Witness Name:
Greenhalgh
Statement No.:
Exhibits:
Dated: 4.3.25

UK COVID-19 INQUIRY

WITNESS STATEMENT OF Professor Patricia (Trisha) Greenhalgh

I, Prof Trisha Greenhalgh, will say as follows: -

1. **My background:** I am an academic GP with a full-time professorial position at the University of Oxford. I initially trained as a hospital physician (diabetes). I also have an intercalated degree in social and political sciences and an MBA. For many years I have undertaken qualitative research into (among other things) innovation and change in health services. My fellowship of the Faculty of Public Health is honorary (i.e. I am not formally trained in public health, though I have set up and run an MSc in Public Health).

2. **My membership of Independent SAGE**. I joined this informal group of scientists by their invitation in April 2022. Previously, I had appeared as a guest expert on their weekly briefings to talk about masks. I attended approximately 40 meetings of Independent SAGE between April 2022 and December 2023.

3. **Disclaimer:** Test, Trace and Isolate (TTI) is not my area of expertise. I have never done any research or (as I recall) written any reviews or commentaries on this topic. I am not an expert on modelling. I was not involved in writing the Independent SAGE reports on TTI or disease modelling (which were mostly published before I joined). I understand that I was invited to contribute to this inquiry mainly because I have previously summarised theoretical and empirical

research on the spread and scale-up of innovations (this was the reason conveyed to me when I queried my Rule 9 letter by email).

4. **My involvement in the open letter to CMOs**. I was asked to comment on an open letter to the Chief Medical Officers of the UK jurisdictions and the Government's Chief Scientific Adviser. The letter, which is listed in the Inquiry's exhibits The letter, which is listed in the Inquiry's exhibits PG/01 [INQ000474965], was originally posted online as a BMJ (British Medical Journal) Opinion piece on 21st September 2020. I do not have written details of the circumstances leading to that letter, so what I say here is from memory. As I recall, several prominent scientists and doctors were at the time raising concerns about restrictions (especially the possibility of another lockdown), which they believed to be unnecessary. Those people were suggesting that instead of attempting to suppress the virus in the entire population, there should be a policy of targeted shielding of vulnerable individuals. The gist of their argument was, I believe, that whilst older and sicker individuals could die from COVID-19, the disease was usually mild in younger and healthier people, who should therefore be allowed to get on with their lives and contribute to the economy. This argument was, for example, put forward by Professor Karol Sikora in a tweet on 21st September 2020, which is listed in the Inquiry's exhibits PG/02 [INQ000474966]. Our open letter was published by BMJ later the same day. I believe that several of us got active on email, collectively drafted a letter expressing an alternative scientific view, and rounded up some signatories. The BMJ Opinion genre requires that a single individual is named as a lead author, and that person then lists the other co-authors in the body of the document. But as I recall, the letter was collectively drafted by all the signatories, who contributed various expertise to the different paragraphs. The purpose of the letter was to provide an authoritative counterweight to what we believed was flawed scientific advice being offered by others. I and my co-signatories were very concerned that a 'let it rip' policy (especially, delaying lockdown or other restrictions in the face of early evidence of an emerging second wave) would lead to a much more severe second wave, with many deaths. And so it turned out. We argued in that letter that attempting to make a clean separation between 'healthy' and 'vulnerable' people in the population was unworkable. I cannot remember for sure whether I got a reply

from the CMOs and CSA, but I think several of them did reply to acknowledge the letter (which I sent to them by email).

5. **My letter 'Airborne pathogens: controlling words won't control transmission'**. I was asked to comment specifically on this letter, which I published in the Lancet on May 11th 2024 (this is listed in the Inquiry's exhibits PG/03 [INQ000474931]). This letter challenged a proposed change in the terminology used to talk about how pathogens transmit through the air. I think it's irrelevant to this Inquiry, partly because it is about terminology (the words used), not the actual science, and partly because it was published in 2024 which is outside the timeframe of this Inquiry. I have published other papers on the airborne spread of SARS-CoV-2, notably 'Ten scientific reasons in support of airborne transmission of SARS-CoV-2', published with co-authors in the Lancet on 1st May 2021. I think this paper, which is listed in the Inquiry's exhibits PG/04 [INQ000474930], may be the paper you wanted me to comment on, rather than the one you listed in your letter to me. In that 2021 paper, we summarised evidence for why the SARS-CoV-2 virus is transmitted substantially (and almost certainly *predominantly*) by the airborne route. The implication of predominantly airborne transmission is that the virus will transmit in any setting in which people gather indoors in under-ventilated spaces, unmasked. 'Social distancing' of 1-2 metres won't protect people much, since airborne particles spread to fill an indoor space (just as one person smoking in the corner of a room eventually fills the whole room with smoke). I have written elsewhere on how policymakers' reluctance to accept the airborne nature of SARS-CoV-2 had grave implications for how the pandemic unfolded, both globally and in the UK (this is listed in the Inquiry's exhibits, PG/05 [INQ000474932].

6. **Overview of my position on spread and scale-up of innovation:** Innovation, spread and scale-up are social processes that occur within and between organisations. They are best conceptualised as complex phenomena occurring in complex systems. They have been extensively researched, but mostly in non-crisis contexts (hence, evidence directly relevant to the Inquiry's analysis of TTI is sparse). With that caveat, I will now summarise the wider evidence base.

7. **Innovation:** A healthcare innovation is (to quote an earlier paper of mine) "a novel set of behaviors, routines, and ways of working that are directed at improving health outcomes, administrative efficiency, cost effectiveness, or users' experience and that are implemented by planned and coordinated actions" (paper listed in the Inquiry's exhibits, PG/06 [INQ000474933]). Innovation is, by definition, discontinuous with previous practice (as opposed to improvement, which refers to continuous and iterative change *without* a clearly-defined innovation e.g. an effort to reduce waiting lists). Importantly, healthcare innovations are not just drugs, tests or technologies but also the people, processes, pathways and infrastructure that support their use. Technologies, for example, are rarely 'plug-and-play'; they typically need new knowledge, new work roles, new interactions between staff groups, and some tweaking of workflows to embed into existing infrastructure. When we study innovations, we should study not just the 'new thing' (the 'hard core' of the innovation) but also, for example, the associated roles, behaviours and routines (the 'soft periphery' in which the innovation must sit), and wider technical and regulatory requirements (see paper listed in the Inquiry's exhibits, PG/07 [INQ000560919].

8. **Spread and scale-up:** Spread occurs when an innovation or improvement is adopted in settings beyond the one where it originated (see sources listed in the Inquiry's exhibits PG/08 [INQ000560925] and PG/09 [INQ000574832]. As those sources emphasise, scale-up is the extent to which the innovation or improvement is adopted more widely within a sector. The latter generally requires strengthening material, technical and human infrastructure and perhaps formally incentivizing the change. Lack of spread, and especially lack of scale-up, has long been recognised as a problem in the UK NHS and in health systems more widely. If an innovation benefits patients or saves money, it should ideally be widely adopted and become the new norm. But this rarely happens.

9. **The Greenhalgh et al Diffusion of Innovations (DOI) systematic review.** Back in the early 2000s, the NHS Service Delivery and Organisation (SDO) Programme funded my team to undertake a systematic review of the literature on how to spread good ideas in the NHS. The resulting paper was published in December 2004 (paper listed in the Inquiry's exhibits, PG/06 [INQ000474933]); it

was widely acclaimed and has been cited by around 10,000 subsequent publications, including many policy documents. To summarise our DOI review, whether and to what extent an innovation spreads (or is scaled up) is influenced by a number of domains which are interacting, interdependent and dynamically evolving (i.e. diffusion of innovations occurs in a complex system—see paragraph 11 below). The components of the system include:

a. **The innovation**. Innovations spread and are scaled up most easily if they offer a clear *relative advantage* over existing practice and are simple (straightforward, few components), *trialable* (can be tried out), *observable* (their benefits can be seen and measured), *compatible* (with existing values and ways of working) and have *potential for reinvention* (e.g. can be tweaked or improved by front-line users to better embed them in a particular context). Conversely, innovations which lack a clear relative advantage and/or which are complex, non-trialable, non-observable, incompatible with existing values and ways of working, and have limited potential for reinvention are much less likely to be adopted (hence, spread and scale-up will be limited). The most important attribute, accounting for most of the variance in innovation adoption in research studies, is relative advantage. Unless an innovation has a demonstrable advantage over existing practice, the chances of spread and scale-up are minimal.

b. **The intended adopters**. People (e.g. NHS staff) vary in their capability and willingness to adopt new practices, technologies and other innovations. But this variation is not, as is often assumed, explained by people's inherent stupidity or stubbornness (there is little evidence, for example, to justify the pejorative term "laggard"). Non-adoption or limited adoption of innovations by individuals is partly explained by lack of relevant training or being expected to work outside the scope of one's job description. Some technologies appear simple ('plug and play') but actually require sophisticated understanding of other parts of the system to be used to their full potential. Reluctance to adopt innovations is also partly explained by individuals' job descriptions (are they even allowed to do the new thing? are they performance managed on some other way of doing things?). Professionals in particular often have concerns about innovations (e.g. will it help my patients? is it safe? is it a good use of my time? how do I make it work?). They need to be informed and trained in a way that allows these concerns (which may be legitimate) to be raised and addressed.

c. **Communication and influence**. Voluntary adoption of innovations by individuals is a social process, strongly influenced by other people. Opinion leaders (people we like and admire), champions (people who extol the benefits of the innovation) and super-users (front-line staff who are already skilled and are willing to show others their technique and help troubleshoot) can greatly increase the uptake of an innovation in a local setting. While the evidence base on interpersonal influence is strong, it has limited relevance for innovations that are imposed top-down as must-dos.

d. **The inner (organisational) context**. Organisations with a high capacity for innovation are generally large and with plenty of 'slack' (money, people and other resources which can be quickly reallocated to a new project). They tend to be well-differentiated (e.g. each key function has its own department) and with flat management hierarchies (i.e. departments and teams can operate semi-autonomously) and to have strong leadership and good managerial relations. Such organisations also have high absorptive capacity (that is, existing systems and know-how for capturing ideas from outside the organisation), a risk-taking climate (people are encouraged to try things out, and failure is seen as an opportunity to learn) and good data systems for monitoring change. They are thus well-positioned to horizon-scan for new ideas, introduce those (perhaps on a pilot basis) and evaluate their impact. Conversely, organisations that are smaller, with limited or no slack, overly hierarchical, poorly differentiated, poorly led, with poor managerial relations, limited absorptive capacity and weak data systems will struggle with any innovation. Even when an organisation has a high *capacity* for innovation in general, it may have low *readiness* to adopt a particular innovation. Readiness depends on (among other things) innovation-system fit (e.g.

does this innovation align with the organisation's mission?), tension for change (is there a 'burning platform' where many people feel that change is urgent?), a well-articulated case for change (e.g. a costed business plan) and a favourable balance of opinion (supporters outnumber opponents and are more strategically placed).

e. **The outer (extra-organisational) context**. Favourable national and local policies (e.g. mandates, incentives) will promote adoption of innovations by healthcare organisations, as will the prevailing economic and regulatory climate, and public opinion. Conversely, spreading and scaling up innovation can be almost impossible if the effort pushes against key policy decisions, occurs in adverse economic circumstances or is deeply unpopular with the public. External shocks (e.g. economic, environmental, political) can (but do not always) act as triggers for innovation (this point is discussed further below in paragraph 12c). The behaviour of other, comparable, organisations can be an important impetus to adopting innovations. There is something akin to the 'opinion leader' at organisational level (e.g. paediatric departments might look to see whether an innovation has been adopted yet at Great Ormond St before making the strategic decision to adopt it themselves). Once a critical mass of similar organisations has adopted an innovation, there is often considerable mimetic pressure for others to follow. The converse is also true—if others are yet to change, there is mimetic pressure *not* to change (yet).

f. **The implementation ('normalisation') process**. Implementation of an innovation takes a lot of work. Success factors include good leadership and internal relationships; adequate resources; a culture of openness which allows people to make sense of the change (and especially to raise concerns and have them addressed); investment in training; outreach support (e.g. IT team will visit and troubleshoot); adapting the innovation to the work process and vice versa; and close monitoring of the innovation's impact. Carl May (who was developing his normalization process theory (see paper listed in the Inquiry's exhibits, PG/10

[INQ000560914]) at about the same time as my team were developing our Diffusion of Innovations framework) talks about four phases to the normalisation of an innovation in an organisation: coherence (making sense of why we are making this change), cognitive participation (building a community of practice in which people are engaging with the change effort and talking about it), collective action (doing the work) and reflexive monitoring (assessing progress).

10. **Updates to Diffusion of Innovations**. Our DOI framework has subsequently influenced, and been incorporated into, several other frameworks, including:

    a. **Damschroder et al's Consolidated Framework for Implementation Research (CFIR)**, which, while widely cited and used, places less emphasis on organisational factors and more on individual ones (so is perhaps less relevant to this report). See paper listed in the Inquiry's exhibits PG/11 [INQ000560915].

    b. **Greenhalgh et al's non-adoption, abandonment and challenges to spread, scale-up and sustainability (NASSS) framework** (Figure 1, adapted from a figure in paper from the Inquiry's exhibits PG/12 [INQ000560920]).

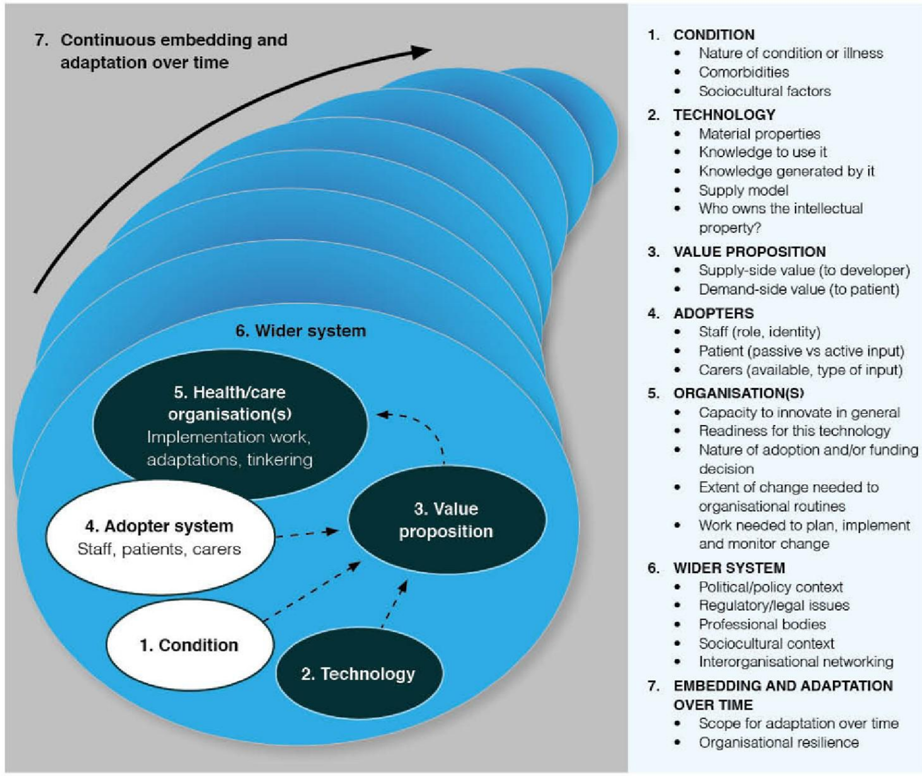

Figure 1: The NASSS framework (see paragraph 10b)

We developed NASSS in 2017 because the Diffusion of Innovations (DOI) framework had not been designed to examine *digital* innovations such as software. NASSS was an adaptation of DOI for this purpose (e.g. 'the innovation' in DOI was replaced with 'the technology' in NASSS, with attention given to issues such as intellectual property and the supply model). Two new domains covered the condition (complexity in the disease for which the digital innovation is aimed) and the value proposition (e.g. financial value to the developer, benefits to the patient, and costs and savings to the health service). We developed complexity assessment tools (NASSS-CAT short, reproduced in the Inquiry's exhibit PG/13 [INQ000574831] and NASSS-CAT long, reproduced in the Inquiry's exhibit PG/14 [INQ000574830]) to support the implementation of the NASSS framework.

11. **The importance of complex systems in spread and scale-up**. All the frameworks discussed above acknowledge that innovations are being introduced

in a complex system. Complex [adaptive] systems are widely talked about but often poorly understood. I have addressed complex systems in a forthcoming book chapter, supplied as the Inquiry's exhibit PG/15 [INQ000574829]. To summarise that chapter:

a. A complex system consists of multiple linked components, interacting dynamically in ways that are not centrally controlled, predetermined or fully predictable. The system is open (i.e. connected to its environment); sub-systems are nested in other systems. A complex system exhibits self-organisation (components respond to local signals, producing a degree of structure and order, with recurring patterns), unpredictability, non-linearity (a fixed input does not produce a fixed output), multiple scales (change can emerge at individual, group, organisational and societal level, and in short-, medium- and long-term timescales), and path-dependency (the system's behaviour is influenced by all the things that occurred in the recent and distant past). The system evolves and adapts to its environment over time. Because of inherent lack of predictability, the only way to know how a complex system will behave is to observe it.

b. Healthcare is a particularly complex system. It is helpful to consider four linked sub-systems: information systems (the flow of information and the associated feedback loops, as in a neural network, e.g. through the lens of cybernetics); living systems (including the clinical complexity of the human body and disease processes, the multi-level influences on human behaviour from genes to society, and the complexity of human groups and societies); organisational systems (highly complex formal systems which are hard to change because they are governed by legal regulations, professional norms and cultural and cognitive expectations); and 'political' systems (in the sense that society is made up of groups who share particular perspectives, values and [vested] interests; these groups may feel strongly about certain issues and interact with one another in a conflictual way).

c. Based on these four linked subsystems, lack of spread and scale-up in a complex system could be analysed, respectively, in terms of a) blocks to information flow (and loss of information richness); b) the multiple, nested (and sometimes unpredictable) interactions between genes, cells, living organisms, human behaviour, communities, organisations and the environment; c) difficulty in shifting the rules, norms and routines in organisations; and d) conflicts between groups with competing interests and values.

d. It is important to note that many writers on complex change do not fully acknowledge or incorporate complex systems thinking. The literature is replete with articles describing how to "develop and test a complex intervention". The problem with much of this literature is that while it *talks* about complexity, it is based largely on linear thinking (e.g. much of this literature assumes that it is possible to develop an intervention and measure its "effect size"). The view of most complexity scholars is that the fortunes of complex interventions introduced in complex systems are *inherently unpredictable*.

12. **Innovation, spread and scale-up in crisis situations**. Of particular relevance to this inquiry are the following papers:

a. In a book written before the COVID-19 pandemic (which is well summarised in its opening chapter, supplied to the Inquiry as PG/16 [INQ000574828]), Boin et al define a crisis (whether political, environmental, economic, epidemiological etc) as "an unusually volatile situation characterised by uncertainty, urgency and threat". Because of the nature of crises, policymakers face what these authors call "tragic choices"—the need (sometimes but not always) to impose a level of restriction on individual freedom that would be unacceptable in non-crisis situations. They highlight five tasks for strategic leaders in such situations: working out what is happening (perhaps using early-warning systems and real-time data analytics); decision-making and coordinating (weighing the ramifications, risks and opportunities of strategic dilemmas and following through on decisions with effective implementation measures), constructing meaning (crafting a narrative for stakeholders and the public about what is happening), managing accountability (explaining what was done to prevent the crisis and managing the return to normality), and learning from the crisis (including designing and implementing system reforms and contingency planning).

b. In a co-authored 2022 paper, I discussed the relationship between science and policy in times of crisis (see paper supplied to the Inquiry PG/17 [INQ000560911]. In sum, at such times there is often lack of agreement on the nature and quality of key evidence, and policy decisions need to be made in the absence of certainty. The maxim "scientists advise; policymakers decide" is easy to announce but problematic in practice because there will inevitably be disagreements among scientists about what the facts are and also on how to handle the uncertainties. In that paper, we propose a pragmatist approach which embraces openness (about the lack of certainty) and encourages deliberation (about what to do in the face of it). We criticised the relatively narrow and opaque selection of expert advisors and the relative secrecy of key science-policy dialogues in UK at the height of the COVID-19 crisis.

c. In a paper on innovation, spread and scale-up of digital innovations in the acute phase of the COVID-19 pandemic, Gkeredakis et al identify this crisis as a period of *opportunity* (the pandemic created new opportunities for developing digital innovations), *disruption* (the context was favourable for organisations to introduce changes, because everyone recognised this as an unusual and high-stakes situation, experimentation was encouraged and regulatory red tape was relaxed) and *exposure* (phenomena that are normally hidden or unnoticed became visible and hence open to scrutiny). See paper supplied to the Inquiry PG/18 [INQ0005609913]. Because of opportunity, many digital innovations were developed—but some were subsequently shown to have limited or negative value. Because of disruption, innovations were often readily adopted, but organisations faced challenges coordinating the new work routines needed for these new technologies and in some cases later had trouble abandoning them (e.g. because contracts had been signed with suppliers). Because of exposure, the complexity of infrastructure (human and technological) needed to support digital innovation, and inequities of provision, were revealed.

13. **Suggested questions to ask about the TTI case**. As noted above, I have no expertise or experience in TTI. But the literature on innovation, spread and scale-up in health systems summarised above suggests that the TTI scheme was a highly complex innovation (see paragraph 11a) which was going to be challenging to implement, even with the impetus and added resources of a crisis. Drawing on the general literature on innovation, spread and scale-up, I suggest that the Inquiry might consider asking a number of key questions of other invited experts. For example:

    a. **What key aspects of the natural history and epidemiology of COVID-19 need to be taken into account? What, exactly, was the nature of the public health crisis?** This question maps to the 'condition or illness' domain of the NASSS framework above (paragraph 10b and Figure 1 above), and to the features of a crisis described by Boin et al (paragraph 12a above). This is a prime example of the complexity of living systems discussed in paragraph 11 above. It will be necessary to consider multiple layers, including but not limited to the structure and behaviour of the SARS-CoV-2 virus, computational models of how the disease was spreading at the time, evidence on which population subgroups were most susceptible, and associated patterns of comorbidity and social vulnerability.

    b. **What were the key technologies involved in TTI?** This is the 'technology' domain of the NASSS framework (paragraph 10b and Figure 1 above). Technologies will include but are probably not limited to: contact tracing apps, data analytics, diagnostic tests such as PCR and RAT, and key communication links. What were the material properties of each of these technologies? How easy were they to use—and what knowledge was required to use them? The latter should include not just the mechanics of working the technology but also the practical wisdom of appropriate clinical care and knowledge about how the wider system works. How accurate were these technologies? How reliable were they? What data did they generate and what kinds of data were they *not* able to generate? What were the implications of technologies' limitations (e.g. in terms of accuracy and reliability) for the system overall? For each technology, what was the nature of the supply chain and what challenges were associated with this?

c. **What were the non-technological components (human and organisational) of the TTI innovation?** This incorporates the 'organisational' domain of the NASSS framework (paragraph 10b and Figure 1 above). It also draws on work by cybernetics scholars on information systems (paragraph 11 above). Consider how humans (some working in organisations) and technologies ('little tech' such as point of care test kits and 'big tech' such as data analytics) were linked in a network. As well as thinking about the individual components, consider the network as a dynamic whole. What were the distinguishing features of this network? How did it emerge, what were its features, and how did it evolve?

d. **What value (positive and negative) did the TTI system generate?** This question maps to the 'value proposition' domain of the NASSS framework above (paragraph 10b and Figure 1 above). What was the financial investment in TTI? What benefits (financial and non-financial) were anticipated and to what extent were these realised? What were the risks—and to what extent were these identified prospectively?

e. T**o what extent did participating organisations have the capacity and readiness to assimilate and deliver the TTI innovation?** This question maps to the 'inner context' domain of the DOI framework (see paragraph 9d and paper listed in the Inquiry's exhibits, PG/06 [INQ000474933]) which is also the 'organisation' domain of the NASSS framework (see paragraph 10b, Figure 1 and paper from the Inquiry's exhibits PG/12 [INQ000560920]). See 11d for a list the features of organisational capacity for innovation in general and organisational readiness for a specific innovation.

f. **In each participating organisation, were staff appropriately skilled and trained? What were their concerns, and to what extent were these concerns acknowledged and addressed?** This question maps to the 'intended adopters' domain of the DOI framework (see paragraph 9d and paper listed in the Inquiry's exhibits, PG/06 [INQ000474933]), which is also the 'adopters' domain of the NASSS framework (see Figure 1, paragraph 10b, and paper from the Inquiry's exhibits PG/12 [INQ000560920]).

g. **As the TTI programme was scaled up, what was the role of inter-organisational support and influence?** This question maps to the 'outer context' domain of the DOI framework (see paragraph 9e and paper listed in the Inquiry's exhibits, PG/06 [INQ000474933]), which is also the 'wider system' domain of the NASSS framework (see paragraph 10b and Figure 1). For example, were participating organisations linked with one another (e.g. to create mimetic pressure and opportunities to learn collectively)? If not, why not?

h. **Within participating organisations, to what extent were the preconditions for successful implementation and routinisation or normalisation of the innovation met?** This question maps to the 'implementation process' domain of the DOI framework (see paragraph 9f and paper listed in the Inquiry's exhibits, PG/06 [INQ000474933]), and is incorporated in the 'organisation' domain of the NASSS framework (see paragraph 10b and Figure 1).

i. **How was information assumed to flow through the TTI system? Did it do so as planned, and if not, why not?** This question maps to the 'information systems' element of complex systems scholarship, specifically cybernetics. Was the system sufficiently flexible to adapt to change? What were the limits in its resilience? The Inquiry might explore whether there was evidence of fragmentation of information flows; accumulation of information at bottlenecks in the system; loss of richness of information; and information flows that were insufficiently timely. See paragraph 11 on the information aspects of complex systems, and the book chapter supplied as PG/15 of the Inquiry's exhibits [INQ000574829].

j. **How did the TTI scheme influence the emergence and spread of COVID-19 from an ecological perspective?** How was the behaviour of the virus influenced by the scheme *in the context of* linked aspects of human behaviour (e.g. staff, patients), community response, and wider environmental influences? See paragraph 11 on the biological / ecological aspects of complex systems, and the book chapter supplied as PG/15 of the Inquiry's exhibits [INQ000574829].

k. **What vested interests were involved?** How did these influence the setting up and running of the scheme? Which stakeholder groups were in conflict? How did these conflicts play out and why? See paragraph 11 on the political aspects of complex systems, and the book chapter supplied as PG/15 of the Inquiry's exhibits [INQ000574829].

l. **How did the highly complex innovation of TTI interface with other parts of the health and care systems?** This question reflects complex systems thinking generally. The TTI system could not operate in isolation. What were its key connections and interdependencies with (for example) laboratory services (NHS and commercial); front-line NHS care (e.g. GP practices, out-of-hours services and hospitals); public health infrastructure (e.g. local authorities, disease surveillance services); social care (e.g. care homes); welfare (e.g. financial aid to those required to self-isolate); and data management and regulatory systems (e.g. in relation to data security)? What were the operational and micropolitical challenges with each key interface? See paragraph 11 on complex systems, and the book chapter supplied as PG/15 of the Inquiry's exhibits [INQ000574829].

m. **What were the consequences of key decisions about the TTI programme that were made in a crisis context?** This question maps to the summary of crisis policymaking in paragraphs 12a, 12b and 12c. To what extent were key decisions about TTI made in haste, under conditions of uncertainty and with a sense of an impending disaster that needed to be averted (see Boin reference, supplied as exhibit PG/16 [INQ000574828])? To what extent did they include "tragic choices" (policies that would prove unpopular but which were arguably necessary in the circumstances)? How much deliberation was involved, and by whom, as these decisions and choices were made? How did the impact of these decisions unfold, and were the decisions revisited as further data emerged?

n. **Opportunity, disruption and exposure?** In terms of new technologies, what opportunities were created, for whom, by the TTI scheme? What were the consequences of these opportunities for other stakeholders? Considering the TTI scheme as a 'disruptive innovation', which organisations, services and pathways were disrupted and how? To what extent did the embedding of the TTI scheme in organisations create path dependencies that were later difficult to reverse? What weaknesses and inequities in the system did the TTI scheme expose?

14. **Conclusion**. The TTI system introduced early in the COVID19 pandemic was a multi-component, multi-level system and hence was inherently complex and unpredictable. I hope that the theoretical frameworks presented in the statement will provide the Inquiry with a useful structure to guide the collection and examination of evidence from topic experts.

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.

Personal Data

Signed:

Dated: 4th March 2025