

Witness Name: Professor Sir Peter Bruce

Statement No.:01

Exhibits: PB1/01

Dated: 21 May 2025

UK COVID-19 INQUIRY

WITNESS STATEMENT OF PROFESSOR SIR PETER BRUCE

I, **Professor Sir Peter Bruce FRS**, former Vice-President and former Physical Secretary of The Royal Society (“the **Society**”), 6-9 Carlton House Terrace, London SW1Y 5AG, will say as follows: -

A. Role, function and responsibilities

1. I am a Fellow and former Vice-President and Physical Secretary [2018-2023] of the Society. In these roles I served on the Council of the Society, which is its governing body.
2. I make this statement in response to the request from the UK Covid-19 Public Inquiry (“the **Inquiry**”), dated 10 April 2025, asking for information from the Society, in relation to the matters under consideration in Module 7 of the Inquiry, concerning Test, Trace and Isolate (“**TTI**”). I am duly authorised to make this statement on behalf of the Society.
3. Save where it is stated otherwise, the contents of this statement are within my own knowledge. This statement has been prepared following consultation with colleagues at the Society, including the following: Julie Maxton, Chief Executive Officer; Professor Mike Cates FRS; Elizabeth Surkovic, Head of Policy, Resilient Futures (2016 -2024); Natasha McCarthy, Head of Policy, Data (2016-2022). I have consulted these colleagues in order to provide as full and accurate an

account as possible on behalf of the Society. This statement is to the best of my knowledge and belief accurate and complete at the time of signature.

4. It is recognised that various statements and comments have been made during the period relevant to Module 7, by individuals or groups of individuals who are Fellows of the Society. However, we have not treated these individual statements as being within the scope of this witness statement. This statement thereby responds to the Inquiry's questions based on what the Society did from an institutional perspective and not what individual Fellows did or said.
5. The Society is a registered charity, learned society and the UK's national academy of science. Founded in the 1660s by King Charles the Second, the Society's mission is to recognise, promote and support excellence in science and to encourage the development and use of science for the benefit of humanity.
6. The Society's work is UK-wide and it engages with individuals and institutions internationally. The Society recognises scientific excellence through its fellowship network and additionally funds and publishes scientific research.
7. As a national academy, the Society represents the UK research community and collaborates with international partners to advocate for science and its benefits. It provides authoritative and independent advice on matters of science that support the public good.
8. The Society provides objective and independent scientific evidence across a broad range of research areas and presents this information in reports and associated publications which are freely available and shared with diverse stakeholders.
9. The Society does not make policy decisions. The Society's views are based on evidence and analysis and serve as a reliable source of the current state of scientific knowledge. As such, the Society's outputs are a useful source of scientific evidence for consideration by policymakers alongside other considerations. Some of the Society's publications offer evidence-based recommendations which policymakers may also consider as part of decision-making.

10. The Society is one of many organisations which engage with the UK Government, providing evidence and analysis relevant to policy decision-making. However, the Society is not party to the Government's decision-making processes and is not aware of the various sources of evidence and judgments that contribute to these. For this reason, the Society cannot determine or demonstrate whether there is any causal link between information provided to the Government through activities undertaken or facilitated by the Society and any policy decisions subsequently taken by Government.

Overview of the Society's involvement with the TTI system between 1 January 2020 and 28 June 2022

11. From the start of the SARS-CoV-2 ("**Covid-19**") pandemic ("the **Pandemic**"), the Society was involved, to varying degrees, in three initiatives which are of relevance to Module 7 of the Inquiry:

- a) **Modelling** i.e., Rapid Assistance in Modelling the Pandemic ("**RAMP**");
- b) **Data Science** i.e., Data Evaluation and Learning for Viral Epidemics ("**DELVE**"); and
- c) **Rapid synthesis** i.e., Science in Emergencies Tasking COVID-19 ("**SET C**").

Further information about each of these three initiatives is set out in the respective sections of this statement below.

12. In summary, RAMP and DELVE were established as a result of Fellows of the Society and individuals within the scientific community coming together with the shared desire to make a positive contribution to dealing with the Pandemic, who then approached the Society for support in rapidly convening experts. SET-C was later initiated by the Society itself, as a formally constituted group of the Society, to draw on the expertise of its Fellows and others to respond to requests for rapid science advice on topics relevant to tackling the Pandemic. These three initiatives were used to enable experts within the Society's network, from multiple disciplines,

to volunteer their knowledge and skills and to contribute to the evolving evidence base on, and the understanding of, Covid-19. These programmes represent efforts to synthesise evidence rapidly and provide analysis to inform policymakers on aspects of the UK's response to the Pandemic.

13. The different subject matter addressed by RAMP, DELVE and SET-C is explained further below, together with details of how the different programmes operated and who was involved.
14. Where reports and published work are referred to in this statement, I have sought to summarise the key findings and conclusions to the extent that they are relevant to Module 7. It is important to recognise that the publications referred to set out the evidence which was available at the time, as it emerged and as was published during the course of the Pandemic. The evidence as summarised from those publications is therefore presented in the 'present tense'. The evidence referred to may now be superseded by more up to date information, and by retrospective evaluations based on the now available evidence.
15. A record of communications between figures within the Society and the UK Government has been submitted in evidence submitted to Module 1 of the Inquiry. This submission can be found here: **INQ000148423**.
16. A full list of the respective steering committees of each of the three groups are publicly available on the web pages for the groups and are submitted as evidence to this module of the inquiry as **Exhibit PB1/01 (INQ000587652; INQ000587653; INQ000587654)**.

International co-operation during the Covid-19 pandemic

17. On 8 April 2020, '*The Critical Need for International co-operation during Covid-19 pandemic: Joint Statement of Academies of Science and Medicine*' was issued [INQ000147970]. This joint statement was signed by 15 academies internationally, including the Society, and set out the critical need for international cooperation during the Pandemic. It emphasised that cooperation and information sharing would be particularly critical in countries and regions where the public health and

health care infrastructure was not adequate. It also stressed the urgency to understand, project, and prepare for the many dimensions of economic and social impact of the disease and on impending humanitarian needs.

18. The statement was led by the Lincei (the Italian national science academy) – on both topic and process, and the Society and other science academies from the G20 countries were invited to comment on/review the text and then sign it, as per the regular annual S20 process. The S20 (Science 20) is the science and technology engagement group of the G20, formed by the national science academies of G20 countries.
19. The Inquiry has asked the Society if the objectives of the statement were met. I am not able to answer this because it requires a broad assessment of how government, academia and the private sector worked together, which I am unable to provide on behalf of the Society.
20. A further joint statement was issued in July 2021, by the S20 Academies *'Pandemic preparedness and the role of science: Joint Statement of S20 Academies* [INQ000147965]. The process of this Joint Statement followed the same process as described in paragraph 18 of this witness statement.
21. The Inquiry has asked for evidence on the Joint Science Academies statement on the need for data readiness published in August 2021. I believe the Inquiry may be referring to the Joint statement published on 31 March 2021 on *'Data for international health emergencies: governance, operations and skills'*. The details of this statement are set out in paragraph 115 of this witness statement.

B. Royal Society Covid-19 DELVE (Data Evaluation and Learning for Viral Epidemics) Steering Group

22. DELVE was a multi-disciplinary group to which the Society provided secretariat support from April 2020¹. DELVE focused on data-driven learning (both in the UK

¹ <https://royalsociety.org/news/2020/04/royal-society-convenes-data-analytics-group-to-tackle-COVID-19/>

and internationally) from the impact of the Pandemic and the different possible approaches to managing it. DELVE contributed data driven analysis to complement the evidence base informing the UK's strategic response. It achieved this through accessing existing research and publications, emerging science, public data sets, together with the knowledge of experts in epidemiology, data science and other disciplines. Efforts were made to secure data that would yield insights into behaviour, although it proved to be difficult to access such data².

23. The functions of DELVE included:

- a) analysing national and international data to determine the effect of different measures and strategies on a range of public health, social and economic outcomes;
- b) using emerging sources of data as new evidence from the Pandemic came to light; and
- c) ensuring that the work of DELVE was coordinated with others and communicated as necessary, both nationally and internationally.

24. The work of DELVE was carried out by three cross-disciplinary groups which were rapidly assembled groups of expert individuals. These groups were formed of Fellows of the Society proactively volunteering to assist in gathering evidence to inform the Pandemic response; members of these core Fellows' networks, who were approached based on expertise; and volunteers in the research community who were within the networks of the core Fellows who initiated the work. There was no formal appointment process to the groups within DELVE which formed as a result of individuals volunteering to take part or being approached by colleagues. The Society helped to convene the groups within DELVE and provided staff (secretariat type) support for their work, but they were not formal Committees of the Society. The three cross-disciplinary groups within DELVE consist of:

² DELVE paper ***Data Readiness: Lessons from an Emergency***, 24 November 2020 available at: <https://rs-delve.github.io/reports/2020/11/24/data-readiness-lessons-from-an-emergency.html#challenges-in-accessing-and-analysing-non-traditional-data-sources-to-inform-covid-19-policy>

- a) the Action team - a team of data scientists and subject-matter experts to carry out data analysis, synthesis of results and rapid review;
- b) the Working Group - a group of subject matter and data experts to work closely with the action team in constructing reports; and
- c) the Steering Committee - a high-level expert group to oversee the work and communicate findings to the Government's Chief Scientific Advisor and his networks in government.

25. The names of the individual members of the three groups within DELVE are available at <https://rs-delve.github.io/people.html#action-team> (a webpage that was last updated on 24 June 2023). To the best of my knowledge and belief, the members listed were the members for the period 2020 to 2022.

Operation of DELVE Action team, Working Group and Steering Committee:

26. The work of DELVE was overseen by the Steering Committee with individuals who lead on particular topics and supported by the work of the DELVE Working Group and DELVE Action Team. The Steering Committee comprised experts from different fields to identify the evidence needs/gaps, to which the DELVE group could most helpfully contribute.

27. The DELVE Working Group identified what research was needed to fill these evidence gaps and designed the specific questions to be asked.

28. The DELVE Action Team then carried out the analysis to answer questions formulated by the Working Group.

29. The DELVE initiative produced a number of significant outputs, further details of which are detailed at paragraphs 30 to 57 below.

Global Covid-19 dataset

30. DELVE accessed existing research and publications, emerging science, and public data sets which it consolidated in the DELVE Global COVID-19 Dataset. The DELVE Global COVID-19 data was an openly-licensed (meaning freely available)

dataset which consolidated country-level information from multiple sources. The dataset contained cases, deaths, tests, non-pharmaceutical interventions, excess mortality, mobility statistics, weather patterns and other metadata for up to 170 countries. The testing data input was retrieved from Our World in Data³, a data repository project of Global Change Data Lab, a charity based in the UK.

31. The sources of the Global Covid-19 dataset are detailed at: https://rs-delve.github.io/data_software/global-dataset.html and include:

- data concerning policy interventions which was retrieved from Oxford Blavatnik School of Government's Coronavirus Government Response Tracker⁴;
- data regarding masks which was extracted from the ACAPS Government Measures Dataset⁵, Masks4All⁶ as well as publicly available news articles;
- COVID-19 cases and deaths figures from the European Centre for Disease Prevention and Control (ECDC)⁷;
- weekly mortality data from the Human Mortality Database⁸ and EuroStat⁹. This data was supplemented with pre-computed excess mortality data from The Economist;
- Six fields of data from the Google Community Mobility Reports¹⁰; and
- country-level population-weighted daily averages of raw measurements, which were provided by the UK Met Office.

Test, trace and isolate explorer simulations software

³ <https://ourworldindata.org/coronavirus-testing>

⁴ <https://www.bsg.ox.ac.uk/research/covid-19-government-response-tracker>

⁵ <https://data.humdata.org/dataset/acaps-covid19-government-measures-dataset>

⁶ <https://masks4all.co/>

⁷ <https://www.ecdc.europa.eu/en/covid-19>

⁸ <https://www.mortality.org/>

⁹ <https://ec.europa.eu/eurostat>

¹⁰ <https://www.google.com/covid19/mobility/>

32. As part of its activities members of DELVE built the **tti-explorer** – a library for simulating infection spread, which was created to explore the impact of various TTI strategies and social distancing measures on the spread of COVID-19 in the UK. The model within tti-explorer builds upon the model of Kucharski et al. (2020) and uses the BBC Pandemic dataset (Klepac et al. (2018)) It used an individual-level transmission and contact simulation model to explore the effectiveness and resource requirements of various test-trace-isolate (TTI) strategies for reducing the spread of SARS-CoV-2 in the UK, in the context of different scenarios with varying levels of stringency of non-pharmaceutical interventions (“**NPIs**”) over the summer period in 2020. NPIs, including TTI measures, are essentially any public health intervention that is not a drug or a vaccine (See: **INQ000250983** for more detailed definitions).

DELVE Report: Test, Trace, Isolate [INQ0001485053]

33. The report paper by the DELVE Initiative (2020) **Test, Trace, Isolate, DELVE Report No. 2** [INQ0001485053] (the “**DELVE TTI Report**”) was published to SAGE on 19 May 2020 and published on the DELVE GitHub (a web-based platform for collaborative computer code development). The media were given a copy under embargo on 26 May 2020, prior to a briefing on 27 May 2020. This was the most detailed output on **TTI**, generated through the Society’s activities in response to the Pandemic.

34. In response to the Inquiry’s questions, I provide the following further information taken from the DELVE TTI Report. The material below is a summary of that Report. As indicated above, the summary uses the present tense: it should be borne in mind that the summary sets out the Report’s findings, rather than the state of knowledge at the date of this statement.

a) The role of TTI in the Covid-19 response

35. The DELVE TTI Report concludes that TTI can contribute to controlling COVID-19 in the UK, but only when effectively implemented at scale as part of a wider

package of public health interventions, including physical and social distancing, control of infection procedures, outbreak investigation and control.

b) Factors that influence optimal performance of a TTI system

36. The DELVE TTI Report discusses the impact of TTI on the Effective Reproduction 'R' Number, that is, the average number of secondary infections produced by a single infected person. This is a common metric for pandemics: if the value of R is greater than 1 then the pandemic is growing. The DELVE TTI Report concludes that TTI is most effective in breaking chains of transmission, and reducing the Effective Reproduction 'R' Number when there is:

- i. maximum speed, i.e., quick turn-around of both index case testing and contact tracing (and testing);
- ii. compliance, i.e., a high proportion of people in each chain are willing and able to follow guidance; and
- iii. coverage, i.e., identification of most chains through integration of consistent case data and real-time, high-precision population surveillance.

37. The speed at which TTI can move along transmission chains is determined by the time between an index case reporting symptoms and their test results being available, and the time required to trace their contacts. App-based contact tracing can reduce the time needed for manual tracing. However, the effectiveness of App-based tracing is determined by overall smart phone usage and the willingness of people to install and use the app.

c) How to increase the speed of testing and tracing

38. The DELVE TTI Report explains that the following processes can be improved to increase the speed of testing and tracing:

- i. time from symptom onset to patient self-reporting;
- ii. time from symptom reporting to test taking place;
- iii. time from testing to lab;
- iv. time to get test results in the lab;

- v. time to lab confirmation of results;
- vi. time to return to result to testee; and
- vii. time from positive result to contract tracing.

39. Within the DELVE TTI Report are suggested practical actions for decision-makers in respect of these identified processes where improvements could be achieved.

d) How to maximise population participation and compliance with TTI guidance

40. The DELVE TTI Report identifies that the ability to maximise population participation and compliance will be determined by psychological, economic, and technological factors. Further, it explains that decision-makers will need to consider negative perceptions from engaging in TTI (e.g., quarantine, or tracking via an app) and incentives for participating (e.g., clear messaging and guidance, local networks where trust is highest).

e) Increasing epidemic coverage of TTI

41. The DELVE TTI Report identifies that pre-symptomatic and asymptomatic transmission means several transmission chains will not be picked up even by a highly efficient TTI system. Identifying the most likely individuals to be infected can increase TTI efficiency. Other factors to consider include standardised data collection across TTI and systems such as symptom tracking apps; the balance between getting to key information through data collection and the loss of data quality and participation if too much is asked; capturing how index case are linked to known transmission chains; and key sociodemographic information such as age and household composition.

f) Managing TTI capacity constraints

42. As explained within the DELVE TTI Report, as tracing and testing capacity is reached, the speed of both tracing and testing is likely to reduce. This in turn reduces the benefits of the TTI system. The Report further notes that since COVID-19 lacks specific symptoms and many cases are asymptomatic or pre-symptomatic, symptom-based tracking may be very resource intensive. The Report suggests that a middle ground between symptom-based (testing all

members of the population with relevant symptoms) and test-positive approaches (where authorities trace only the contacts of index cases who have tested positive for COVID-19, regardless of symptoms) could use additional information about index cases (like transmission risk factors such as occupation) to decide whether to start contact tracing immediately. As COVID-19 symptoms overlap with those of other respiratory infections, and pre-symptomatic and asymptomatic infections are common, a symptom-based screening only could miss many chains of transmission. However, there are trade-offs associated with the economic impacts of policies to quarantine contacts of false-positive cases.

g) Effective TTI within a broader epidemic response

43. It is noted within the DELVE TTI Report that TTI may offer a policy tool that allows greater relaxation of other NPIs. Therefore, the costs associated with TTI and its implementation may be smaller than the resulting increase in economic productivity from the relaxation in other NPIs (such as social distancing measures, school closures and stay-at-home orders) which it may allow for.
44. The DELVE TTI Report concludes that contact tracing works best when there is a clear picture of contact chains through good surveillance and reporting, when TTI can handle most known contact chains, and when speed, efficiency, and compliance are high.

h) Next steps proposed by the DELVE TTI Report

45. The next steps set out in the DELVE TTI Report were not a policy prescription but suggested topics for further research and evaluation of a TTI system as it is rolled out.

Technical appendices to the DELVE TTI Report

46. The DELVE TTI Report contains four separate Technical Appendices, each prepared by individual members of DELVE as inputs into the report. These were:
- **TTI-TD1:** The Potential Role of Firms in Test, Trace, Isolate Prepared for the DELVE Initiative by Tim Besley.

- **TTI-TD2:** Surveillance for Test, Trace, Isolate Prepared for the DELVE Initiative by Sylvia Richardson, Peter Diggle.
- **TTI-TD3:** Effectiveness and Resource Requirements of Test Trace Isolate Strategies Prepared for the DELVE Initiative by Bobby He, Sheheryar Zaidi, Bryn Elesedy, Michael Hutchinson, Andrei Paleyes, Guy Harling, Anne Johnson, Yee Whye.
- **TTI-TD4:** A Review of International Approaches to Test, Trace, Isolate Prepared for the DELVE Initiative by Genevie Fernandes, Devi Sridhar, Diva Fanian, Mariana Soto Pacheco.

47. In response to the Inquiry's questions, I provide the following further information taken from the DELVE TTI Report Technical Appendices.

a) *TTI-TD1: The potential role of firms in TTI*

48. **TTI-TD1** sets out how an effective TTI system has to align with the incentives of firms, individuals and households. The logistics of the TTI system must be tied to the economic incentives. TTI-TD1 explains a risk assessment will be needed of each type of business. TTI-TD1 also sets out how the employer could be responsible for compliance by workers, with incentives such as tying positive results to furlough grants. It notes that resource will have to be prioritised, depending on the impact on the spread of infection, and economic value created. TTI-TD1 highlights that evidence based, systematic criteria can make the system more effective and that a bespoke programme will be needed to ensure economic incentives align for the self-employed and very small businesses. TTI-TD1 also identifies that alternative testing arrangements will be needed for those not included by an employee-based system. Harnessing existing social networks can aid information diffusion and trust and even small individual incentives for testing can also be important.

b) *TTI-TD2: Surveillance for Test, Trace, Isolate*

49. **TTI-TD2** determines that any TTI strategy that can only involve a fraction of the at-risk population, and that it must begin with a surveillance study to establish how incidence, and therefore potential disease transmission, varies between sub-

populations and between individuals within sub-populations. TTI-TD2 describes how a surveillance study might be designed and analysed, taking account of varying patterns of exposure and risk across the population, and potentially drawing information from multiple data-sources.

50. TTI-TD2 explains that implementation of a surveillance system for TTI requires: designing and regularly carrying out a nationwide, structured sampling of individuals; testing the selected individuals; and, analysing the data in real time to create detailed maps showing the likelihood of infection in different groups, which would guide follow-up testing, tracing, and future sampling to improve effectiveness.
51. TTI-TD2 concludes that comparing multiple sources of non-randomised self-reported symptom data on probable/possible case incidence would also be desirable. The reason is that this would enable gold-standard and self-reported sources of data to be analysed together to make best possible use of all relevant data-sources, thus creating a real-time surveillance system that can be exploited to increase the efficiency of the TTI process in response to data.

c) ***TTI-TD3: Effectiveness and Resource Requirements of Test Trace Isolate Strategies***

52. In respect of the question of effectiveness of TTI strategies, **TTI-TD3** finds that TTI has moderate effect on 'R' (i.e., the reproduction number) across the range of scenarios considered and that implementation along with other NPIs will be necessary to control the COVID-19 epidemic in the UK.
53. TTI-TD3 concludes -that implementation of test-based TTI strategies, on top of current UK government recommendations to self-isolate and quarantine households on COVID-19 symptoms, reduce R between 10-15%, while symptom-based TTI reduces R between 15-20%. To explain the distinction being drawn - symptom based TTI would be a system where those exhibiting symptoms consistent with SARS-CoV-2 infection are treated as positive cases, while test-based would rely on a positive test result before the trace and isolate actions are carried out.

54. TTI-TD3 states that the main factors determining the effectiveness of TTI strategies are the time required for testing and contact tracing, and coverage and compliance, including maximising app uptake.

55. In respect of the question of resource requirements of TTI systems, TTI-TD3 identifies this includes three areas for consideration, which are:

- i. **Manual contact tracing:** If uptake of a contact-tracing app is insufficiently high, manual contact tracing is necessary and is the main resource requirement of TTI strategies.
- ii. **Low specificity of symptom-based TTI:** A typical baseline of COVID-like symptoms among the general COVID-negative population means that symptom-based TTI has low specificity (i.e. there are many false positives) and requires significantly higher numbers of manual contact tracings and person-days quarantined.
- iii. **Impact of additional testing in test-based TTI:** In a test-based TTI strategy, additional testing of contacts has a marginal impact on R when modelled in the paper (due to identification of asymptomatic COVID-positive contacts) but can significantly reduce the number of person-days of contacts quarantined. However, testing too early in the incubation period, and likely variability in the length of incubation periods might lead to missing infected contacts, necessitating repeat testing.

d) *TTI-TD4: A Review of International Approaches to Test, Trace, Isolate*

56. TTI-TD4 examines six countries: Germany, South Korea, Taiwan, Singapore, New Zealand and Iceland, and makes the following findings:

- i. Each of these countries initiated TTI as soon as the first COVID-19 cases were reported and have been consistently implementing it, with the three components of testing, contact tracing and isolation being implemented in tandem.
- ii. Each country has an expanded testing criteria in place. All countries use polymerase chain reaction (PCR) tests for symptomatic cases, high risk

individuals, and health workers. South Korea, New Zealand and Iceland have gone a step further by introducing mass testing for individuals at the community level regardless of symptoms. Germany and Iceland have also started conducting antibody testing. One area that needs to be further investigated is the consideration of repeat testing, especially for health workers as they have repeated risk of exposure.

- iii. Random community testing and antibody tests are being used to inform countries' future steps such as plans to exit from lockdowns.
- iv. All countries offer testing across traditional healthcare settings (clinics and hospitals) as well as novel locations (drive through centres, walk-through centres, mobile sites outside supermarkets).
- v. The countries have managed contact tracing through a combination of physical teams (consisting of multisectoral public staff), big data analytics and mobile-based applications. Four countries (South Korea, Singapore, New Zealand and Iceland) initiate contact tracing after a confirmed positive test results; whereas in Taiwan, this process begins even within a suspected case. South Korea, for instance, leverages technology to aid its contact tracing efforts. The government has a computer system that automatically integrates GPS data, credit card information and CCTV footage to create a moving history (transmission route) for the confirmed case in a span of 10 minutes. This data is verified by patient interviews, contacts are then identified and sent automated text messages on the same day. The transmission route of the confirmed patients (anonymised) is also uploaded on government websites, so that citizens can avoid these places to reduce the risk of transmission.
- vi. The total time for TTI (i.e., from testing, tracing and tracking contacts to instructing contacts to isolate) is around 2 to 3 days in South Korea, Singapore, Taiwan, and New Zealand. Test results in these four countries are available in 4 to 5 hours.

- vii. While digital applications can aid contact tracing teams, they can also raise privacy concerns, for example relating to the risk of personal data being repurposed for causes other than outbreak control, and concerns about location and duration of storage of personal data. Iceland has tried to address these privacy concerns before launching their contact tracing app, by gaining certification by an independent reviewer, making it voluntary for users to download the app and agree to share GPS information, and storing anonymised data on the user's device.
- viii. In all the six countries, close contacts, once identified, must self-isolate for 14 days and seek testing on displaying any symptoms. Approaches to ensure isolation and quarantine measures vary across countries. While Germany, New Zealand and Iceland have recommended isolation for certain individuals, South Korea, Taiwan and Singapore have made quarantine mandatory and enforce it through the use of smartphone apps and fines.
- ix. Countries made use of existing national capabilities in implementing this strategy. Germany and South Korea used their robust biotechnology industry and laboratory networks and Iceland employed a public-private partnership to ramp up testing. Singapore and Taiwan used big data and multisectoral response teams, who integrate the response across different fields such as epidemiology, logistics and data science.
- x. A range of challenges implementing TTI have already been reported, including staff fatigue (especially frontline and laboratory staff), logistical hurdles of sourcing testing materials, privacy concerns over smart phone applications, and public adherence to social distancing and isolation guidance.

57. The minutes of SAGE meeting 37 stated that "SAGE noted the Royal Society DELVE report on Test, Trace, and Isolate (TTI). The key findings reinforce existing SAGE advice". They also state Anne Johnson and Venki Ramakrishnan

attended, with their affiliation listed as Royal Society. We are not able to provide any further information than what was recorded in the minutes.

58. I am unable to answer how HMG responded as these are not decisions or actions of the Society. It is suggested that these questions are a matter for members of SAGE and those responsible for taking any actions in response within HMG.

C. RAMP Group (Rapid Assistance in Modelling the Pandemic)

59. The RAMP initiative was established to support the Pandemic 'modelling community' as a facilitation structure for individuals and groups. As explained in paragraphs 11-12 above, RAMP was not initiated by the Society. It was an initiative involving hundreds of volunteer scientists, coordinated by a small central Steering Group, to which the Society provided secretariat support.

60. The work of the RAMP modelling initiative is set out in: <https://royalsocietypublishing.org/doi/full/10.1098/rsta.2021.0316>.

61. The key elements of RAMP activity were:

- i. offering volunteers to join the SAGE modelling sub-group ("**SPI-M**");
- ii. supporting new modelling groups on areas of policy and operational significance;
- iii. providing a rapid review group to provide 24-48 hour reviews of new modelling in order to provide advice on the methodological rigour and policy relevance of the findings; and
- iv. acting as a forum for sharing and discussion of emerging modelling work.

62. RAMP was able to support SPI-M, through provision of a volunteer network providing rapid peer reviews of modelling papers, and through the sourcing of modellers, to bolster SPI-M's working capacity.

63. There were a few dozen volunteers with software and coding skills in demand from SPI-M, who were seconded directly to SPI-M teams.
64. A few hundred other volunteers were coordinated by the RAMP Steering Group into project teams addressing interdisciplinary questions such as environmental transmission, in-host dynamics, novel epidemic modelling strategies. More volunteers joined an online forum system to help review the emergent literature, identify significant work, and to essentially 'pass it upward' to the attention of SPI-M.
65. As part of the work of RAMP, a large number of online workshops were also held.
66. RAMP's ability to provide the government critique of the methodology and findings of new modelling within 48 hours was achieved through the rapid review group inviting those who volunteered their modelling skills to rapidly review outputs.
67. The RAMP rapid review group fielded requests from SPI-M (and sometimes direct from Government) to expertly review reports of potential interest and filter those worthy of further SPI-M or Government attention. It did the same for papers identified by an online volunteer forum as potentially policy-significant, passing through the latter to SPI-M. The RAMP rapid review group function was like that of refereeing a paper. It was able to achieve this work within 24-48 hours by having a large group of experts who were willing at very short notice (and to move other commitments as needed) to spend a day or so scrutinizing reports as requested.
68. After an initial six-month intensive phase, the majority of volunteers returned to their pre-Covid research activities. However, a significant minority remained involved in these activities via an Engineering and Physical Sciences Research Council funded 'RAMP Continuity' project.
69. Non-exhaustive examples of work where RAMP had a role in facilitating can be found here: https://epcced.github.io/ramp/previous-updates.html#what_and_why.

D. SET-C (Science in Emergencies Tasking Covid-19)

70. The Society established SET-C as means of convening the expertise of Fellows and others in its network to provide scientific advice on topics relevant to the Pandemic. SET-C consisted of Fellows and scientists, the names of members are in the list of those involved produced at INQ000587654. The SET-C membership comprised scientists with expertise in virology, immunology, epidemiology and other disciplines. Society staff provided the secretariat function and observers from the Government Office for Science (“GO-S”) attended on occasion.
71. The work of SET-C was a combination of responding to forthcoming SAGE needs as well as providing evidence on issues where SET-C members believed there was a need for an evaluation of emerging science in order to inform HMG. The outputs from SET-C were peer reviewed and approved by the Society before dissemination, and were turned around promptly, usually within a two-week period, which in terms of scientific output was rapid.
72. The work of SET-C in respect of the use of face masks, on the issue of long covid and the significance of vitamin-D are examples of issues that SET-C identified as being matters that HMG needed to know about and were proactively provided to SAGE.
73. The outputs and papers from SET-C were made available on the Society’s website and were communicated to SAGE. As set out in paragraph 10, the Society was not party to internal decision-making process of Government and so cannot comment on whether these publications were regarded as timely, or the impact of this expertise on Government decision making.
74. The Inquiry has specifically asked about the August 2020 publication from SET-C [INQ000147916] which dealt with the Reproduction number of the Covid-19 epidemic. I set out below some points in relation to that paper by way of the Society’s response.

Reproduction number (R) and growth rate (r) of the COVID-19 epidemic in the UK: methods of estimation, data sources, causes of heterogeneity, and use as a guide in

policy formulation August 2020 publication [INQ000147916] (the “SET-C R number Paper”)

75. The SET-C R number Paper examines how estimates of the reproduction number (R) and the epidemic growth rate (r) are made, what data are used in their estimation, the models on which the estimation methods are based, what other data sources and epidemiological parameters could be employed to assess the effectiveness of social distancing measures ('lockdown') and to evaluate the impact of the relaxation of these measures.
76. Specifically, on TTI, the SET-C R number Paper describes contact tracing as an important technique in community-based infection control and in epidemiological study for many reasons. It identifies how contact tracing can generate information on key epidemiological parameters and their distribution properties. It concludes that contact tracing is also the key measure to find and isolate contacts with an infectious person to try and limit onward spread and hence the generation of secondary cases.
77. The SET-C R number Paper highlights that in the international context, tracing has been employed with success in a number of countries/regions, including South Korea, Taiwan, Singapore, China, Japan and Hong Kong and that this has given rise to some of the best estimates of key epidemiological parameters and their distributions, such as the incubation period and R . More importantly, the SET-C R number Paper identifies that, in some of these countries the effective implementation of contact tracing has played the key role in mitigation measures to stop spread.
78. The SET-C R number Paper notes progress in the UK on contact tracing and the development of associated technologies such as individual proximity tracking by mobile phone apps has been very disappointing to date. It further notes that the current stage of decline in the epidemic in the UK due to lockdown measures has been encouraging, but as the measures in place are slowly released over the months of June, July and August, contact tracing becomes of high importance to rapidly eliminating small outbreaks before they expand.

79. The SET-C R number Paper notes that the Department of Health stated on 18 June 2020, that the next phase of the development of effective contact tracing will bring together the work done so far on the NHS COVID-19 app and the new Google/Apple framework. It further identifies that following field testing and a trial on the Isle of Wight, challenges have been identified with both the NHS app and the Google/Apple app framework.
80. Within the SET-C R number Paper it explains that the NHS Test and Trace system is designed as a crude form of contact tracing to facilitate stopping the spread of coronavirus. The NHS argues that tens of thousands more people who may have otherwise unwittingly spread the virus are now remaining safely at home because of this system. However, the SET-C August Paper concludes that the evidence on its effectiveness is unclear at present.
81. The SET-C R number Paper states that what is urgently required at present is a much greater focus on using our experience in, for example contact tracing for sexually transmitted infections, to put in place as soon as possible a system to follow up all cases and contacts of diagnosed COVID-19 infection. Part of such an effort is greatly expanding the countries capability to offer tests to detect active COVID-19 infection to all who ask for them and all contacts of a known infected individuals. The large percentage of asymptomatic infections highlights the need to contact trace and test rapidly if a high proportion of onward chains of transmission are to be eliminated. This issue must be effectively managed by government before a resurgence of COVID-19 cases arises as lockdown is relaxed and autumn approaches.
82. The SET-C R number Paper references a recent report released by SAGE on Case Identification, Contact Tracing and Case Isolation (“CCI”) (“**the SAGE CCI Paper**”). In the SAGE CCI Paper, SAGE concludes that the existing capacity of Public Health England (“**PHE**”) is insufficient to carry out effective CCI. They recommend a tenfold increase in capacity. The SET-C R number Paper builds on this by stating that even a tenfold increase might be inadequate during a rapidly growing phase of the epidemic. The SAGE paper suggests that CCI efforts should be ceased if the number of tracing events required exceeds 8,000 per day, using this as a rough

threshold. However, the SET-C R number Paper cautions that this recommendation could have unintended consequences - specifically, it might discourage investment in building the UK's capacity to carry out TTI effectively. The SET-C R number Paper emphasises the urgent need to convince the government to allocate adequate resources to CCI. Including that this is especially important during the current low phase of case numbers, in order to prepare for a potential surge in cases in the autumn (or earlier). Finally, the SET-C R number Paper notes that this need will persist for some time, as mass vaccine manufacturing and distribution is unlikely to be achieved before mid to late next year, even under optimistic scenarios.

83. The Inquiry has asked the Society what response did HMG take in respect of SET-C R number Paper and were steps taken after August 2020 to put in place an effective Test and Trace system for the UK? I am unable to answer these questions as these are not decisions or actions of the Society. It is suggested that these questions are a matter for those responsible for taking any actions in response within HMG.

E. System readiness

84. The Society has not conducted research with a view to address the efficacy and usefulness of NHS T&T and does not have a view on this matter. As stated in paragraph 10, the Society is not party to the Government's decision-making processes. It has not conducted research or formed an institutional view on the broad topic of system readiness.

E. Co-working

85. Details of the manner in which the Society worked and collaborated with government departments, agencies, advisory bodies and other relevant stakeholders relating to TTI are set out elsewhere within this statement.

G. NHS Test & Trace

86. The Society had no direct involvement in the development of NHST&T. The Society's involvement was limited to its inputs to SAGE.
87. The Society has not conducted research with a view to address the efficacy and usefulness of NHST&T and does not have an organisational view on this matter.

H. Policies and strategies for TTI

88. I set out below a summary chronology of the work the Society undertook in relation to the development of policies and strategies for TTI in England, Scotland, Wales and Northern Ireland between 1 January 2020 and 28 June 2022:

- 8 April 2020, *'The Critical Need for International co-operation during Covid-19 pandemic: Joint Statement of Academies of Science and Medicine'* was issued. [INQ000147970].
- 19 May 2020, *DELVE delivers TTI report to SAGE*
- 27 May 2020, *DELVE publishes TTI report and hosts media briefing with the Science Media Centre*
- 2 August 2020, *SET -C publishes R number paper*
- 18 August 2020, The Society provided a submission to the Commons Science & Technology Select Committee inquiry into UK Science, Research and Technology Capability and Influence in Global Disease Outbreaks
- 26 August 2020, *SET-C publishes 'The SARS-CoV-2 genome: variation, implication and application'*

- 14 December 2020, SET- C publishes SARS-CoV-2: Where do people acquire infection and ‘who infects whom’?
- 3 November 2020, The Royal Society submission to the Public Administration and Constitutional Affairs Committee inquiry into Data transparency and accountability: Covid 19
- 31 March 2021, S7 publishes Data for international health emergencies: governance, operations and skills – Joint statement
- 8 July 2021, SET-C hosts online workshop on exploring COVID-19 and its impact on minority ethnic groups in the UK.¹¹
- July 2021 (Royal Society Press Release 6th August 2021 Joint Statement of S20 Academies Pandemic preparedness and the role of science
- 1 September 2021 Establishment of Global Pandemic Data Alliance

Devolved nations

89. The Society has not conducted research with a view to address the consistency of approaches of TTI policy and strategy across the nations of the UK and does not have a view on this matter.

I. Policy context

Testing technologies and strategies

90. The Society was asked to provide detailed input on several thematic areas related to testing technologies and strategies. The reports and scientific advice set out in the documentation referenced within this witness statement address these topics. For ease of reference, I highlight the parts of this statement which deal with the

¹¹ <https://royalsociety.org/-/media/policy/Publications/2022/covid-19-and-minority-ethnic-groups-workshop-report-royal-society-and-British-Academy.pdf?la=en-GB&hash=2BE0BD6F2AE0BF3EE761DB23ABBA4937>

following specific areas, or identify where I am unable to provide further information on behalf of the Society:

- a. PCR tests and Lateral Flow tests – paragraphs 56, 103-105;
- b. The development of antibody and/or genomic testing – paragraphs 56, 101-105, 107, 109-110;
- c. Other forms of testing which may have been relevant including wastewater testing – I have not identified any Society reports that provided scientific advice on wastewater testing, within the scope of Module 7;
- d. How testing could be used to support detection of new variants – paragraph 105;
- e. Other forms of testing identified but not pursued, and the reasons for this – no other forms of testing were identified by the advice published by the Society;
- f. Use of symptom trackers, such as the Zoe app – paragraphs 54-56, 79;
- g. Asymptomatic transmission of Covid-19 and the development of testing strategies to address asymptomatic infection – paragraphs 41, 42, 55(iii), 81, 125-126.

Centralisation

91. The Society did not have any involvement in relation to the development of TTI infrastructure and TTI technologies other than the scientific input as set out elsewhere within this statement.
92. With the exception of the scientific advice published by DELVE, and SET-C as set out in this statement, the Society had no further formal input into the development of TTI and related government decisions on the operation of TTI infrastructure. I am unable therefore to provide a collective view on behalf of the Society as to the extent to which the centralised approach initially adopted in relation to testing and tracing meant that local sources were not fully utilised.

Testing capacity

93. With the exception of the scientific advice published by DELVE, and SET-C as set out in this statement, I am not aware of any formal input the Society had on testing capacity, at an institutional level. I am unable therefore, to provide any further collective view on behalf of the Society in respect of the Inquiry's questions regarding testing capacity.

J. Tracing

94. Details of the Society's involvement and advice provided in relation to the Inquiry's questions regarding tracing are set out elsewhere within this statement. I am unable to provide any further collective view on behalf of the Society in respect of the Inquiry's questions regarding tracing.

Digital

95. Details of the Society's involvement and advice provided in relation to the Inquiry's questions regarding digital tracing systems, are set out elsewhere within this statement.

96. With the exception of the scientific inputs referred to elsewhere within this statement, I am unable to provide any further collective opinion of the Society as to the efficacy and impact of Apps and digital tracing systems.

K. Isolation

97. Details of the Society's involvement and the advice it provided regarding the TTI approach to isolation are dealt with elsewhere within this statement and I do not have any further collective opinion of the Society in response to the Inquiry's questions on this topic.

L. Data and modelling

98. Details of the Society's involvement and role in respect of data and modelling are dealt with elsewhere within this statement and I do not have any further collective opinion of the Society in response to the Inquiry's questions on this topic.

M. Royal Society's response to the Covid-19 pandemic: research and publications

99. In responding to the Inquiry's questions, the Society has taken 'publication' to mean 'placed in the public domain' and not limited to publication in scientific, peer reviewed journals.

100. In addition to those papers and publication which have been dealt with in other sections of this witness statement, I provide the below summaries of other published work that the Society produced which is relevant to Module 7.

*SET-C Rapid Review: **The SARS-CoV-2 genome: variation, implication and application** – 26 August 2020 (the "**SET-C Genome Paper**")*

101. This rapid review describes the SARS-CoV-2 genome, its relationship to other coronaviruses, the variation that has occurred since SARS-CoV-2 emerged in Wuhan in late 2019, the implications of these changes and how knowledge of these changes may be utilised.

102. Although providing valuable automation, the introduction into testing centres of integrated diagnostic platforms has seen the success rate of sequencing drop below 50%. Whole genome sequencing is a valuable additional control measure; and test, track and trace should become test, sequence, track and trace.

103. Currently, the low level of changes in the SARS-CoV-2 genome [PCR test] makes false negative results improbable. In addition, the availability of new SARS-CoV-2 genome sequences as they are deposited openly in a global database of COVID-19 sequences (GISAID), enables the commercial manufacturers of test kits

to monitor whether the primers chosen for current tests are likely to remain sensitive and specific, or require updating

104. Although tests using monoclonal antibodies are less sensitive than PCR-based tests, they have advantages of simplicity and speed and do not require an equipped laboratory setting. As such, these point-of-care tests have utility in field conditions or in developing nations where access to equipped laboratories is more limited.

105. A part of the virus recognised by an antibody might be changed by mutation, such that lateral flow tests that use antibodies may not detect the virus. However, SARS-CoV-2 does not mutate as much as some other viruses. Tests can also be designed to recognise parts of the virus that tend to change less, and can use multiple antibodies to reduce the risk of false negatives.

SET-C Rapid Review: SARS-CoV-2: Where do people acquire infection and ‘who infects whom’? SET-C, 14th December 2020 (the “SET-C Infection Paper”)

106. This rapid review of the science of infection and COVID-19 from the Society was provided to assist SAGE in relation to COVID-19. This paper was published as a pre-print and had been subject to formal peer-review. All 18 pages of this paper discuss the performance of the TTI system, and insights that had been collected up to November 2020. Below are key excerpts from the executive summary

107. Data sources for gaining a better understanding of where people acquire SARS-CoV-2 infection are contact tracing, household studies and whole genome sequencing (WGS) of the virus, to ascertain who infects whom. Data sources and publications on these topics are limited at present in the UK.

108. The TTI system as a tool to control spread, and as a source of epidemiological information, has limitations when viral spread is extensive given the enormous workload involved in tracing contacts. It is best employed to control transmission during phases when rates of infection are low, as well illustrated in many East Asian countries.

109. Too little attention has been directed to detail local, contact tracing, household and whole genome sequencing studies within UK settings. Such studies should be encouraged as a matter of urgency. Local contact tracing studies with clearly defined aims are needed, working with the Research Councils, in partnership with local public health authorities. Local knowledge is important, given great heterogeneity in where people acquire infection by region, social grouping, income level and ethnicity.
110. There is a lack of good data from European countries on contact tracing, household studies and whole genome sequencing to ascertain who infects whom. Open access via PHE to TTI data for detailed analysis, and smaller, focused research studies in defined populations and settings are needed.
111. I do not have any further details of the Society's research or publications in response to the Inquiry's questions on this topic.

N. Borders

112. The Society did not have any role in respect of the development of border policy and quarantine in relation to TTI.

O. Public messaging

113. The extent to which the Society itself engaged in public messaging / communications regarding TTI is summarised below. The Society was not involved in providing input into how HMG or other bodies communicated information to the public. Beyond the details provided, I am unable to provide a

collective view on behalf of the Society of the efficacy or otherwise of the public messaging / communications regarding TTI.

Media briefing on the DELVE TTI Report, May 2020

114. Following the publication of DELVE TTI Report, the Society worked with the Science Media Centre to brief journalists on its findings. The speakers for this were Professor Anne Johnson, Professor of Infectious Disease Epidemiology at University College London, Vice President of the Academy of Medical Sciences and Member of the DELVE Steering Committee; Professor Yee Whye Teh, Professor at the Department of Statistics of the University of Oxford and member of the DELVE Working Group; and Dr Guy Harling, Sir Henry Dale Senior Research Fellow, University College London.
115. The Society had no other engagement with public information campaigns surrounding test, trace and isolate other than the scientific reports published by RAMP, DELVE and SET-C.

Data for international health emergencies: governance, operations and skills – Joint statement – 31 March 2021¹²

116. The work of the DELVE grouping was limited by access to data, which led to the Science Academies of the G7 to set out their view on the need for the G7 countries to realise a better level of data readiness for future health emergencies.
117. In the statement issued on the 31 March 2021, four recommendations were issued for the G7 nations, setting out how working together can help to develop the principles, systems and skills to safely and rapidly share data in health emergencies. These recommendations concerned governance, operations and

¹² <https://royalsociety.org/-/media/about-us/international/g-science-statements/G7-data-for-international-health-emergencies-31-03-2021.pdf>

infrastructure, skills, and establishing a commission to agree on the mechanisms by which to fulfil them.

Establishment of Global Pandemic Data Alliance (“GDPA”)

118. Formed in 2021, the GDPA included the Society, data.org, I-DAIR, and The Trinity Challenge.

119. The GPDA was intended to address data issues for access around pandemics. In 2023, following an unsuccessful bid for funding from the Department of Business, Energy and Industrial Strategy, to enable it to continue its work, GPDA then merged with the Pandemic Data Preparedness Group at the World Health Organisation (“WHO”), which now provides the WHO Hub for Pandemic and Epidemic Intelligence¹³. The GPDA group has since been dissolved.

Invitation to GPDA to drive implementation of G7 Recommendations

120. Following the joint statement, in a press release on 1 September 2021¹⁴, the UK invited the GPDA to drive the implementation of the S7 Recommendations to improve safe data access and use for health emergencies. At that time, the GDPA had started work on a two-year implementation roadmap to meet the challenges set out by the S7 to ensure the availability and accessibility of data as a source for critical insights in public health emergencies¹⁵.

P. Inequalities

121. Details of some of the Society’s work to consider whether there were groups disproportionately impacted by Covid-19 are contained within the published summary note of an online workshop held on 8 July 2021, exploring COVID-19

¹³ <https://pandemichub.who.int/>

¹⁴ <https://royalsociety.org/-/media/news/2021/global-pandemic-data-alliance-press-release.pdf>

¹⁵ <https://royalsociety.org/news/2021/09/global-pandemic-data-alliance/>

and its impact on minority ethnic groups in the UK.¹⁶ The workshop was jointly hosted by the Society and the British Academy and was chaired by the then UK's National Statistician, Sir Ian Diamond FBA.

122. Presentations delivered during the workshop by Dr Gwenetta Curry and Dr Saffron Karlsen, as summarised in the note, highlighted that there was now a large body of work demonstrating that several minority ethnic groups in the UK were at increased risk of poor outcomes from COVID-19. It noted how the increased likelihood among minority ethnic groups for people to live in multigenerational households, for example, can make interventions such as self-isolation and social distancing difficult to achieve.

Q. Existing evidence on the Royal Society's work during the pandemic

123. By November 2020, the Society was able to draw upon the experience and insight that it had gained from the work across its three initiatives; DELVE, RAMP and SET-C and combine this with its own existing body of policy advice relating to data and digital technologies. All of which informed the Society's view at that time of the strategic and societal importance of well-governed access to data.

124. The 'Submission to the Public Administration and Constitutional Affairs Committee inquiry into Data transparency and accountability: Covid 19' recognised significant limitations in data systems that hampered the UK's COVID-19 response. As part of this submission, the Society set out a number of steps to build upon the rapid digital transformation: systematic data collection, quality and timely data, connected data, data access and data governance. The Society also set out how giving everybody the tools to critically engage with science, including promoting science education, will also support a healthy trust in science and engagement with its findings

¹⁶ <https://royalsociety.org/-/media/policy/Publications/2022/covid-19-and-minority-ethnic-groups-workshop-report-royal-society-and-British-Academy.pdf?la=en-GB&hash=2BE0BD6F2AE0BF3EE761DB23ABBA4937>

125. The Society provided a submission to the Commons Science & Technology Select Committee inquiry into UK Science, Research and Technology Capability and Influence in Global Disease Outbreaks on 18 of August 2020. The submission highlighted rapid test development as an example of the crucial role that science played in responding to COVID-19. The submission also pointed out that rapid research led to the discovery of asymptomatic transmission and the extensive prevalence of asymptomatic transmission, which in turn led to an understanding of the need to put in place a high level of testing.

126. The submission stated that despite the increasing recognition of asymptomatic transmission, the implications took time to impact on the approach to testing and tracing, yet the implications are profound. There is limited merit in a TTI system that relies on symptoms to trigger TTI when there is significant asymptomatic transmission.

R. Lessons learned and legacy of Covid-19

127. The Society has not performed research or taken an organisational view on lessons learned and the legacy of Covid-19 above and beyond the other policy measures set out within this statement.

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 in its truth.

Signed:

PD

Dated: 21 May 2025