

Witness Name: Dr Elizabeth  
Fearon  
Statement No: 1  
Exhibits: EF1/01 - 18  
Dated: 6 May 2025

## UK COVID-19 INQUIRY

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### WITNESS STATEMENT OF DR ELIZABETH FEARON

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I, Dr Elizabeth Fearon, will say as follows: -

#### INTRODUCTION

1. I am currently employed as an Associate Professor of Infectious Disease Epidemiology at the Institute for Global Health at University College London. During the time period 1 January 2020 – 28 June 2022, I was:
  - a. Employed as an Assistant Professor at the London School of Hygiene and Tropical Medicine (until Dec 31 2022).
  - b. On maternity leave (covering the period 01 Jan 2020 - Feb 2020).
  - c. A Visiting Research Fellow at the University of Manchester Department of Mathematics (Feb 2020 - Aug 2021).
  - d. Project Lead for *An analytical framework for test, trace, isolate in the UK*, a UKRI-funded COVID-19 rapid response research project, Sept 1 2020 - Aug 31 2021.

## **BACKGROUND**

2. I obtained my PhD in Epidemiology from the London School of Hygiene and Tropical Medicine in 2014, which focused on social epidemiology of HIV in Southern Africa and social network influences on health. I worked in HIV epidemiology, surveillance and intervention evaluation research until 2018 as a Research Fellow and then Assistant Professor at LSHTM, with a focus on marginalised populations and methodologically on networks. I began a Medical Research Council Skills Development Fellowship in network modelling in 2018. I paused this fellowship to respond to the COVID-19 pandemic in Sept 2020, working on Test Trace Isolation (TTI), which is a network-based intervention.
3. Publications I have contributed to or led on in relation to Test, Trace and Isolate are in Annex 1.

### **Test, Trace and Isolation**

4. My involvement with providing scientific advice in relation to COVID-19 began in March 2020 assisting SPI-M member colleagues at the University of Manchester, where I had recently begun a research visit. I began working with colleagues on further developing a mathematical model with which to explore TTI strategies in April 2020.
5. The meetings I attended in relation to presenting scientific evidence about test, trace and isolate strategies, including SPI-M-O and SAGE meetings, are listed as part of my previous submission to the Inquiry (**EF1/1- INQ000056401**) and (**EF1/2 - INQ000056402**).

## **TTI Purpose**

6. The purpose of TTI for control of COVID-19 was broadly to identify people who were infectious ('test') and facilitate them being isolated away from others to whom they might pass infection ('isolate'). Further, it sought to identify these people with whom the infected person had had contact ('trace'), who might therefore have acquired the infection themselves. If these individuals could be reached and facilitated to quarantine before they became infectious then the transmission chain could be halted. I use 'quarantine' to refer to actions to prevent social contact among contacts of someone who has tested positive, and 'isolation' for those who have actually tested positive.
7. While lockdowns/closures/blanket social contact restrictions aim to control transmission by limiting contact across the population as a whole, and therefore also preventing contact between people who are not infected/infectious, TTI is a more targeted intervention in that it aims to prevent contacts only between susceptible and infectious individuals.
8. TTI is a complex intervention with multiple components. Different variations of TTI, and combinations of its components were used in response to the COVID-19 pandemic in the UK. These include a list given in Littlecott et al 2023 (EF1/3 - INQ000563596).

## **TTI Effectiveness**

9. Various factors determine the effectiveness of TTI interventions across characteristics of the pathogen, characteristics of the population or setting in which transmission is occurring, implementation and resourcing of the intervention, combination with other control interventions, and the extent to which the population is enabled and supported to engage with policies. These include:

- a. Timelines of infection: The period of time during which an individual with an infection can pass on the infection to others is known as their 'infectious period' and this is not generally the same as the total time in which they have an infection or are experiencing disease. The period of time between an individual becoming infected and becoming infectious themselves is called the latent period. The period of time between becoming infected and developing symptoms is known as the incubation period. The length and overlaps of these periods affects how difficult it is to control infections in the population using TTI. For symptomatic testing, testing takes place only once a case develops and recognises symptoms and accesses a test. The timeframe in which effective contact tracing must occur lies between time of test return of the original case and the interview to determine their contacts, and the time at which these contacts become infectious, if they have become infected. Effectiveness is more difficult to achieve when the latent period is short and when symptoms/case identification occurs after infectiousness begins.
  
- b. Pre-symptomatic and asymptomatic transmission - if individuals are infectious before they are aware of it (their infectious period begins before symptoms, or symptoms do not appear or are very mild) then they will not be aware to take (timely) actions to prevent passing their infection to others, including engaging in TTI interventions.
  
- c. Specificity of symptoms: if symptoms of an infection are generic to many different infections, then it is more difficult to identify cases of the disease of concern. The symptom criteria for testing risks being so broad as to include many people with different infections, increasing testing demand and burden, or too narrow so as to exclude some who might truly have the infection of concern.

- d. Characteristics of contact networks, (average number of contacts but also heterogeneity of contact numbers across the population): If on average the population among whom transmission is occurring have many contacts of short periods, then tracing will be more challenging and time-consuming.
- e. Extent to which the TTI intervention is tailored to the needs of diverse populations, and people are supported and enabled to engage fully with the intervention at each stage: TTI will not be effective if people do not or cannot take up testing, tracing and adhere to isolation/quarantine.
- f. Extent to which infrastructure and systems are in place for rapid response, data sharing, surge capacity: when an epidemic is growing exponentially it can be difficult to keep on top of rapidly growing number of cases and even more rapidly growing number of contacts to trace.

### **TTI Government Decision-Makers**

10. I had no direct contact with government decision-makers during this time period. The only indication I had as to what government decision-makers were considering at any given time was through the questions we were being asked to look at. This was communicated via the SPI-M-O secretariat.

### **TTI Commissions**

11. Along with colleagues at the University of Manchester, I began responding to SPI-M-O commissions on the effectiveness of TTI in reducing transmission as lockdown restrictions relaxed in May 2020, and explored a range of TTI design choices through summer 2020, which are mostly documented in Fyles and

Fearon et al 2021 (EF1/4 - INQ000563590) (later written up for academic publication, in Annex).

12. We joined other academic epidemiological and modelling colleagues at the University of Oxford also working on TTI effectiveness and design and partnered with a behavioural scientist, Lucy Yardley, Co-Chair of SPI-B at the University of Bristol and a clinician scientist with experience in contact tracing at the Liverpool School of Tropical Medicine, Tom Wingfield, to successfully apply for a UKRI/NIHR COVID-19 rapid response 12 month project. This project was called: *An analytical framework for Test, Trace and Isolate in the UK: optimising and targeting deployment alongside other measures*. The project aimed to inform TTI design and its use alongside other epidemic control measures, such as contact reduction interventions. We primarily used mathematical modelling to assess different TTI design choices (e.g. length of quarantine, use and duration of daily contact testing in lieu of quarantine) and their likely effectiveness in controlling transmission, with input into model specification and interpretation from our interdisciplinary project team. We used the growing evidence base about SARS-CoV-2 and real-time data about transmission, behaviour and contact tracing, where available, to inform the models. The primary aim of the project was to be responsive to questions posed of us, which mostly came via SPI-M-O. We also initiated some topics through our own assessment of what questions were also important, or anticipated those that might become so, as the epidemic progressed.

13. We used two mathematical models of SARS-CoV-2 transmission and TTI implementation in 2020 and early 2021:

- a. A 'household structured branching process model': a model of generations of cases where within-household and between-household transmission are modelled separately, fit to an epidemic growth rate and observed household secondary attack rate (i.e. what % of household

members acquire infection from a first household member acquiring infection). The generations of cases form a tree-like network over which we simulated a TTI process. We modelled the TTI process to represent how most TTI was implemented among the general public in England by NHS Test and Trace (not reflecting specific settings such as schools or hospitals) and investigated proposed variations alongside sets of assumptions, such as percentage uptake, or given a particular distribution of delays. This model is described further in Fyles and Fearon et al 2021 (**EF1/4 - INQ000563590**) and the code for the model is publicly available here: (as of 24/01/2025) (**EF1/5 - INQ000563591**).

- b. An individual-level branching process model: model of generations of cases without differentiating household and non-household members. This model also represented SARS-CoV-2 transmission and TTI policies and was used, among other things, to explore potential trade-offs between duration of quarantine and uptake of testing. This model is described further in Davis et al 2021 (**EF1/6 - INQ000563594**): and the model code is available here: (**EF1/7 - INQ000563589**).

14. We later adapted an existing, more complex model ('Covasim', Kerr et al 2021) (**EF1/8 - INQ000563597**) of contact networks to explore questions over Spring-Autumn 2021. This model simulates a whole population (i.e. not only generations of cases like the branching process models) which enabled us to better reflect the epidemic phase at the time, including the presence of immunity from vaccination and previous infection in the population. The code for our model adaptations is available at (**EF1/9 - INQ000563600**) and (as of 25/01/2025) (**EF1/10 - INQ000563601**).

15. The list of TTI topics that we examined over 2020-2021 can be found via the titles of documents contributed to SPI-M-O over this time period.

16. As an overview, in the autumn and winter of 2020 we examined:

- a. the potential effectiveness of out-of-household isolation of identified cases and contacts to prevent transmission to vulnerable individuals within households.
- b. consequences of exceeding testing capacity on TTI effectiveness.
- c. potential trade-offs between reducing the length of contact quarantine and whether this would result in an improvement in the percentage of those with symptoms taking up testing.
- d. effect on epidemic growth if contacts of cases take daily rapid antigen tests (isolating if positive) instead of/in addition to quarantining at home ('Daily Contact Testing').
- e. assessing the effect of quarantine and testing strategies on potential transmission from travellers returning to households from abroad.
- f. assessment of the diversity of COVID-19 symptom phenotypes and the potential implications for TTI effectiveness.

17. In the summer and autumn of 2021 we considered the effectiveness of repeat asymptomatic testing and costs in relation to days spent in isolation, on top of a symptomatic testing and contact tracing policy. This work is described in Silva et al 2023, (reported at SPI-M-O prior to academic publication) **(EF1/11 - INQ000562944)**.

18. Our project primarily sought to provide evidence about TTI via SPI-M-O reports, presentations and discussions. In a few cases, I and members of my research project met directly with government employees:

- a. Members of our research project and I had a conversation with the Joint Biosecurity Centre (JBC) and NHS Test and Trace modellers to informally discuss approaches to modelling TTI in January 2021.
- b. Feb 2021: I met with the ONS to make recommendations about what to ask the public about their engagement with TTI in preparation for one of their surveys.
- c. May 2021: members of our research project and I met twice with a modeller from NHS Test and Trace to discuss and informally peer-review a model that they were using internally to inform TTI policy.
- d. Spring 2021: I was part of a group from SPI-M-O who commented on the DCMS Events research programme study design and attended a meeting with them on this topic. (I was not involved in this further.)
- e. Sept 2021: I contributed to a document about reducing the likelihood of a high burden epidemic wave over winter 21/22 (**EF1/12 - INQ000563602**).
- f. Dec 2021: Colleagues and I provided comments to the Department for Transport on a model they were using to investigate the effect of testing strategies in reducing the likelihood that people arriving from overseas with infection went on to pass the infection further.

### **TTI intervention purpose and technology choice**

19. Different testing technologies were available or became available in the UK during the pandemic for SARS-CoV-2. Here I discuss PCR and Lateral Flow

Devices (rapid antigen tests) as these were the most commonly employed. I did not work on antibody testing.

- a. Polymerase Chain Reaction (PCR) tests: a sample is taken using a nasopharyngeal swab and sent to a laboratory for testing for viral RNA using amplification, and therefore capable of detecting relatively low levels of virus. PCR testing was used for symptomatic testing among the general public through NHS Test and Trace after May 2020, and in some cases, such as large hospitals or universities, on-site for staff/patient testing programmes. Because samples must be sent to a lab for processing, there is a delay between when the test is taken and when results are obtained and communicated. During the COVID-19 pandemic in the UK, this delay varied but tended to be around 1-3 days in England (higher in times of high demand) **(EF1/13 - INQ000563599)**. These delays, in addition to time between the onset symptoms and taking the test and tracing delays, could negatively affect the effectiveness of TTI on reducing transmission, because cases and contacts isolate/quarantine themselves later into their infectious periods, thus preventing less transmission.
- b. Lateral flow devices (LFDs) detect viral antigen. These tests could be packaged into small inexpensive devices and do not require laboratory analysis. After taking a sample through a nasal and/or throat swab, LFDs could be used by lay people to obtain a result within 15-30 minutes, depending on the brand. Their relative cheapness and speed of result enabled their mass distribution and use of repeated testing regimes over time, thus making asymptomatic testing more feasible in comparison to relying only on PCR testing and associated lab infrastructure.

20. It is important when considering the pros and cons of different testing technologies to consider their purpose. Tests can be used primarily to identify *a correct infection diagnosis*, which will inform treatment or clinical management. Tests can also be used in a variety of contexts as part of interventions to *reduce transmission of the infection through the population*. There are more specific applications within these two major categories but this is a useful distinction. Different uses of tests favour different characteristics: for instance, a test to inform treatment management might require especially high sensitivity but might not need to be operated by people without professional experience if being conducted in a healthcare setting. A test to prevent transmission might be valued highly for speed of result, particularly when the time window for effective isolation of the cases and notification and quarantine of their contacts, is narrow.

21. Testing can also be used to reduce the burden of an intervention while maintaining efficacy on transmission reduction. For example, asking contacts of a case to take a rapid test every day for a set period during which they are most likely to test positive if infectious and asking only those testing positive to isolate, could reduce the burden of TTI throughout the population via removing the requirement to quarantine (Daily Contact Testing, DCT). Using modelling, we found that a DCT policy was not inferior to asking all contacts to quarantine (modelling with different assumptions as described in SPI-M-O Consensus Statement March 2021) (**EF1/14 - INQ000563588**), as did other modelling investigations and a subsequent empirical trial (**EF1/8 - INQ000563597**).

22. The effectiveness of a testing programme is contingent on uptake of the action that testing is intended to prompt. If individuals testing positive are not enabled and supported to take up isolation and adhere over time, then the testing alone will not be effective. If the testing programme intends individuals to only attend an event if testing negative within a given time period, for instance, the effectiveness of the policy is contingent on behaviour after the test.

## Viral Kinetics and Test Sensitivity Dynamics

23. From the time of infection with SARS-CoV-2, viral load rises rapidly but is too low to be detected for a few days, then rises to an infectious level a day or two prior to symptom onset, peaks and remains high for several days until a more gradual drop, Figure 1, with a total infectious period of around 10-12 days. Trajectories of viral load, including maximum levels, vary across individuals but this is the average pattern.
24. Both PCR and LFD sensitivity is higher when viral load is higher, but their thresholds for detection are different, **FIGURE 1**. LFD's have a higher threshold for detection than do PCR tests; PCR can detect infection at a lower level of viral load. This means that there is a short period of around one day or so early in infection when an individual with the virus might test positive on a PCR test but not an LFD. How much of an advantage this was for epidemic control depended on the test results turnaround time, which was generally longer than 24 hours when the sample was sent to a laboratory. People with infection will also test positive for longer on PCR than on LFD, as their viral load drops again from its peak and past the time period when they are most infectious.
25. Viral load is proportional to infectiousness; people are more infectious, given contact patterns, when their viral load is higher. If the intention of a test is to identify individuals who are infected and *infectious*, rather than only *infected*, then a higher viral load threshold of detection could be acceptable. There remains concern particularly about early infection when someone might test negative but soon become infectious. This risk can be reduced by repeat testing regimes, and by testing as soon as possible prior to having contact with others, e.g. attending an event.

**FIGURE 1: SARS-CoV-2 viral load and test sensitivity of the course of infection**

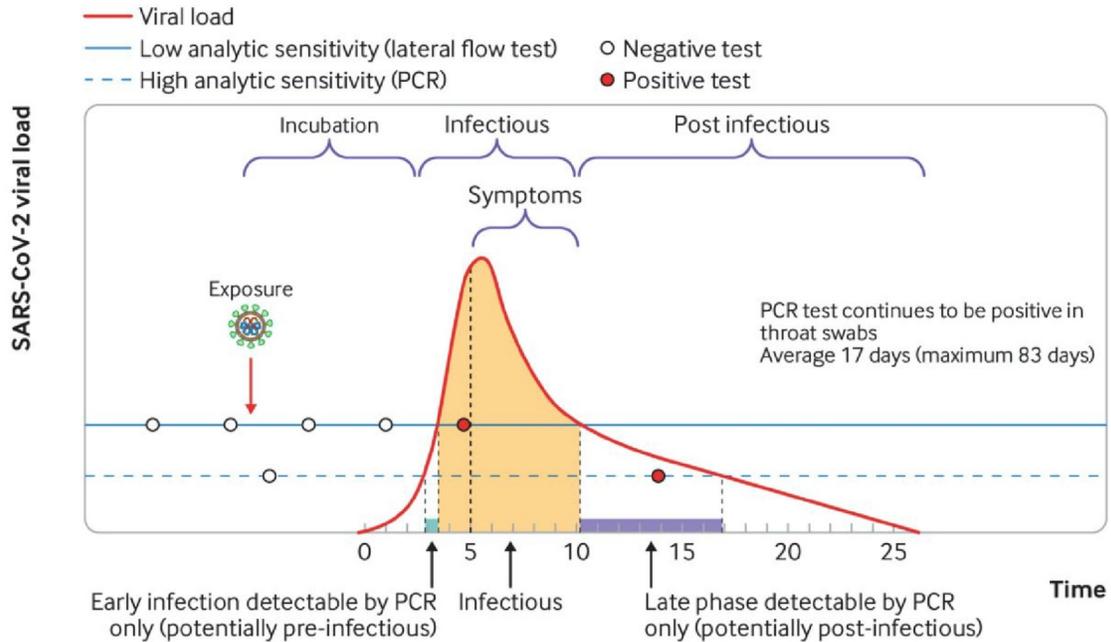


Figure from Crozier A, Rajan S, Buchan I, McKee M. Put to the test: the use of rapid testing technologies for covid-19. *BMJ* 2021;372:n208 (EF1/15 - INQ000563593).

26. Viral load dynamics and test sensitivity changes over time also underscore the importance of stratifying by viral load (sometimes with PCR Cycle Threshold (CT) value as a proxy for viral load) in assessing a test’s sensitivity relative to PCR. Because viral load varies across the course of infection, the average age of infection of a population in which testing is being compared (i.e. the average length of time since infection, which varies at different stages of an epidemic wave) also needs to be considered in interpretation of test sensitivity comparison findings.

27. Understanding of viral load over the full course of infection (i.e. prior to symptom onset), relationship to infectiousness, relationship to test sensitivity

and timing with respect to symptoms was very valuable information in the design of SARS-CoV-2 testing programmes.

### **TTI and Symptomatic Population or 'Mass' testing**

28. The primary general population testing made available from May 2020 through NHS Test and Trace was symptomatic testing - that is, individuals who experienced at least one of fever, new continuous cough and/or loss of taste or smell were instructed to undertake a SARS-CoV-2 PCR test either through drive through, walk-through testing centres or postal test kits. Their testing sample was sent to a laboratory, the result recorded and communicated back to them, which also initiated the tracing process.
29. Mass symptomatic testing outside of specific groups was available to the UK general population from May 2020 to April 2022.
30. A symptomatic testing approach therefore meant that infected individuals who had not already been contact traced and quarantined were still potentially able to infect others before they developed symptoms. Their contacts were not traced until after the test sample had been analysed, the case spoken to and their contacts traced and notified.
31. A TTI strategy based on symptomatic testing is less effective if members of the public cannot recognize the symptoms intended to initiate testing or if their symptoms are mild or not present. The CORSAIR behavioural survey found that approximately half of adults, consistently between May 2020 and January 2021 knew the symptoms prompting testing, while only around one fifth reported requesting a test if symptomatic, referenced in Smith et al 2021 (**EF1/16 - INQ000563592**).

## TTI and Asymptomatic Population or 'Mass' testing

32. 'Mass asymptomatic testing', generally meant testing everyone in the population, not limited to those experiencing symptoms (who should have accessed symptomatic testing). To increase the probability that individuals with infection were detected, particularly those early in infection who did not yet have sufficient viral load to test positive, mass testing regimes often advised repeat testing over time, e.g. every day or twice a week depending on the programme and setting. This approach meant that even individuals who were pre-symptomatic but infectious or who developed no or very mild symptoms, could be identified as having infection and facilitated to isolate away from others.
33. Mass testing is enabled by a readily available and inexpensive test that can be used by lay people themselves. This was the case for LFD tests but not PCR tests in most settings (outside of sites with existing lab capacity/resources).
34. Modelling was used by our group (Silva et al 2023, SPI-M-O DCT Consensus Statement) (**EF1/11 - INQ000562944**); (**EF1/14 - INQ000563588**) and others to explore the effects on control of transmission, of repeat asymptomatic testing at different frequencies, given what we understood about test sensitivity and viral load dynamics. Behaviour in terms of testing, isolation uptake if positive and contact/pre-cautionary behaviour if negative is also relevant in practice. There was some limited behavioural data about this (e.g. from Daily Contact Testing pilot studies) and social surveys such as the CORSAIR study.
35. Both symptomatic and asymptomatic testing strategies require the public to be informed about the actions that they should take if they test positive, or if they test negative, and what test results mean. For example, people should understand that testing negative once does not rule out the possibility of being infected and particularly cautioned about the possibility of being early in one's infection and therefore potentially infectious over the next few days. In both

cases, members of the public need to be supported and enabled to take up actions required on the basis of test results.

### **TTI in specific settings**

36. Specific TTI interventions were undertaken in different settings over the course of the COVID-19 pandemic, including in education, health and social care. Our research project did not investigate TTI in these specific settings. Other modelling groups and interdisciplinary research projects did investigate testing strategies for these settings, so I will not discuss them here.

### **TTI and Surge testing**

37. 'Surge testing' was used at points during the epidemic particularly in areas where circulation of newly identified variants of concern (VOC) were identified, in order to try and find cases with these VOCs, ensure their isolation and more intensively trace and quarantine their contacts to try and contain and prevent the further spread of these VOCs. Because prevalence of these VOCs was low early in their establishment, door-to-door public health teams aimed to test as many members of the population as possible to find the very small number of cases as quickly as possible.

38. My project and I did not specifically model VOC testing strategies but the modelling approach to do so is analogous to investigating the potential for different TTI strategies to contain early growth of the epidemic.

### **TTI and Tracing Strategies**

39. There are different strategies and methods for conducting contact tracing that were used throughout the COVID-19 pandemic in the UK.

40. Manual tracing refers to a system in which a newly identified case (upon return of a positive PCR test result in the UK) is interviewed about the contacts that they have had, over the period of time over which they are estimated to have been infectious. In England, for people tested on the basis of symptoms, this was taken to have been 48 hours before symptom onset or time of the positive test for asymptomatic cases.
41. The description of TTI I have given so far describes what is known as ‘forwards’ contact tracing. Here, the objective is to identify people to whom the identified case might have passed infection and prevent onward transmission from them. In ‘backwards’ contact tracing, the aim is to identify the person from whom the identified case acquired their infection. This then enables investigation of what other contacts that person might have had, and then, now tracing forwards, identify people and who might have been exposed who have not yet been identified. Backwards tracing can be part of a more intensive outbreak investigation to identify a time/place in which transmission occurred and therefore the wider group of exposed individuals.
42. Theoretical work by others highlighted that for an infection like SARS-CoV-2, which is characterized by an ‘over-dispersed’ secondary case distribution – meaning that while many cases infect no or fewer people, a smaller proportion of cases lead to many secondary cases – backwards tracing could be especially effective, referenced in Kojaku (**EF1/17 - INQ000563598**).
43. In practice, backwards tracing could be implemented by extending back in time the window over which a case’s contacts are collected and traced, e.g. instead of asking for all contacts from 2 days pre-symptom onset onwards, we ask for all those 4 or 8 or 10 days back from symptom onset.
44. My research project investigated backwards contact tracing in a limited way, as reported in Fyles and Fearon et al 2021 (**EF1/4 - INQ000563590**), finding that effectiveness of TTI in reducing epidemic growth could be more effective

extending the time window over which contacts were traced, but that if individuals began to recall contacts less well over time, with a more distant period of time to remember, then this effectiveness advantage could be lost. This decay in recall was not based on empirical data but was hypothetical.

### **Digital tracing**

45. Modelling by many groups investigating potential TTI effectiveness early in the pandemic identified the strong sensitivity of effectiveness in reducing transmission to delays in the TTI process. I have discussed testing delays above. Time to collect data about, trace and notify contacts is also relevant. Early modelling suggested that if tracing delays could be eliminated and coverage of all contacts improved (identifying more contacts than someone might know or remember to report), then effectiveness of TTI in controlling epidemic growth could be improved, referenced in Ferretti (**EF1/18 - INQ000563595**). Work was undertaken in the UK and elsewhere to develop a mobile phone application that could be used to conduct this digital tracing.

46. For a contact to be successfully digitally traced, both the case and the contact needed to have the app running at the time of contact. This emphasises the need for high coverage of app usage, though in practice it is likely that app usage would not be randomly distributed across the population. The app settings regarding contact definition (e.g. how close, for how long) need to be appropriate to mode and probability of transmission. There are additional behavioural considerations regarding probability of quarantining given tracing by different methods, and the extent to which contacts are provided support needed to quarantine and test if needed. There are different design decisions for contact tracing apps, considering both epidemiological and privacy concerns, that were employed in different countries and which could be considered for future infections with adaptation for different infection and most affected populations.

47. In the UK, a digital contact tracing app was made available through the NHS COVID-19 app in addition to standard manual tracing performed for the general population through NHS Test and Trace. Modelling studies and empirical analyses of observed testing data suggest it was effective in reducing transmission at the population level (**EF1/11 - INQ000562944**), evidence included in our systematic review in 2023. My research group 2020-2021 did not specifically work on digital contact tracing, beyond early theoretical effectiveness analysis included in Fyles and Fearon et al 2021 (**EF1/4 - INQ000563590**).

### **Local/centralised approaches**

48. Contact tracing for COVID-19 was performed both nationally (centrally by NHS Test and Trace and locally by local public health teams organized as:

- a. Tier 1: cases that were potentially linked to outbreaks in vulnerable settings (eg social care) were handled by local public health teams.
- b. Tier 2: Initial calls to cases potentially linked to local outbreaks were handled by national specialists.
- c. Tier 3: cases not linked to outbreaks in vulnerable settings (Tier 1) were handled centrally by NHS Test and Trace call handlers. The NHS Test and Trace manual tracing approach that I have described above refers to Tier 3 and this is what we generally were modelling, rather than Tier 1 local outbreak investigation and contact tracing.

49. The organisation, resourcing, relative responsibilities across local/central bodies and infrastructure for TTI is not something that I specifically worked on, so I do not discuss it further, but it is important to review and consider.

## **Modelling**

50. As above, I do not have insight into exactly how models or analyses my research project and I produced were utilised, considered or deployed by Government decision makers. I did not have direct contact with government decision-makers.

51. Given the time frame over which we were being asked to investigate questions, the type of models we were using, and data availability, we were not seeking to make precise predictions about the exact quantitative effect that TTI would have on epidemic trajectories. Rather, we used modelling to understand:

- a. sensitivity of TTI effectiveness to different parameters (e.g. proportion symptom recognition and testing, testing delays, uptake of isolation, adherence to isolation over time, length of quarantine).
- b. the contribution that TTI might have in reducing epidemic growth, in combination with other contact reduction interventions (e.g. given overall between-household contact reductions of 20%, 40%, or 60% what might we expect about the extent to which TTI could prevent growth of a large epidemic).
- c. potential effects of and trade-offs in varying adherence over different TTI components (e.g. if reducing length of contact quarantine and test isolation by x days led to a y% increase in the proportion of people experiencing symptoms testing, would this represent a more effective policy in reducing transmission overall?).
- d. assess potential efficacy of changes or additions to TTI policy, some of which were then tested empirically (e.g. how does Daily Contact Testing among contacts in lieu of quarantine at home compare to status quo

policies, assuming X days of daily testing and assumptions about update and changes to behaviour?).

52. The household structured branching process model was particularly useful because it reflected both patterns of transmission, with increased likelihood of spread within household, and also the policy of isolation/quarantine at home. Our model findings highlighted that at-home isolation and quarantine, while practical from many perspectives, did mean that the TTI was 'leaky' even if fully adhered to and with high TTI performance (% contacts traced, low delays), which was not captured by similar individual-level branching process models.

53. We investigated TTI effectiveness almost entirely in relation to its effect on reducing or preventing transmission of SARS CoV-2. As with any public health policy there are decisions to be made about benefits of the intervention on transmission (and therefore also on the stringency of other interventions required) and harms resulting from policies, including economic, education, social and well-being. In Silva et al 2023 (**EF1/11 - INQ000562944**) we additionally examined the number of days in isolation/quarantine among those not truly positive for SARS-CoV-2 for different asymptomatic + symptomatic testing regimes. These need to be assessed in the context of other interventions that would be necessary in the absence of the TTI policy (Fearon et al 2021) (**EF1/4 - INQ000563590**).

### **Empirical**

54. In January-February 2023 colleagues and I conducted a systematic literature review to identify evidence as to effectiveness of TTI interventions conducted in community settings (i.e. not specific settings such as healthcare, education or social care) on reducing transmission (i.e. not effectiveness on reducing severe disease given infection, for instance). This review captures the time period post June 2022 and so I have not gone into detail. Overall,

acknowledging a paucity of robust real-world evidence, heterogeneity in intervention types and settings and challenges in disentangling the effects of TTI from other co-occurring interventions, we broadly found that the majority of studies, including those of highest quality and those from the UK, did show evidence of effectiveness of TTI measures on reducing SARS-CoV-2 transmission.

### **Lessons learnt and recommendations**

55. I am asked to consider lessons that can be learned about TTI in epidemic response. These views are based on: my experience during the COVID-19 pandemic including the time period this statement refers to; readings, discussions and research since the time period this statement refers to, including a 2023 review of empirical evidence as to TTI effectiveness; and my broader epidemiological training and experience.

56. In my opinion the potential use and deployment of rapid antigen tests should be explored further in epidemic response as part of TTI interventions. This could include mass/population or setting-specific approaches, but also approaches that use testing to mitigate harm of interventions, e.g. reducing quarantine requirements.

57. In my experience, for the design of SARS-CoV-2 testing programmes, data to inform viral load kinetics, relationship to infectiousness, relationship to test sensitivity to timeline of infection and presence of symptoms was essential for informing TTI design. It is likely that this information will be important for future pandemic infections so the timely and open collection of data to inform this understanding is important to plan for.

58. Based on experiences with SARS-CoV-2, there is a need for test evaluation methods and metrics reflecting that test sensitivity is dynamic over time, and

that results of test comparisons (e.g. comparison to PCR) will differ by average age of infection in the population.

59. In my view, further research into testing, tracing and isolation interventions is a key part of epidemic preparedness. This research should proceed from the following tenets:

- a. TTI is a complex intervention. There are multiple components which might be combined in different ways, multiple behaviours are targeted, multiple technologies are involved and the intervention(s) need to be adaptable to different settings, populations and epidemic phases.
- b. TTI components, particularly testing, can be deployed for a variety of purposes, which likely shift alongside changing objectives as an epidemic might progress. Choice of technology and intervention design should be guided by the purpose.
- c. Understanding of needs of diverse populations, including informational, economic and social needs, is essential to enable uptake and adherence to each of the TTI components. This work, which requires community involvement as well as interdisciplinary perspectives, underpins understanding to improve equity of health outcomes.
- d. Modelling of TTI interventions is useful to explore the complex intersecting factors that affect its potential effectiveness, (discussed previously).
- e. Pragmatic and robust approaches (study design, methods and data sources) to empirically assessing TTI interventions and informing their design within a timeline useful to informing epidemic response are needed.

**Statement of Truth**

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

Signed: **Personal Data** \_\_\_\_\_

Dated: 6 May 2025

## Annex 1

### List of relevant publications

1. Fearon E, Buchan IE, Das R, Davis EL, Fyles M, Hall I, Hollingsworth TD, House T, Jay C, Medley GF, Pellis L, Quilty BJ, Silva MEP, Stage HB, Wingfield T. SARS-CoV-2 antigen testing: weighing the false positives against the costs of failing to control transmission. *Lancet Respir Med*.
2. Kretzschmar ME, Ashby B, Fearon E, Overton CE, Panovska-Griffiths J, Pellis L, Quaife M, Rozhnova G, Scarabel F, Stage HB, Swallow B, Thompson RN, Tildesley MJ, Vilella D. Challenges for modelling interventions for future pandemics. *Epidemics* 2022; 38.
3. Fearon E, Fyles M, Overton C, University of Manchester COVID-19 Modelling Group, Wingfield, T, Medley GF, Hall I, Pellis L, House T. Using a household-structured branching process to analyse contact tracing in the SARS-CoV-2 pandemic. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 2021; 376(1829).
4. Pellis L, Scarabel F, Stage HB, Overton CE, Chappell LHK, Fearon E, Bennett E, Lythgoe KA, House TA, Hall I, University of Manchester COVID-19 Modelling Group. Challenges in control of COVID-19: short doubling time and long delay to effect of interventions. *Philosophical Transactions of the Royal Society of London. Series B, Biological sciences* 2021; 376(1829).
5. Overton CE, Stage HB, Ahmad S, Curran-Sebastian J, Dark P, Das R, Fearon E, Felton T, Fyles M, Gent N, Hall I, House T, Lewkowicz H, Pang X, Pellis L, Sawko R, Ustianowski A, Vekaria B, Webb L. Using statistics and mathematical modelling to understand infectious disease outbreaks: COVID-19 as an example. *Infectious Disease Modeling* 2020 409-441.
6. Fearon E, Buchan IE, Das R, Davis EL, Fyles M, Hall I, Hollingsworth TD, House T, Jay C, Medley GF, Pellis L, Quilty BJ, Silva MEP, Stage HB,

- Wingfield T. SARS-CoV-2 antigen testing: weighing the false positives against the costs of failing to control transmission. *The Lancet Respiratory Medicine* 2021; 9(7): 685-687.
7. Silva MEP, Fyles M, Pi L, Panovska-Griffiths J, Jay C, House T, Fearon E. The role of regular asymptomatic testing in reducing the impact of a COVID-19 wave.
  8. Marshall GC, Skeva R, Jay C, Silva MEP, Fyles M, House T, Davis EL, Pi L, Medley GF, Quilty BJ, Dyson L, Yardley L, Fearon E. Public perceptions and interactions with UK COVID-19 Test, Trace and Isolate policies, and implications for pandemic infectious disease modelling.
  9. Fyles M, Vihta KD, Sudre C, Long H, Das R, Jay C, Wingfield T, Cumming F, Green W, Hadjipantelis P, Kirk J, Steves CJ, Ourselin S, Medley GF, House T, Fearon E. Diversity of symptom phenotypes in SARS-CoV-2 infections observed in multiple large datasets.
  10. SAGE. Considerations for potential impact of Plan B measures. October 2021.
  11. Fyles M, Gledson A, Crowther P, Fearon E. Household Branching Process Testing Contact Model. (Software). July 2021;
  12. Fearon E et al. A response to 'Covid-19: Controversial rapid test policy divides doctors and scientists'. *BMJ* 2021; 372 doi: (Rapid Response letter);
  13. Fearon E, Fyles M and TTI modelling group. Comparison of quarantine and testing strategies to prevent onwards infection from infected travellers returning to the UK from abroad. SAGE. December 2020.
  14. Fearon E, Fyles M and TTI Modelling group. On the use of LFA tests in contact tracing: preliminary findings. SAGE. November 2020. 4 Recommendations for Augmenting Contact Tracing in the UK: Learning from Other Diseases. June 2020. Isaac Newton Institute for Mathematical Sciences, University of Cambridge.

15. Fearon E. Lessons from research to support Test, Trace and Isolate policies in the UK. Isaac Newton Institute, University of Cambridge. Workshop on Asymptomatic testing and COVID-19. Jun 2022;
16. Fearon E. Use of data provided via the ONS Secure Research Service for advice about Test, Trace and Isolate (TTI) strategies for control of the COVID-19 epidemic in the UK 2020-2021. ONS Research Accreditation Panel meeting. Dec 2021;
17. Fearon E, Fyles M, Overton C, Pellis L, Hall I, Medley Graham F, et al. Considering household structure to improve the effectiveness of testing, tracing and isolation (TTI) interventions in the control of SARS CoV-2 epidemics. Epidemics 8 conference. Nov 2021;
18. Fearon E. Test, trace and isolate strategies for the control of SARS-CoV-2 in the UK. Department for Global Health and Development COVID-19 seminar series, LSHTM. Apr 2021;
19. Fearon E. Test, trace and isolate strategies for the control of SARS-CoV-2 in the UK. British Mathematical Colloquium (BMC-BAMC). Apr 2021;
20. Fearon E and Fyles M. A household structured model of contact tracing. Isaac Newton Institute, University of Cambridge, Infectious Dynamics of Pandemics Workshop. Jul 2020;
21. Challenges for modelling interventions for future pandemics - ScienceDirect;
22. Using a household-structured branching process to analyse contact tracing in the SARS-CoV-2 pandemic;
23. Challenges in control of COVID-19: short doubling time and long delay to effect of interventions;
24. Using statistics and mathematical modelling to understand infectious disease outbreaks: COVID-19 as an example;
25. The role of regular asymptomatic testing in reducing the impact of a COVID-19 wave;
26. A response to 'Covid-19: government must urgently rethink lateral flow test roll-out': lateral flow testing in contact tracing