected) are vanishingly rare. Sensitivity is more complex and varies throughout the course of infection; crucially it depends whether we want tests that can identify infected or infectious individuals.

c. PCR (polymerase chain reaction) testing was seen as the gold standard; in simple terms it detects parts of the SARS-CoV-2 virus. PCR testing is slower, more expensive and requires processing of tests in a laboratory. PCR has higher sensitivity (compared to LFT), especially at detecting during early and late stages of infection. The lab-based nature of PCR testing means that samples can also be used for genomic analysis – providing a more detailed understanding of pathogen mutations and evolution.

d. LFTs (lateral flow tests) are cheap self-administered tests, that give extremely rapid results. LFTs detect antigens produced by the body against the SARS-CoV-2 virus, and therefore are far more sensitive during the period when someone is infectious. LFT testing allowed individuals to take responsibility for their own actions and hence to minimise the risk to others.

e. Tracing also took two forms: manual tracing (as part of the Test-Trace-Isolate scheme), and electronic tracing via the COVID-19 App. Clearly App-based tracing requires far less resources (once the App is developed), and eliminates recall bias, but is driven by App usage. App-based tracing circumvents the need for the infected individual to be able to identify their contacts (e.g not random strangers they encountered), but does require both parties using the App. Both methods rely on individuals acting to reduce infection in the population. For manual tracing this mean identifying all contacts, including those that may not wish to isolate; for App-based tracing, it means having the App active at all times.

23. As stated in our review paper, 'Effectiveness of testing, contact tracing and isolation interventions among the general population on reducing transmission of SARS-CoV-2: a systematic review' [Exhibit MK3/01 - INQ000564294] there are seven uses of TTI:

a. *Focused testing of symptomatic and high-risk individuals* especially during the early phase of an in-country outbreak, when infection is rare, to contain the spread and prevent transmission among the wider population. This was the case in the UK during the early outbreak, when symptomatic individuals, in combination with other specific travel histories and contact-based criteria, were tested and manual contact tracing performed. In some countries, an intensive TTI system was implemented that aimed to fully contain re-introduced epidemics following periods of zero or very low transmission.

b. *Mass testing of those with symptomatic respiratory disease* to identify SARS-CoV-2 infection, such that individuals could take appropriate action including home isolation and authorities could organize contact tracing. In the UK, this was deployed from May 2020 to April 2022, with minor differences across the four nations; prior to an increase in testing capacity, the UK had adopted a less specific approach of asking everyone with a new onset cough or fever to isolate.

c. *Mass testing of those entering healthcare or other vulnerable settings* such as care homes. Here, the aim was to block the interaction between vulnerable susceptible people and those who were infectious, thereby reducing transmission to individuals most likely to suffer severe consequences.

d. *Mass asymptomatic testing of all individuals*, to identify both symptomatic and asymptomatic infections and hence dramatically reduce the amount of circulating infection.

e. *Regular asymptomatic testing to identify all infectious individuals in workplace and educational settings*. In the UK, this process required healthcare workers, care home workers and secondary school children to perform regular (twice weekly) tests using lateral flow devices (LFDs) in attempts to minimize spread.

f. *The requirement of a negative test result to undertake specific activities or enter particular settings*. Of these, the need for negative tests before international travel was common.

g. *Testing of identified at-risk individuals*. While the previous testing protocols are concerned with identifying infections, tests could also be used to reduce the time spent in isolation; either to inform the safe early release from isolation or testing at-risk contacts rather than asking them to isolate. In January 2022, the UK advised that people could end self-isolation after 5 days, if they had two negative lateral flow tests taken on consecutive days.

My Role in Test, Trace and Isolate.

24. In general, myself and (I believe) the majority of members of SPI-M-O were users of testing and tracing data, and had very limited input into the operation of the testing schemes. I cannot recall SPI-M-O ever being asked its scientific opinion on changes to the testing, tracing and/or isolation policy.

25. My own work during the pandemic made extensive use of testing data: testing data was a key element of fitting my predictive model; and test data helped elucidate the spread of novel variants. The overwhelming majority of my documents submitted to SPI-M-O simply used the testing data as a rich source of information, but the following 7 pieces of work made some recommendations about testing in general.

    a. **Thoughts on School Closures and Workplaces** (17/05/2020) [Exhibit MK3/02 - INQ000564296] and **Thoughts on School Closures Assessing False Positives** (07/07/2020) [Exhibit MK3/03 - INQ000564298]. Following the strict track-and-trace rules, any school class with an identified case needs to close with the children being quarantined. We addressed the key questions: What are the implications of closing for a suspected (rather than confirmed) case? Using historical data from schools we found that there is a 2% chance of absenteeism due to illness (and a 25% chance of the illness being respiratory) – this suggests that shutting schools based on suspected cases would lead to too many false positives. It was also noted that with the first-wave parameters, it is impossible to generate “large-scale symptomatic outbreaks in a classroom setting", and we should expect to see multiple isolated outbreaks. These concepts were extended to workplaces of different sizes.

    In general, we concluded that closures need to be based on test-positive rather than suspected cases; although it would be pragmatic for suspected cases to quarantine themselves until test results were available.

    b. **Some Preliminary Thoughts on Pillar 2 swabbing** (20/08/2020) [Exhibit MK3/04 - INQ000564299] and **Multiple Ways of Looking at Pillar 2 Data** (21/08/2021) [Exhibit MK3/05 - INQ000564300]. These documents consider the underlying complexities in the number of reported cases – which was related to both the level of testing and the prevalence of infection. We concluded that there was complex feedback between prevalence of infection, perceived risk and amount of testing, which obscured the true patterns – better data on the reason for testing would have helped resolve this. We noted that testing is predominantly in the 20-34 age group, which may have been suitable for detecting and isolating cases but was unlikely to be directly correlated with more severe outcomes. For each Lower Tier Local Authority ('LTLA'), we compared number of swabs per 100,000 people, the number of positive swabs per 100,000 people, and the proportion of swabs that are positive. We concluded that using proportion positive may help to highlight new problem areas where relatively high levels of cases are found with little testing effort.

This work was updated in mid-2021. The reanalysis suggested that examining the proportion of tests that are positive helps to remove biased due to testing behaviour but may introduce other biases if the relationship between symptoms and testing changes. Since mid-July 2021 we observed a decrease in testing, but an increase in proportions testing positive in the younger (<20s) age groups.

c. **Thoughts on Test-and-Trace Targeting** (13/10/2020) [Exhibit MK3/06 - INQ000564297]. During 2020 there was limited local capacity for PRC testing. Using a simple model, we showed there was a step-change in the impact of testing depending on whether there was sufficient testing capacity of not. This suggested that testing capacity should be locally targeted towards regions with the greatest need. We suggested that potentially the best that can be achieved is a moderate testing capacity in all regions of the country, with additional capacity at regions identified as having high growth rates and high proportions of positive tests.

d. **Lateral Flow Tests in Liverpool** (16/11/2020) [Exhibit MK3/07 - INQ000564295]. This was an analysis of the mass Lateral Flow Testing in Liverpool (from 6th to 12th November). While the deployment of LFT was seen as a worthwhile epidemiological control – we raised concerns about how the data was likely to be made available. In particular, we saw a far lower proportion of LFTs test positive and a clear age-bias with even lower proportions in the older age-groups. This clearly suggested that LFT and PRC needed to be recorded and reported separately, and that LFTs might be a less effective way of detecting infection in older individuals (or that older individuals were more likely to seek PCR testing).

e. **The impact of uptake and adherence on transmission and absences resulting from secondary school reopening strategies involving rapid testing** (03/03/2021) [Exhibit MK3/08 - INQ000533209]. This document assessed the likely consequences of reopening schools, in terms of infection and absences, based on different testing and isolation policies. Sensitivity to uptake (pupils agreeing to participate in rapid testing), adherence (participating pupils taking tests at home), close contact group size, and transmission risk was explored. We found that there is therefore a trade-off between minimising infection (which required high levels of testing coupled with isolation) and minimising school absence (which occurs when testing is limited and few infections are detected). It was clear that isolating of entire school years led to the greatest number of school days missed; other strategies produced similar numbers of school days missed, but a combination of weekly mass-testing and serial contact testing minimised the risk of large numbers of cases.

f. **Cost Effectiveness of Testing** (16/02/2022) [Exhibit MK3/09 - INQ000564293] In this brief note we considered the economic impact of an imminent change of control policy - the suspension of free LFT - through very simple analysis. It illustrated the key point that a change in policy that leads to a slowing of the epidemic decline may be a false economy. At the time it was plausible that a suspension of free LFTs could even lead to an increase in cases in some areas. We found that the continued funding of LFTs would have been cost-saving if it helped ensure the rate of decline of cases.

26. I have been asked by the Inquiry to provide a high-level assessment of how modelling was considered, utilised and deployed by Government decision-makers with respect to TTI during the pandemic. I do not have any particular insights in this regard. My role was simply to provide model-based projections; policy decisions that considered the modelling were squarely for government decision makers. My perception is that the flow of data from TTI to the modelling teams was extremely limited, and the expertise of SPI-M-O was rarely utilised by TTI.

27. I have also been asked by the Inquiry to provide a high-level assessment of how different strategies were considered, utilised and deployed by Government decision-makers in rolling out TTI during the pandemic in the UK. Again, I have no particular insight in relation to this; policy decisions were for government decision makers.

Effectiveness of Test, Trace and Isolate in the UK

28. Test, trace and isolate has the potential to limit the spread of any infectious disease by identifying infected and potentially infected individuals, and isolating them from society. Therefore, an effective TTI system needs to be able to (i) rapidly detect new infections (ii) identify all potential contacts that may have been infected (iii) allow all these individuals to remove themselves from social and family mixing. Dealing with these three elements in turn:

(i) The TTI system in the UK was reactive, relying on individuals with symptoms to come forward for PCR testing. As such the approach was limited by testing capacity, both at the point of testing but also in the laboratory processing of tests. Other approaches are possible:

a) Slovakia imposed mass-testing of over 4 million people in October and November 2020, which was estimated to reduce prevalence by 56% [Exhibit MK3/10 – INQ000564287].
b) Cheaper and logistically simpler Lateral Flow Tests provide an alternative to PCR testing. When used regularly (weekly or twice a week), as was performed with school children in the UK in 2021, these can be an effective means of early detection.
c) Lateral Flow Tests were also used as surge testing in Liverpool in November 2020 – again demonstrating their potential to identify infected individuals.

These three examples share the capacity to detect asymptotic infections (ones without overt symptoms), which is especially useful for younger individuals who are less likely to have major symptoms.

(ii) Manually identifying contacts is often a time-consuming process, relying on individual recall (and honesty) of the identified infected individual, and unable to trace strangers. The TTI system performed much of the tracing by telephone interviews with identified cases; my understanding is that the vast majority of contacts found in this way were household members – who were generally required to isolate anyway; but this may be a reflection of the reduced mixing over this period.

The contact-tracing App circumvented the problems of recall bias and contact identification. However, my view is that the App also suffers from a number of problems. It requires users to carry their phone and have the App switched on at all times, this probably means it is least effective for the elderly who require the most protection. It is only effective if both parties have the App switched on during their encounter. Unlike manual tracing, the App was unable to account for the setting a contact occurred in – so would equally weight a meeting outdoors and a meeting in an enclosed and poorly ventilated space. Due to privacy concerns the App transmitted very limited information (I believe just the ID of the contact) – yet in principle an App has the potential to provide much more data, generating a national picture of social mixing and potentially allowing for refinement for the tracing criteria.

Quite strikingly, during the "pingdemic" in July 2021, when the App was successfully identifying many contacts (and therefore many potential infected individuals) its sensitivity was reduced. This was performed for economic reasons, to limit the number of individuals away from work – but as shown by a randomised control trial, isolation of these individuals could have been replaced by daily LFD testing [Exhibit MK3/11 – INQ000564292], providing epidemic control while limiting the economic impact.

(iii) Isolation is a very effective control measure – breaking the potential chains of transmission between infected and susceptible individuals. However, in my view the system adopted in the UK suffered from multiple issues. The capacity to effectively isolate is very much driven by the home environment, and many cases would struggle to be isolated from family members. Some countries isolated cases in hotels [Exhibit MK3/12 – INQ000564288], but this is only likely to be effective in the early stages of the pandemic when there is sufficient capacity. The other issue is the financial burden of isolation, especially for individuals on zero-hours contracts – many countries introduced payments or incentives for individuals to remain isolated.

While isolation of those identified as infected cases is clearly a must, the potential to replace the isolation of contacts with daily LFD testing [Exhibit MK3/11 – INQ000564292] is a powerful alternative. Although it also requires compliance, as well as tracing from any contacts that test positive.

29. As with any intervention, TTI relies on a balance between costs and epidemiological effectiveness. From an epidemiological perspective, regular mass testing, highly sensitive contact tracing (with a low threshold for being identified) coupled with long and effective isolation of both cases and contacts is the ideal way to limit the infection. However, each of these comes with an economic and social burden. The balance between these two competing elements (epidemiological vs socio-economic) is a policy decision and will vary during the course of an outbreak (and will vary between different pathogens). In 2023, I led a systematic review into literature on the effectiveness of Test-Trace-Isolate [Exhibit MK3/01 - INQ000564294]. This study sought evidence that TTI (in multiple forms) had been effective at reducing transmission. This is a difficult scientific problem, as during the pandemic the aim had been to minimise infection and severe disease – not performing the type of scientific experiment that would quantify the impact. Out of 26,720 titles and abstracts screened, we only identified 25 studies that quantified the reduction in transmission due to testing, tracing and isolating. Of these studies, we found 5 that relate directly to the UK:

   a. Kendall *et al*. [Exhibit MK3/13 – INQ000564289] focused on the pilot of the contact tracing app launched on the Isle of Wight during May and June 2020, and estimated the reproductive ratio R_t on the Isle of Wight and in 150 other Upper-Tier Local Authorities in England. It was found that on the Isle of Wight, R_t had reduced from 1.3 (the third highest in England) before the app to 0.5 (the twelfth lowest) after the piloting of the app.

   A later analysis of the App data [Exhibit MK3/14 – INQ000575448] has highlighted the power of the data for informing public health measures. Most notably there were distinct peaks of transmission detect by the App: (1) on days when England played in the Euro2020 football tournant (held in June/July 2021), which coincided with a rise in random contact; and (2) during December 2021 – January 2022 when the Omicron BA.1 outbreak occurred when contacts were lower but the new variant was more transmissible.

   b. Wymant *et al*. [Exhibit MK3/15 – INQ000509697] supported Kendall *et al*.'s findings; looking at the proportion of the population that used the app in each of 338 Lower-Tier Local Authorities they found a 1.1% (between October and November 2020) and 2.7% (between November and December 2020) reduction in cases for every percentage increase in app usage.

c. Fetzer *et al.* [Exhibit MK3/16 – INQ000564290] examined data from September 2020, when data handling issues within the public health authority led to delays of 6–14 days in the time taken to perform contact tracing; compared to such long delays, regression analysis suggested that timely tracing led to 63% fewer infections and 63% fewer deaths over this period.

d. Zhang *et al.* [Exhibit MK3/17 – INQ000564291] estimated the effects of an asymptomatic testing pilot using rapid antigen tests on transmission, comparing hospitalizations in Liverpool city middle layer super output areas (MSOA, small geographical areas of around 7200 people) to a synthetic control based on comparative MSOAs without availability of asymptomatic testing in November and December 2020. While the intervention evolved somewhat in its design over time and included effects of increased publicity around COVID-19 associated with the intervention, the study's primary finding was a reduction in hospitalizations of 25% (35% to 11%) in intervention districts compared to synthetic control.

e. Love *et al.* [Exhibit MK3/11 – INQ000564292] conducted a non-inferiority RCT on around 55 000 adults identified by contact tracing in England between 29 April and 28 July 2021. This study compared home-based self-quarantine of contacts for 10 days (policy at the time) versus daily LFD testing for 7 days and no quarantine while the LFD tests were negative. The outcome was the proportion of contacts-of-contacts reporting positive tests to the national testing and contact tracing authority, a proxy for the attack rate among this group of contacts. Individuals from each group that became infected had a similar number of contacts (approx. 2.2 per case), and the percentage of them reporting positive tests was lower in the intervention arm (–1.2%, 95%CI of −2.3% to −0.2%) so the daily contact testing intervention was judged non-inferior to home isolation.

30. The conclusion of these papers is that (i) the COVID App was highly effective at reducing transmission – although these studies were performed before the "pingdemic" which saw the criteria for notification relaxed; (ii) timely TTI could reduce transmission by over 50%; (iii) a single mass asymptomatic testing campaign (e.g. LFT) could reduce transmission by around 25%; (iv) daily LFD testing (followed by isolative if positive) was a viable substitute for quarantining of contacts. All of these remain critical lessons for the next pandemic outbreak.

Reflections

31. There was limited interaction between TTI and the scientists on SPI-M-O. I feel this was a missed opportunity. The modelling and statistical expertise on SPI-M-O could have benefited the TTI system, providing insights into the efficacy of the different TTI elements.

32. For much of the pandemic, a positive LFT had to be confirmed by a positive PCR test – this lowers the overall sensitivity of the testing protocol, and hence leads to more false negatives than using the LFT result alone.

33. LFT were cheap, reliable and gave individuals the power to mitigate their own risks. The discontinuation of free LFTs in early 2022 was likely not cost-effective; that is the cost of LFTs was probably less that the costs of infections they would prevent. Given LFTs could be purchased by members of the public, this is likely to increase health inequalities exacerbating infection in the less well-off sectors of the population.

34. My understanding is that the vast majority of individuals traced through the TTI scheme were household contacts. Given that the advice was for these household members to isolate anyway, the benefit of much of the tracing was marginal.

35. The COVID-19 App was a highly effective way of identifying potential contacts (especially via random encounters where the name and details of the contact would be unknown). However, the App was hampered by privacy concerns. While privacy is obviously hugely important, allowing users to opt-in and voluntarily provide more information could have been extremely important, providing information on location of contact, periods when the App was switched off, and general patterns of mixing. In addition, when mixing increased in July/August 2021, the App identified more contacts leading to the so-called "pingdemic". This is obviously a sign of successful identification of contacts, but rather than use this added control, the sensitivity criterion of the App was reduced so that fewer contacts would be identified.

36. While the data that routinely came to SPI-M-O from the multiple testing sources was hugely useful, much of the contact tracing data (either from TTI or from the App) was not available. Some information, such as the proportion and nature of contacts that later tested positive, could have provided important epidemiological insights.

37. Genetic data – available as a consequence of PCR testing – was under-used throughout the pandemic. This was primarily because there existed other markers that

informed about the abundance of each new variant. In future we will likely need better pipelines between the genomic data and model projections.

38. Looking to the future, there are several directions in which TTI strategies could be vastly improved:

(i) More rapid development of Lateral Flow Devices for home-based testing in the early stages of an outbreak – such devices need to be freely available for the duration of the pandemic, and there should be recommendations for regular mass-testing. (The frequency of mass-testing could be determined as a trade-off between costs and impact, which could vary during an outbreak). Considerable research is required to determine the sensitivity and specificity of tests, and how these quantities vary during the course of infection. Some of this testing needs to be supplemented by PCR testing and genotyping to monitor any evolutionary changes.

(ii) There are numerous changes that could be made to the App to encourage its use and to maximise the public health data that is available. Studies of the App data during the pandemic have already demonstrated its power, but this could be built upon for future outbreaks. App use was generally an altruistic activity, relying on people wanting information about their risk (and the risk they posed to others); ideally higher App use and keeping the App switched on could be incentivised.

(iii) In addition, because of privacy concerns the App only transmitted the ID of contacts (who conformed to the 15-minute duration definition) when the user was identified as a case. More information (provided on a voluntary basis) could improve public health measures. For example: informative on all contacts (including those of less than 15 minutes) could help shape the most appropriate definition of a contact; the location of contacts would help rapidly determine the risk of indoor and outdoor mixing; and data from all App-users (not just cases) would provide a rapid and reliable signal of regional movement patterns at a high resolution.

(iv) Far greater incentives for compliance with isolation recommendations, or at least removal of the barriers for compliance. Additionally, while for COVID-19, it has been demonstrated that daily LFD testing could replace the isolation of contacts (until the individual tests positive), this might not be true for future outbreaks. LFD tests and contact tracing Apps are beneficial as they shift the burden of TTI from centralised organisations with finite capacity to individuals – as such they are far more robust to increases in the scale of an outbreak with can quickly overwhelm more resource limited methods.

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: __19/03/2025____