TONY BLAIR INSTITUTE FOR GLOBAL CHANGE

Changing the Game on Testing

LIZZIE INSALL
RYAN WAIN
DANIEL SLEAT
ANDREW BENNETT

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Foreword by Tony Blair

Britain is unfortunately in a different and worse position than most comparable countries. We are opening up with a death rate and level of new infections that are comparatively high. The risks are obvious.

In addition, even if existing strategy succeeds completely in suppressing the disease during the summer months, we face along with all countries the possibility of fresh outbreaks of the disease in the autumn and winter.

We need to prepare for this now.

We believe this requires a radical and urgent shift in government strategy. In earlier reports we have suggested a series of containment measures, including the provision of masks, wearable devices to alert people to early signs of Covid-19, a different approach to track and trace and provision of oximeters to people suffering symptoms, and we have of course highlighted the importance of testing.

Today we make a more fundamental suggestion.

This is that the government change its testing strategy from one that is targeted to certain groups and those with symptoms, is reliant on lab-based tests and will therefore only test a minority of the population to mass testing using available and soon-to-be available rapid on-the-spot antigen and antibody tests, which do not require lab processing, so that a majority of the population can be tested and regularly.

We believe this should be at the core of the containment strategy.

To achieve this we recommend:

1. Even within existing government strategy, we should increase lab-based testing capacity by incorporating all NHS and any willing private-sector labs, which we estimate could increase capacity by 50,000 tests per day.
2. Ensure that anyone subject to quarantine is tested, irrespective of whether they have symptoms, and that those who test negative, released.
3. Alongside lab-based tests for those in the defined government categories, to provide support for antigen and antibody rapid tests, develop out-of-lab test provision, including funding, better access to defined patient samples, lab space, and enhanced support and resources for validation.

4. Create a specific impact fund for advance purchase of rapid, point-of-care tests using new Covid-19 innovation bonds and distribute across multiple providers.
5. Expedite the validation of innovative tests through independent assessment, openly and immediately publishing results and introducing a US-style Emergency Use Authorisation for new tests.
6. Set up testing infrastructure at key ports and terminals with integrated data collection and sharing.
7. Those arriving in the UK should be tested on arrival with rapid antigen and antibody tests, regardless of whether the person has symptoms.
8. Distribute rapid, on-the-spot antigen tests to businesses and other services.
9. Make available rapid, on-the-spot antigen tests for the public as part of a test, track and trace strategy.
10. Distribute rapid antibody tests to regions for epidemiological sampling and to the public, where positives will be fast-tracked for a confirmatory ELISA test.
11. Develop a framework for a mobility credential that links with a digital identity.
12. Develop a communications campaign to describe how the portfolio of testing fits together.

Tony Blair, Executive Chairman

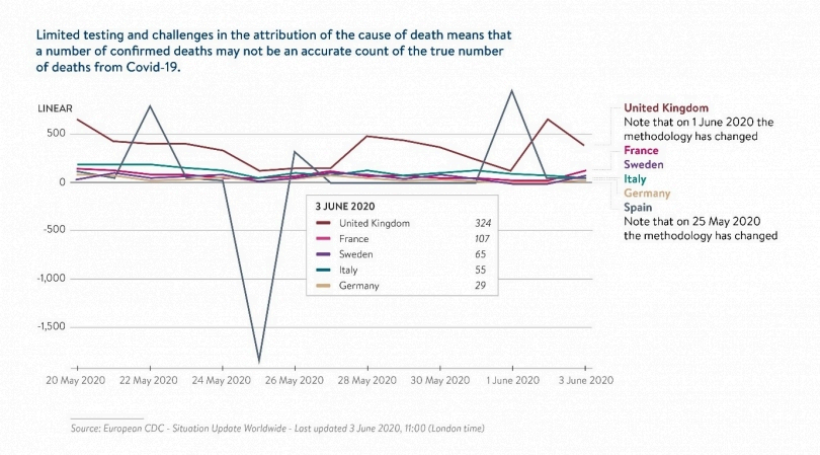
Why Is the UK Different?

As the UK begins to ease lockdown, the new measures it puts in place must reflect the persistently high volume of infections and new cases. These levels mark the UK out from other countries and mean that, in order to ease the lockdown and prevent a resurgence of the virus, our approach must look different.

There are an estimated 54,000 new Covid-19 community infections per week in the UK[1]. This is significant and stubbornly high. It is a markedly different number from similar-sized countries, such as Germany, where there were 3,677 cases in a comparable week (new Covid-19 infections have consistently been below 500 per day with high testing[2]) and South Korea, which recorded just 139 cases per week.

On Tuesday 2 June alone, the UK had more deaths than France, Germany, Italy, Spain and Sweden combined.

Figure 1 – Daily confirmed Covid-19 deaths



It is right that all countries see testing as the cornerstone of containment measures. However, the volume of cases in the UK means that the role testing plays and therefore the scale of testing required is very different to other countries where there are much smaller numbers of new cases. The below table shows the stark contrast between the UK and the countries it is often compared to.

Table 1 – Total and weekly confirmed Covid-19 cases and deaths by country

1 Source: DHSC, NHS England and devolved administrations. Estimated weekly number presented at daily press briefing of 28th May 2020.

2 https://www.economist.com/europe/2020/05/28/germanys-contact-tracers-try-to-block-a-second-covid-19-wave

Country	Total confirmed cases[3]	Total deaths	Weekly confirmed cases*	Weekly deaths[4]
UK	272,826	38,376	15,672	1,701
Italy	232,997	33,415	3,161	630
France	188,882	28,802	6,832	435
Spain	286,509	27,127	4,6056	134[5]
Belgium	58,381	9,467	1,376	216
Germany	183,332	8,602	3,201	253
South Korea	11,468	270	278	4
Australia	7,195	103	79	1
Singapore	34,884	23	3,298	0

**Weekly case figure is skewed by the number of tests administered. Estimated weekly cases were not available for all countries but this is significantly higher in the UK than confirmed cases.*

For the likes of South Korea and Germany, a predominantly lab-based, targeted, controlled testing regime is enough to identify and contain relatively small outbreaks of Covid-19. It is sufficient to underpin a test, track and isolate system. The UK requires something more than this. We call for mass testing. First, we have set out the current approach to testing in the country.

3 https://www.worldometers.info/coronavirus/ - Data accurate as of 2000hrs on 31st May

4 Source: European CDC, 24th to 31st May

5 This data is taken from European CDC, covering 23-31st May. It discounts 24th May

which shows a negative death total in Spain owed to changes in data collection (See: https://uk.reuters.com/article/uk-health-coronavirus-spain-tally/data-puzzle-as-spain-tweaks-coronavirus-tracking-system-idUKKBN2322OE)

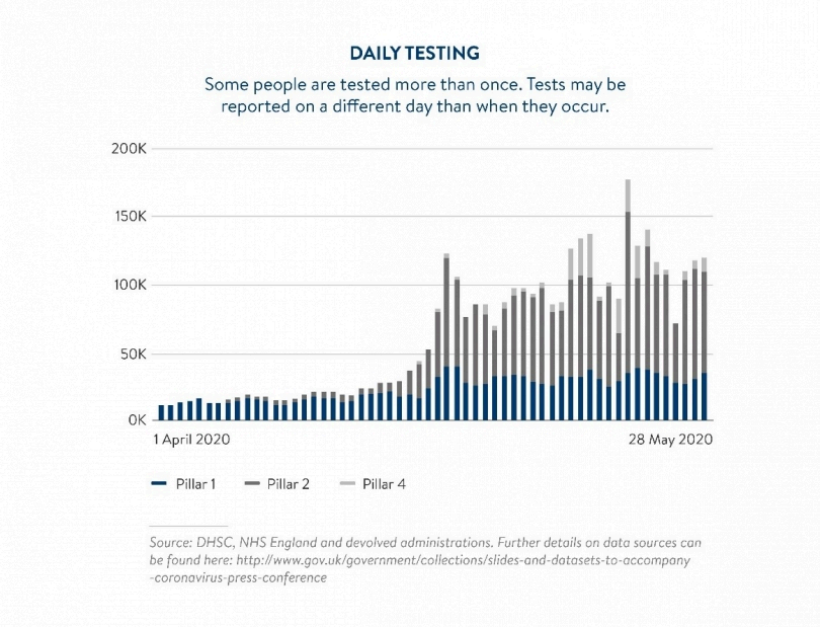
The UK's Current Testing Strategy: Lab-Based and Targeted

The UK currently has a targeted approach to testing that is predominately concentrated on lab-based tests for those with symptoms and critical workers. Despite the five pillars the government set out in its testing strategy on 4 April, all tests currently conducted are in pillars 1, 2 and 4.

Table 2 – The government's five pillar testing strategy

Pillar 1	Scaling up NHS swab testing for those with a medical need and, where possible, the most critical key workers
Pillar 2	Mass-swab testing for critical key workers in the NHS, social care and other sectors
Pillar 3	Mass-antibody testing to help determine if people have immunity to coronavirus
Pillar 4	Surveillance testing to learn more about the disease and help develop new tests and treatments
Pillar 5	Spearheading a Diagnostics National Effort to build a mass-testing capacity at a completely new scale

Figure 2 – Daily testing numbers in the UK by pillar



Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/888353/2020-05-28_COVID-19_Press_Conference_Slides.pdf

Testing under pillars 1 and 2 both rely on lab-based PCR swab testing, which takes around 24 hours to deliver a result.

In recent weeks there has also been some progress on antibody surveillance capacity in pillar 4. All of these pillars are lab-based and reflect a rigid approach using partnerships with international large-testing providers such as ThermoFischer, Abbott and Roche. The two pillars never included on the daily briefings – 3 and 5 – can only be delivered through innovative suppliers and a decentralised approach.

In recent days the government has announced that a trial has begun in Hampshire on a rapid test for the virus. Despite misreporting of it being a rapid antigen test, we understand the recent trial announced is for a loop-mediated isothermal amplification (LAMP) test.[6]

The announced trial in Hampshire will use a point-of-care reader by Optigene. The test has been misreported as giving a 20-minute result. A high viral load could return a positive result within 20 minutes, but the entire process requires a full LAMP reaction – which takes about an hour – to confirm negatives.

The gap in the government strategy arises in the area of rapid, on-the-spot testing.

How Accurate Are Tests?

Before we can explore mass testing using non-lab-based tests, it's important to understand the accuracy of existing tests. One of the key bottlenecks the government highlights in the delay in bringing onstream rapid on-the-spot tests has been concerns over their accuracy.

They are set against a "gold standard" test which, in the case of assessing if a patient has Covid-19, is the PCR test. This is a false dichotomy.

PCR Tests Are Not 100% Accurate

A systematic review[7] of the accuracy of the tests reported false negative rates of between 2 per cent and 29 per cent (equating to sensitivity of 71 to 98 per cent), based on negative RT-PCR tests that were positive on repeat testing. This *BMJ* paper set out guidance on how clinicians should communicate test results and, after noting the "marked variation" in studies and the likelihood of these to "overestimate sensitivity", concluded that RT-PCR test outcomes should assume 70 per cent for sensitivity and 95 per cent for specificity.

One community-based[8] study of 4,653 close contacts of patients with Covid-19 tested RT-PCR throat swabs every 48 hours during a 14-day quarantine period. Of 129 eventually diagnosed with Covid-19 by RT-PCR, 92 (71.3 per cent) had a positive test on the first throat swab, equating to a sensitivity of 71 per cent in this lower prevalence, community setting.

Additionally, the type of specimen collected matters. In one study[9], sensitivity of RT-PCR in 205 patients varied, at 93 per cent for broncho-alveolar lavage, 72 per cent for sputum, 63 per cent for nasal swabs and only 32 per cent for throat swabs.

These studies run counter to a public assumption that RT-PCR tests are 100 per cent accurate. They are not. This has led to delays in validating rapid tests and a damaging public narrative that pits lab-based tests against point-of-care tests.

6 https://www.gov.uk/government/news/trial-of-rapid-coronavirus-test-launched-in-hampshire

7 BMJ 2020;369:m1808 doi: 10.1136/bmj.m1808 (Published 12 May 2020)

8 Luo L, Liu D, Liao X-l, et al. Modes of contact and risk of transmission in COVID-19 among close contacts. medRxiv 20042606. 2020. 10.1101/2020.03.24.20042606%J

9 Wang W, Xu Y, Gao R, etal . Detection of SARS-CoV-2 in different types of clinical specimens[JAMA.]. JAMA 2020. 10.1001/jama.2020.3786. 32159775

The UK's Testing Strategy Should Be Mass Testing

As stated, the UK position is different from other countries. Case numbers remain high. Therefore, rather than continue with a targeted, controlled testing regime, the government must shift – at speed – to building a mass-testing regime.

The prevalence of the virus means that mass testing is required to continue to screen a high proportion of the population, identifying cases to keep the disease in check and to help large numbers of people make informed decisions about how they should behave based on their disease status.

The current approach places a high dependence on a track and trace model that is neither fully ready, nor workable in the absence of mass testing. The two must work together for the population to safely engage with the easing of lockdown measures. For example, rather than relying on identified contacts self-isolating for 14 days without testing, a mass-testing regime would mean that a test would be available once someone is informed that they have come into contact with a Covid-19-positive patient. There are concerns that early tests may not pick up the virus – but under mass testing not only are tests available for all regardless of symptoms but there could also be scope for a contacted citizen to take two tests, seven days apart, and if both returned negative, the individual would be eligible to exit self-isolation early. This differs from the current requirement to self-isolate without being tested unless symptoms develop.

Mass testing would include the following:

- Rapid testing of those identifying with symptoms (results within 24 hours).
- Testing of any individual who has come into contact with someone who has tested positive for Covid-19 (on a presumed 30 contacts[10] per positive case), using a combination of digital and manual contact tracing.
- Regular testing for a sizeable part of the population with both antigen and antibody testing, with those proving immune removed from the cycle. This would utilise the STIR model, set out in our recent paper on mass testing.
- This would include testing in workplaces, at transit hubs and categories of the public not covered by the existing testing regime.

10 https://institute.global/policy/architecture-containment-getting-gold#article-

- Weekly testing, at the minimum, for frontline health-care staff.

Mass Testing Will Give the Public Confidence to Exit Lockdown

Compared to other countries, the UK is more fearful about the public-health impacts of the virus than its economic impacts. This is understandable given that case numbers remain relatively high. Elsewhere in Europe, where the number of new cases is lower, the trend is moving towards prioritising the economy. For example, opinion polling shows that approximately 70 per cent of the UK public continues to agree that "the government's priority is to stop the spread of virus." In contrast, Germany has moved down to just 49 percent agreeing this, with 33 percent prioritising stopping a recession versus 14 per cent in the UK.[11]

This is problematic as such fear will prevent people from returning as fully active economic and social participants. They may be reluctant to enter businesses or leisure facilities, even when the government says it is safe to do so. By shifting to mass testing, people will be able to know their own Covid-19 status and have this checked regularly, while rapid, on-the-spot tests can be deployed at businesses and other facilities to give confidence that there is no one with an active infection present. Further, by introducing testing into the trace and isolate system, there will be greater public confidence that where outbreaks of Covid-19 do arise, they will be quickly isolated.

We are aware of a number of UK and international organisations that have put in place weekly testing for staff. One of them told us it has been vital in giving staff confidence they are entering a safe workplace.

The Capacity Needed to Deliver Mass Testing Is Available

Mass testing can only be realised through an approach to testing that brings together lab-based capacity with supplementary rapid antibody and rapid antigen tests from smaller, innovative providers. This will require a step-change from the government including:

- Operational support for innovative testing providers, including funding,

summary-footnote-4

access to patient samples and access to lab space for validation

- Expediting and making fully transparent the validation of innovative tests, including a US-style Emergency Use Authorisation

This will take some time and requires the government to move at a speed as yet unseen in this crisis. It requires political will and the ability to make decisions quickly, and should be led by a Minister for Testing, reporting into the Prime Minister. This has been set out in previous papers.[12]

Many rapid-testing suppliers have expressed their frustration at the lack of communication and, once communication has been established, the speed at which validation has (or hasn't) occurred. This is exacerbated when they see their tests deprioritised in the UK, yet validated quickly by other countries which have introduced expedited validation processes, including the US, where the Food & Drug Administration (FDA) is making use of Emergency Use Authorisations to get tests on the market.

A mass-testing regime must go beyond centralised lab-based testing that uses a small number of large testing providers, and instead uses a range of technology and applications to reach scale. South Korea's experience with testing demonstrates the effectiveness of a decentralised approach.

Maximising Lab Capacity in the UK

With mass testing as its central objective, the government will require every inch of lab space available in the UK to be put to use in a coordinated way, reaching out to regional and local facilities. From conversations with experts, we understand there is considerable latent lab space available in the UK that could adequately boost testing capacity by a further 350,000 per week.

While the government cultivates an ecosystem of innovative suppliers, it should continue to draw on public-private partnerships and maximise all lab space available. As is stands, there is unused capacity.

Smaller Labs

A recent attempt to create a consortium of independent labs brought together about 100 labs. These labs ranged in capacity from around 200 tests per day to 2,000, with an average capacity of around 500 tests each.

11 https://www.kekstcnc.com/media/2590/kekst-cnc_research-report_covid-19-opinion-tracker_wave-2_final-1.pdf

12 https://institute.global/tony-blair/path-mass-testing

Our contacts believe this leaves a latent capacity of at least 50,000 tests per day.

Large Labs

Regarding large-lab capacity, experts we have spoken to believe the biggest constraint so far has been lack of imagination. Many of the big labs have a significant deployment of automation and further detection technology, such as Next Gen Sequencing, could have been used.

In the US, by contrast, a $70 million investment by Illumina and private investors will be reconfiguring the synthetic biology lab by Gingko Bioworks to provide 500,000 tests per day based on sequencing as the detection technology.[13]

Testing based on loop-mediated isothermal amplification (or LAMP, as described above) – while not uncomplicated to scale – and other molecular platforms have the capacity to also unlock many hundreds of thousands of tests per day. These tests work by turning plate readers, the backbone of instruments in every molecular biology lab in the UK, into diagnostic tools. The key to unlocking this capacity is expediting regulatory approval for a wider range of testing technologies, particularly those that draw on different reagent and equipment supply chains.

In order to maximise the capacity, we recommend:

- All NHS labs be supported in their ambitions to conduct Covid-19 testing and that their procurement is focused on flexible technology such as ELISA tests that don't need expensive machines to operate, and draw on existing competence within the laboratory community
- All private labs be given fast-track access validation from Public Health England and support in procuring analysers, ensuring alignment with a mass-testing strategy

Critically, a mass-testing strategy also requires that an ecosystem of innovative testing providers be fully harnessed and grown at scale. This is a collective effort. Indirectly, this would assist in creating the robust diagnostics industry that the government claimed was absent in the UK at the start of the outbreak[14]. This network of providers, many of whom are already supplying tests privately and in other countries, would offer both antigen and antibody tests in a rapid, point-of-care form. The accuracy of these tests is, at minimum, comparable to lab-based based tests.

13 https://www.prnewswire.com/news-releases/ginkgo-bioworks-to-build-infrastructure-for-rapid-epidemic-response-with-70mm-investment-301066763.html

14 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/878121/coronavirus-covid-19-testing-strategy.pdf

From Few to Many Testing Suppliers

In its mass-testing regime, the UK will require millions of **rapid antigen tests** becoming readily available and easily administered at the point of care outside of a lab. This means that when someone enters a public event or attends a conference, they would be subject to a test that determines if they have Covid-19. Businesses could also deploy these tests to ensure their workers are not infectious. These tests would need to be used regularly, and longitudinal data collected would need to be collected to monitor progression of an individual who initially tests negative.

Complementing this would be **rapid antibody tests.** Detecting if someone has had the virus, these tests would play a specific role as part of a mass-testing strategy depending on their accuracy. In contrast, lab-based antibody tests that are 100 per cent specific have a longer turnaround time, require phlebotomists to collect samples and are therefore not practically suitable for mass testing. These lab-based tests would still be used to validate those who have the antibodies to Covid-19 confirmed by rapid tests and therefore have some presumed immunity to the virus.

Both tests would be supplementary to the existing regime, enabling coverage of a broader population, and at greater pace. However, in both cases the **results could be confirmed** by highly accurate NHS tests – either a PCR swab or saliva test, or the highly specific lab-based serology test.

Scaling and Funding Rapid Testing: A "Pay-for-Success" Covid-19 Initiative

In addition to supporting providers of innovative tests with expedited validation and access to patient samples, the government should allocate a specific fund for advance purchase of mass tests. This could be done in partnership with other countries, or the UK could take this approach alone. It was an idea first propagated by Sir Ronald Cohen[15].

Building on the advance market commitments (AMCs) successfully used to supply pneumococcal vaccines in 2009, and drawing on the principles of impact investment, investors would be incentivised to finance and support the development and manufacturing of effective tests, with their investment effectively guaranteed by the UK government.

Demand would be established through a government contract that includes pre-agreed prices. The contract would incentivise improvement in the elements of tests that are key to the UK's mass-testing strategy, for example around the speed of antigen tests and the accuracy of antibody tests. In this model, the government would commit to purchase all tests produced at the prices agreed, within agreed maximum quantities and time frames.

Sir Cohen calls for the tests to be funded by government-created *Covid-19 Innovation Impact Bonds*. These bonds would be guaranteed by the government(s) at the time they sign a purchase contract for the delivery of tests. The approach has the added benefit of providing economic stimulus as young and established companies engage deeply in efforts to solve the crisis.

Given that lockdown is estimated to cost the UK economy £2.4 billon per day[16], the *Covid-19 Innovation Impact Bonds* would actually save the country money by expediting the speed at which we can return and remain in an active economy. Even if it saved just two days of lockdown, the bonds could cover the costs of every single person being tested with both a rapid antigen and antibody test priced at £30 each. As set out in this paper, there are tests already available well below this amount.

The Role of Rapid Tests in a Mass-Testing Strategy

Rapid tests, both antibody and antigen, offer the opportunity to increase testing capacity and provide on-the-spot results, both of which support a quicker return to normal life.

On-the-Spot Testing

The pace at which rapid antigen tests provide results means that they could be used in conjunction with mobility credentials and deployed effectively at places like borders to ensure that a hierarchy is not created between those who have and have not had the virus.

15 https://www.barrons.com/articles/how-to-get-enough-coronavirus-tests-pay-only-for-success-51587221753

16 https://www.thetimes.co.uk/edition/business/consumer-confidence-at-its-lowest-since-the-financial-crisis-p6phf7x3k

The window of use for antigen tests is narrow, operating during the period between symptoms and antibody production. This could be as short as days and may be up to two weeks. If a sample is not collected and a test is not completed during this period, then an infection could be missed.

Table 3 – An integrated testing regime

	Lab-based		**Rapid**	
Antibody (the most important component is accuracy)	Highly accurate; multiple-hour-long processing time; technical sample-collection process	Recommendation: Require this test to acquire antibody-based mobility credentials	Easy to distribute and administer; not as accurate as the lab-based test; results in 10-15 minutes	Recommendation: Use these tests: 1) to conduct population sampling to understand prevalence of immunity and 2) as part of a screening process to identify people for more expensive lab-based testing
Antigen (at a population level, the most important component is speed followed by accuracy)	The most reliable antigen tests available; 24-48 hours to receive results	Recommendation: Provide these tests for priority workers such as frontline care staff and keyworkers where accuracy is imperative	Easy to distribute and administer; results within 15 minutes	Recommendation: Use these tests: 1) to enable mass population testing and 2) at the point of use, e.g. in airports, conferences, etc)

The Role of Rapid Antibody Testing

Sampling the population in the UK

Antibody tests should be used extensively for epidemiological purposes, across the globe, including in developing countries. Used in a longitudinal study or used to test individuals twice as is typical in pregnancy testing, the chances of error are very small.

Helping to filter candidates for greater-accuracy antibody testing

If someone tests positive on a rapid antibody test – suggesting antibodies are present and the individual has some degree of immunity to the virus – there is a risk that this is a false positive. Therefore, when someone tests positive using a rapid antibody test, they would then qualify for a lab-based

government ELISA test, which is highly specific. If the primary result is confirmed, the individual would then be issued a mobility credential as part of their digital identity wallet, enabling them to leave the mass-testing regime.[17]

The Role of Rapid Antigen Testing

Widespread, routine screening

The hierarchy of testing that we proposed in our previous paper on testing ("The Path to Mass Testing") is now in place, with anyone in the population able to put themselves forward for a PCR test. This is a huge improvement on the position of one month ago, however, as more distributed mechanisms to test individuals come online, it presents an opportunity to shift from a focus on capacity to one of strategy.

Rapid antigen tests reopen the possibility of more routine testing of the population. By removing the need for swabbing centres and lab processing that necessarily restrict capacity, rapid testing creates an opportunity to test a broader cross-section of the population, including those not currently showing symptoms. For example, they could be deployed very effectively in projects like the proposal to regularly test the 140,000 population of Norwich, identifying and tracing the interactions of asymptomatic carriers.

Operationalising the Use of Rapid Tests

Integrating rapid tests into the regime requires both the distribution networks to get tests to people and the systems to communicate the results to the appropriate parties.

The government has already set up a mechanism for people to request a PCR test. This system could be expanded to include the distribution of both rapid antigen and antibody tests to all members of the public that require them (whether or not they are showing symptoms). Once registered for a test, examples of how they could be distributed include:

- Royal Mail or private courier
- Local hubs with dedicated teams that hold and distribute kits to shorten supply chains
- Stockpiles held in local communities, with pick-up points that the public

can easily access

- Local institutions that hold kits for their employees/students

Businesses and other commercial institutions should also be able to purchase tests for their own use to support their ability to, for example, open an office or run a conference.

Informing Others of Results

Establishing systems for communicating the results is an important element of a distributed testing regime. Testing is not just about knowing if an individual has the virus and their according need to self-isolate, it is also about understanding the prevalence of the virus in the wider population.

Many national policy decisions are being made on the basis of understanding the rate of reproduction in society (with the imperative to keep R well below 1), but there will also be localised decisions about the closing of offices, schools or public buildings based not on R but on the test results of one or more relevant individuals.

In issuing the test, there must be clear instructions that are simple and easy to follow to communicate your results to the relevant parties. This will be both national and local, but the government should create a single system that is then accessible to all the relevant authorities. Ideally this would be integrated with the tracing regime but will require the building of systems to do so.

17 The period of time a person leaves the testing regime will link to ongoing research on the length of immunity antibodies provide.

Combining On-the-Spot Tests and Lab-Based Tests Manages Risk

Critically, in this paper, we are not advocating replacing lab-based tests with on-the-spot tests. We argue these two processes should be combined.

Antigen Testing

- In the case of on-the-spot antigen testing, we recommend a positive result for Covid-19 be followed up with confirmation with a lab-based PCR test. This would maximise the chances of correctly identifying a positive case.
- Anyone presenting with suspected Covid-19 symptoms is already offered a PCR swab test.
- The gap in this approach is in asymptomatic individuals who test negative but do in fact have the virus. Such false-negative cases, however, are not covered under the existing government strategy in any case.
- The strategy we propose would apply a double check on positive cases.

Antibody Testing

- We apply the same recommendations to on-the-spot antibody testing. Any positive case would be confirmed using the highly accurate lab-based ELISA test.
- The gap here arises where somebody could receive a negative result but actually has antibodies. In such a case no risk arises – the person has short-to-medium term immunity but isn't aware of it.

There is a lower risk with combined rapid and lab-based testing than arises in the current government strategy.

On-the-Spot Antigen Tests – What's Out There?

A key part of addressing this testing gap is working with industry, particularly smaller UK-based firms, to expedite bringing onstream viable rapid tests. Problems continue with these firms being unable to navigate the validation process for various reasons, including government prioritisation. This compares unfavourably with, for instance, the US system where an Emergency Use Authorisation from the FDA can be gained within 14 days. The UK faces the prospect of having very limited capacity on rapid and innovative testing capacity and ending up over-reliant on lab-based testing, with all the problems that go along with this. The US by contrast is quickly validating a whole range of tests, giving it the full spectrum of providers to underpin a mass-testing strategy.

How They Work

Antigen tests use antibodies to look for viral proteins, including those that would come from the spikes on the outer surface of the coronavirus, detecting the presence of a virus.

The rapid antigen tests can be done via a nasopharyngeal sample or via a saliva sample with reports emerging on the suitability of testing from saliva samples performing equally or better than swab.

The tests work in a similar way to a pregnancy-style test (a lateral flow assay).

These tests could deliver a result within 15 minutes with minimal user intervention.

Are They Accurate?

The nature of rapid antigen tests means they work better when there is a higher viral load in order for there to be enough viral proteins for the antibodies used in the test to bind to. While reservations remain over the accuracy of the tests, there have been recent positive developments. We argue that the government should fully support efforts to get rapid antigen tests onstream. Easing lockdown is about mitigating, not eliminating, risk – because it will always be present. The accuracy of rapid tests can be

managed through a regular drumbeat of testing while the positive of establishing a mass-testing regime now outweighs the risks of not doing so.

Quidel, the maker of the rapid antigen test approved in the US, says its test has demonstrated a clinical sensitivity of 80 per cent and specificity of 100 per cent when compared with an EUA (Emergency Use Authorisation) molecular device.[18]

A new study in the *Journal of Infectious Diseases*, "Evaluation of Novel Antigen-Based Rapid Detection Test for the Diagnosis of SARS-CoV-2 in Respiratory Samples", assessed the fluorescence immunochromatographic SARS-CoV-2 antigen test made by Bioeasy Biotechnology Co using nasopharyngeal and oropharyngeal swabs from suspected Covid-19 cases. Diagnostic accuracy was determined in comparison to SARS-CoV-2 real time (RT)-PCR. A total of 127 samples were included; 82 were RT-PCR positive. Overall sensitivity and specificity were 93.9 per cent and 100 per cent (CI95 per cent 92.1–100), respectively, with a diagnostic accuracy of 96.1 per cent. Sensitivity was significantly higher in samples with high viral loads.[19]

A 2016 analysis by Jeremie Cohen, Nathalie Bertille, Robert Cohen and Martin Chalumeau[20] of 116 rapid antigen tests (looking for the bacteria that causes strep throat) found they had an average sensitivity of 86 per cent. Tests to diagnose viral infections, like the flu, can be less sensitive. Their specificity is higher and can exceed 95 per cent.[21]

On the Market

According to the website FindDX, which the European Centre for Disease Prevention and Control refers to, 20 rapid antigen tests *() ()* have been commercialised (16 have been CE marked, while four are designated as research-use only).

In the US the FDA authorised its first rapid antigen test earlier this month, made by Quidel. The Sofia 2 antigen test was approved for use in equipped laboratories and as a point-of-care test in hospitals, care clinics and other settings.

We understand a number of reliable antigen tests are in the process of being developed and should be onstream and could be scaled in the coming months.

18 https://www.quidel.com/sites/default/files/product/documents/EF1438900EN00_0.pdf">https://www.quidel.com/sites/default/files/product/documents/EF1438900EN00_0.pdf

19 https://www.ijidonline.com/article/S1201-9712(20)30405-7/fulltext

Pipeline of Innovations:

COVID Detect by Homodeus

COVID Detect by Homodeus is an accurate, rapid, affordable home test for the novel coronavirus currently under development. A true home test, its methodology does not require samples be sent to a lab for verification. *COVID Detect* is built for scalability, and Homodeus is working to ensure Covid-19 is the last pandemic in which people do not have easy means to get tested.

Homodeus is a US life-sciences company based in Guilford, Connecticut, and led by Chairman Dr Jonathan Rothberg. Rothberg won the 2013 National Medal of Technology and Innovation from President Obama for pioneering inventions and commercialisation of next generation DNA sequencing technologies, and leads the 4Catalyzer incubator – seven companies that combine proprietary hardware innovation with artificial intelligence and cloud computing to make medicine and diagnostics more accessible globally.

As reported by Homodeus, *COVID Detect* is moving an entire laboratory into an at-home do-it-yourself nucleic acid home test with test results in less than an hour. This contrasts with lab-, clinic- and hospital-based tests, which require a trained technician and a significant upfront cost per device, and can take several hours.

As a nucleic acid (molecular) test, *COVID Detect* identifies the genetic material of the virus as soon as it is present, even in asymptomatic people. The company's approach also differentiates from the common Covid-19 antigen and antibody tests, which cannot rule out active infection and are effective only at a much later point in the infection lifecycle (three to five days, and seven to ten days later, respectively, than molecular tests).

Working closely with the FDA and pending FDA Emergency Use Authorisations, Homodeus aims to first distribute *COVID Detect* for point-of-care facilities, then in home settings shortly after.

QuantLase Imaging Lab

QuantLase Imaging Lab, a UAE-based company, has recently announced it has developed new equipment enabling faster mass screenings, with results available quickly.

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20 https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD010502.pub2/full

21 https://www.scientificamerican.com/article/breakthrough-covid-19-tests-are-currently-cheap-fast-and-not-very-accurate1/

Dr Pramod Kumar, who leads the team of researchers at the lab has said that, "The equipment, which uses a CMOS detector, will enable mass-scale screening with results made available in seconds … In fact, our laser-based DPI [Diffractive Phase Interferometry] technique, based on optical-phase modulation, is able to give a signature of infection within a few seconds. What's more, it is user-friendly, non-invasive and low-cost. We believe it will be a game-changer in tackling the spread of the coronavirus."[22] (The technique is able to differentiate between a healthy blood cell image and an infected blood cell image.)

22 https://www.businesswire.com/news/home/20200520005743/en/UAE-Develops-Rapid-Coronavirus-Laser-Testing-Technology

On-the-Spot Antibody Tests – What's Out There?

How They Work

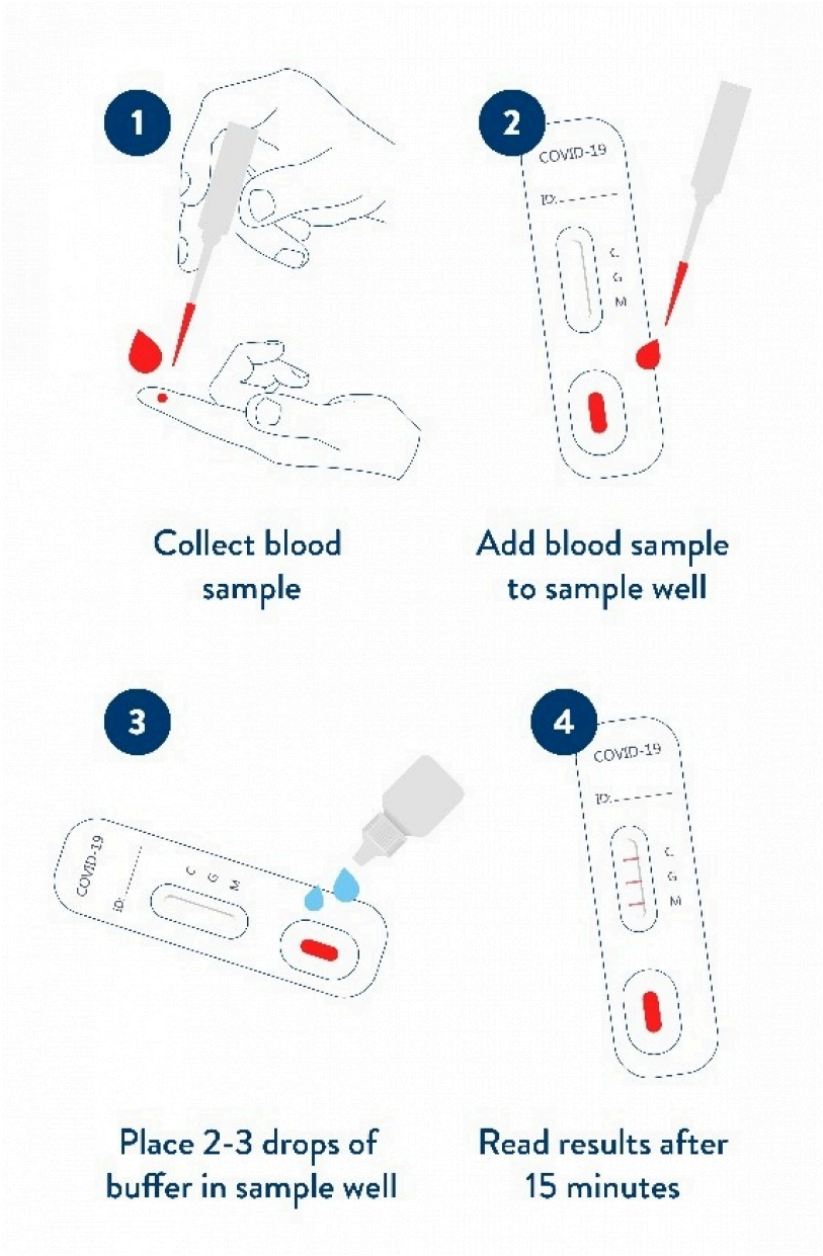
Rapid antibody tests are a simple positive/negative lateral flow assay test, like a pregnancy test kit, that can be done at home or at point of care.

Typically, these tests use a finger prick to produce a small blood sample but could also utilise saliva samples or nasal swabs.

These tests would take between 10 and 30 minutes.

An example of how this works with a test by BioMedomics is included below:

Figure 3 – How a finger-prick rapid antibody test works



Source: https://www.azbio.org/bd-biomedomics-announce-launch-of-rapid-serology-test-to-detect-exposure-to-covid-19

On the Market

According to FindDX there are 163 rapid antibody tests available for commercial use.

In the UK, only two antibody tests, by Roche and Abbott, have been assessed by Public Health England (PHE) and approved by the Medicines and Healthcare products Regulatory Agency (MHRA), neither of which are rapid tests.

PHE laboratories have conducted analysis on these two tests. Professor Jon Deeks (head of the Test Evaluation Research Group at the University of Birmingham) outlined that: "For the Roche test, 93 samples with COVID-19 were tested, of which 78 (84%) gave positive test results. Thus 16% were missed. For the Abbott test, 96 samples with COVID-19 were tested, of which 90 (94%) gave positive test results. Thus 6% were missed."[23]

There are, however, a number of UK-based companies with antibody tests that we believe are good enough to be used publicly, especially when backed up by confirmation through a lab-based ELISA test. These companies include:

- **BioPanda:** A Northern Irish biotech company that produces a rapid antibody test. The firm is selling its testing privately within the UK and has also previously despatched orders "throughout Europe and across the world."
- **SureScreen:** Private company based in Derby that says it has developed a rapid test that can reach results with 98 per cent accuracy. It is based on using a finger-prick blood sample and can produce a result in 10 minutes. SureScreen says its tests are being used by private buyers in the UK, Ireland, Germany, Kuwait, Netherlands, Oman, Spain, Switzerland, Turkey and the UAE.
- **Mologic:** UK-based bioscience company based in Bedfordshire that has produced a rapid antibody test and have an antigen test under accelerated development. It is expected to receive a European CE mark for the tests but has not yet been approved by the MHRA. Mologic announced in May that a preliminary independent assessment by St George's University London and Liverpool School of Tropical Medicine showed their rapid diagnostic test achieved clinical performance data of 98 per cent sensitivity (at days 14 to 21) and specificity of 96 per cent. Mologic have established a social enterprise, Global Access Diagnostics, with support from FINDDx and the Bill & Melinda Gates Foundation to delink production from commercial interests and scale rapid diagnostics for low-income settings. [24]

23 https://www.sciencemediacentre.org/expert-reaction-to-phe-laboratory-evaluations-of-roche-and-abbott-antibody-tests/

24 https://mologic.co.uk/preliminary-clinical-performance-data-for-professional-use-covid-19-rapid-diagnostic-test/

Pipeline of Innovations

We are aware of a number of other rapid antibody tests in development.

One of these is a product the size of a mobile phone that has two modalities: antibody or a DNA molecule produced from amplification of existing virally infected cells. This means it could detect both whether someone has the virus or has had the virus. Results would be produced rapidly and could be automatically reported to health authorities. Subject to approval, the testing device could be mass produced and affordable for widespread use

Lab-Based Rapid Tests

Alongside rapid on-the-spot antigen and antibody tests, there are also tests that use a PCR swab but deliver results more quickly.

These include the prospect of completing rapid molecular tests in different locations without the need of a laboratory or expensive equipment. Three companies with such products in development include Biocrucible (UK), Mammoth Biosciences and Sherlock Biosciences.

Two of these PCR testing kits are:

- Xpert Xpress SARS-CoV-2 by Cepheid
- Abbott ID NOW test

These tests have shorter turnaround times than a normal PCR swab test. The Cepheid kit delivers a result in 30 minutes, while the Abbott test can return a positive result in five minutes.

There are, however, constraints with this type of test.

First, these tests are still lab-based, meaning they are not point-of-use tests. This adds a potential ceiling on maximum numbers of tests and the setting in which they need to be done, and the respective cost.

Second, concerns have been raised about their accuracy. On 15 May, for instance, the FDA released an alert about the Abbott ID NOW test and its potential to give inaccurate negative results.[25]

25 https://www.medicaldevice-network.com/comment/questions-raised-abbott-id-now-covid-19-test/

Mass Testing Alongside Other Measures

Mass testing, alongside other containment measures we set out in a recent paper *"The Architecture of Containment: Getting to Gold"*, will mitigate the risks in lifting lockdown.

Masks

In the short-term, we recommend use of either a custom face covering or a disposable surgical mask. In the medium- to long-term, we recommend the government commits to onshoring the manufacturing of both disposable medical masks and high-grade N95 masks with an ambition to develop enough stock to equip the entire nation.

Tech

We recommend the deployment of wearables and symptom trackers that can monitor symptoms, as well as new detection mechanisms such as smart thermometers and oximeters.

Track and Trace

In terms of track and trace, alongside harnessing the critical role rapid testing can play, we recommend recruiting up to 100,000 contact tracers drawing on the 700,000 NHS volunteers, creating software to allocate tasks and send notifications as well as using anonymised location data to identify hotspots and trends.

Towards a Digital Identity

A mass-testing regime is a crucial piece of containment infrastructure. But beyond informing individuals of the result, many close-proximity spaces such as care homes, airports and airplanes need a way to ensure that everyone who enters is safe to do so. To meet this need, tests should confer a mobility credential, a biometrically secured digital code (e.g. a QR code) stored on a person's phone. Individuals would then be required to present this code for verification when entering specific settings.

Different credentials would be issued depending on the type of test received, in turn conferring different privileges on recipients:

Basis for credential	Permits travel + access to settings	Further testing and tracing
Lab-based, positive antibody test	Yes, at least medium term, possibly permanent	Exempt, at least medium term
Point-of-use, negative antigen test	Yes, temporary	Still participates

If the lab-based positive antibody test credential is like a passport, the point-of-use credential is more like a visa. This helps to avoid retesting people unnecessarily several times a day, such as when coming and going from an office, without exempting them permanently. It would be for authorities to set out when credentials expire (e.g. over time, or after visiting multiple locations), but a digital system allows for this flexibility in a way that a paper-based system could not. The different types of credentials also highlight that the fundamental use case is to assess who can travel or access other settings, and on what basis, not who is immune *per se*.

Broader challenges remain to secure widespread public consent for implementing a digital-identity infrastructure, and we will address these issues in a forthcoming paper. But many countries face the same challenges to protect close-proximity spaces and other settings, and the need isn't going away. In particular, international travel will require countries to work together to mutually recognise credentials, so the UK should lead in coordinating this effort.

Conclusion

As the UK eases lockdown, we find ourselves at a critical juncture for the country. New case numbers are higher than our international neighbours and any wrong move could set off a second spike of the virus. Only through rigorous, extensive, mass testing can the government identify and quash outbreaks before they spread too far.

This requires the government's approach to testing to fundamentally change. An over-reliance on centralised lab-based testing must be dropped to mobilise the full range of lab space in the country.

The most pressing gap in the government's existing strategy is on rapid testing, particularly point-of-use tests. Without a clear way to know, quickly, if someone has, or has had, the virus, how can businesses properly return to work? How can travel, international and domestic, restart? Here, the government must work, urgently and collaboratively, with smaller UK-based firms to bring online all viable rapid-testing capacity, expediting validation and unlocking investment in innovative startups through Covid-19 innovation bonds.

Without rapid point-of-use testing, where results are available in minutes not days, the country will face a choice between a cycle of lockdowns or exiting the current lockdown with a real risk of the disease spreading.

After months of sacrifice, the country stands at the point of maximum danger as we begin easing restrictions. We cannot afford to get this wrong. To get it right we need full-spectrum capacity and capability on testing within a robust system of measures to limit transmission and exposure. This demands an urgent change of approach.

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