COVID-19 and Coronavirus evidence alerting

Rapid scan 4: Screening and testing strategies

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Midlands and Lancashire
Commissioning Support Unit

The Strategy Unit is working in collaboration with the Health Foundation, King's Fund, Nuffield Trust, and Imperial College Healthcare Partners to provide additional analytical support to the NHS nationally in its overall response to COVID-19. The organisations will use their expertise to focus on questions that the NHS may lack the immediate resources to look at, which may be more medium-term, cut across sectors, or benefit from independent analysis. They will be sharing their knowledge, information, multi-disciplinary analytical skills, and extensive links to support different parts of the health and care system, arms-length bodies and government departments working on the COVID-19 response. For more information please email mlcsu.covid.analytics@nhs.net.

This rapid summary is part of an evidence alert service which has developed from requests for evidence to support recovery planning. Our first priority is to highlight key papers to inform decisions, policy and planning and our approach is pragmatic rather than exhaustive. More information on our methodology is provided in the Appendix.

A short note about evidence analysis and COVID-19

The emerging evidence base on COVID-19 and Coronavirus is growing quickly. The research community has responded to the pandemic quickly and publishers are fast-tracking papers and providing open access. This inevitably leads to some trade-offs:

- Findings are shared quickly but there are implications for quality as the usual peer review is curtailed - so we need to be mindful of bias in research methods and quality of reporting.
- The pace of learning is such that, at the moment, it is not feasible to conduct a traditional review which summarises and synthesises what we know. The evidence base is growing so quickly that our understanding is continually shifting.

Our approach is to trawl the rapidly growing knowledge base, to filter findings which are relevant to planning and policy and to highlight new and emerging learning:

- This rapid scan provides a snapshot of emerging evidence.
- A weekly alert will highlight new papers.
- We will also maintain an evidence tracker, providing a single point of access to the papers highlighted in this scan and in weekly alerts.

There are, of course, initiatives around the UK and internationally to scan and track evidence and we'll endeavour to avoid duplication as far as possible.

Summary

Scope

- Screening and testing strategies form only one element of an overall epidemic response and need to be considered within the context of all actions, including broader public health measures such as surveillance, that are designed to optimise healthcare requirements and successfully manage COVID-19.
- This scan sets out the current policy decisions about screening and testing in the UK; looks at international strategies; offers key international expert guidance and analysis on the topic and examines the most recent scientific empirical literature. This literature is presented under the themes: What strategies make COVID-19 testing effective?; Group testing/pooled testing; Scaling up testing and population-scale testing; Testing strategies on release from lockdown; Digital technology; Impact of testing on the case fatality rate; Testing strategies in a vulnerable setting; Limitations of testing strategies

Headlines

- **Testing strategies** can be used to achieve three main goals:
- Suppressing the resurgence of local outbreaks (through antibody testing)
- Identifying people who have developed some form of immunity and can safely return to work (through antigen testing)
- Gaining intelligence on the evolution of the epidemic, including on when a threshold for herd immunity has been reached.

What the experts say about testing strategies

- Find, test, treat, and isolate is the established public health method of containment in a communicable disease situation
- The WHO, EU and other international experts all recommended this approach, with mass testing as far as is practicable
- Diagnostic testing may be better undertaken locally and there is evidence that point-of-care testing may improve efficiency
- Contact tracing is universally considered to be particularly important, with it referred to as the "cornerstone" of effective public health response in the face of infectious disease outbreaks

Summary

Current UK Strategy - evolution

- The Department of Health and Social Care published its testing strategy *Coronavirus (Covid-19): scaling up our testing programmes* on 4 April, setting out its plan across 5 "pillars" of: NHS swab testing; commercial swab testing; antibody testing; surveillance testing; diagnostics national effort.
- The Health Foundation Policy Tracker provides a timeline of how policy and health system responses during the pandemic, including measures to limit spread.
- There are some differences in the approaches to lockdown and exiting lockdown in Wales, Scotland and Northern Ireland. Further information on testing and screening strategies are available, as follows:
    - Wales
    - Scotland
    - Northern Ireland
- The Health System Response Monitor provides a comparison of testing strategies across different countries.

Key features of the current UK strategy

- The Government has committed to "ramp up" testing, with an ambition to achieve 200 000 tests a day by the end of May.
- A centralised approach has been adopted, with testing contracted to four large private "Lighthouse" laboratories.
- A programme of antibody testing has begun to track the extent of viral spread in the community
- Surveillance is also underway with a pilot phase undertaken of swab tests
- A test and trace programme is outlined in the Government's recovery strategy, which involves both a manual (telephone) approach and the development of a tracing app which is currently being trialled on the Isle of Wight

Summary

International testing strategies

- Policies vary from country to country and even region/city to region/city within a country as countries respond to local outbreak needs
- Issues around supplies, shortages and priorities have led policy decisions
- Testing strategies fall on a spectrum from limited and delayed to aggressive and early action on testing
- Italy, UK and the US have principally been testing patients with severe symptoms and have largely withheld testing asymptomatic individuals.
- By contrast Germany, Iceland and South Korea have quickly expanded testing regimens to mildly symptomatic cases, and to asymptomatic individuals who work in jobs where, should the become infected, have a high chance of spreading the virus to many others e.g. healthcare staff and workers in transportation hubs
- Countries which persisted with expanded and rigorous testing and tracing programmes, such as Germany, South Korea, Hong Kong, Singapore, and New Zealand, have fared better with lower deaths rates than those which did not, such as Belgium, France, Italy, Spain, UK and the USA

Testing and easing of lockdown

- Independent SAGE has stated that transition from lockdown needs sufficient public health and health system capacity in place to identify, isolate, test and treat all cases, and to trace and quarantine contacts. Ideally testing should be at a local level.
- This type of approach is also suggested by OECD and public health experts and epidemiologists

Summary

Empirical studies

Evidence from empirical studies: Effectiveness

- This is a fast-moving situation, with new studies published daily. However, there are limitations with these studies. Due to time constraints and urgency needed to release findings into the public domain, few studies have been peer-reviewed. Most are either case studies or else modelling studies
- The most robust analysis comes from Imperial College Report 16, which looks at the role of testing in COVID-19 control. Using modelling to investigate the effectiveness of various testing strategies, the study finds that testing is most useful when targeted at high-risk groups such as healthcare and care home staff and other at-risk groups, where weekly screening using PCR or point-of-care tests for infection irrespective of symptoms in addition to testing of symptomatic individuals may prevent an additional 25-33 % of their contribution to transmission in hospital and the community.

BUT

- This is dependent upon test results being delivered quickly (less than 24 hours after the swab is taken)
- Widespread PCR testing of the general population is essential for pandemic surveillance but this report suggests its direct contribution to the prevention of transmission is likely to be limited to patients, HCWs and other high-risk groups.
- Immunity passports - using infection testing or antibody testing to demonstrate that someone has had and recovered from Covid-19 and now has immunity - could help people return to work but these face significant technical, legal and ethical challenges.
- Findings related to the benefits of periodic testing of healthcare staff have been confirmed by several other studies, both modelling and case studies in UK hospitals
- A systematic review of interventions to suppress the COVID-19 pandemic suggests there is lower quality evidence that the most cost-effective interventions are swift contact tracing and case isolation and surveillance networks
- Capacity issues does not allow high-throughput and community level scans of COVID-19 infections. Various studies have supported the principle of “group testing” or “pooled testing” to overcome this issue.
- There is evidence suggesting that this may be a feasible and promising approach when the resources are scarce, but different pooling protocols are needed.

Summary

Evidence from empirical studies: Group testing/pooled testing

- Capacity issues do not allow high-throughput and community level scans of COVID-19 infections. Various studies have supported the principle of "group testing" or "pooled testing" to overcome this issue.
- This approach means that the swabs of multiple patients are grouped together and tested.
- There is evidence from modelling studies suggesting that this may be a feasible and promising approach when the resources are scarce, but different pooling protocols are needed depending on estimated prevalence, target specificity, and high- vs. low-risk population

Evidence from empirical studies: Scaling up testing and population-scale testing

- There is some evidence for the effectiveness of this approach (and that it may even be cost-saving and population-scale testing does not need to be very accurate), but it remains scant and equivocal and should be interpreted cautiously

Evidence from empirical studies: Testing strategies on release from lockdown

- Evidence from these studies confirm the need for adequate surveillance and contact tracing to be in place to manage lockdown and to avoid overload of health systems

Evidence from empirical studies: Testing strategies: Digital technology

- Only one study was found which reported that a mitigation strategy combining smart testing with contact counting (STeCC) and contact tracing in one app may reduce R0 by 2.4-fold

Evidence from empirical studies: Testing strategies: impact of testing on the case fatality rate

- There is very limited evidence from a few studies that local testing and that extensive testing all have a positive impact on mortality rates, with the countries with the highest testing rates per population having the lowest death rates

Summary

Evidence from empirical studies: Testing strategies: Vulnerable populations

- Only one study was found which reports that improving COVID-19 surveillance can alert healthcare institutions to emerging outbreaks before they escalate. Group testing patients and staff with any COVID-like symptoms was both the most timely and efficient strategy.

Evidence from empirical studies: Testing strategies: Limitations

- Limited test capacity means confirmed case numbers can be significantly lower than the actual number of infections
- Increased testing capacity alone may not provide a solution to lockdown measures in the UK. The progression of the epidemic and peak infections depends heavily on test characteristics, test targeting, and prevalence of the infection. Antibody based immunity passports are rejected as a solution to ending lockdown, as they can put the population at risk if poorly targeted.

Mass screening for active viral infection may only be beneficial if it can be sufficiently well targeted, otherwise reliance on this approach for protection of the population can again put them at risk. A well targeted active viral test combined with a slow release rate is a viable strategy for continuous suppression of the virus.

Evidence from empirical studies: Testing strategies: Vulnerable populations

- Only one study was found which reports that improving COVID-19 surveillance can alert healthcare institutions to emerging outbreaks before they escalate. Group testing patients and staff with any COVID-like symptoms was both the most timely and efficient strategy

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Background

There are two key types of testing for individuals.
Antigen test: tells us if an individual currently has the disease (swab testing - RT-PCR test)
Antibody test: tells us whether an individual has had the virus in the past (serology testing)
At a **population level** these test results can help inform and direct policy strategy and health service response to the virus.
Testing strategies can be used to achieve three main goals:

- Suppressing the resurgence of local outbreaks
- Identifying people who have developed some form of immunity and can safely return to work
- Gaining intelligence on the evolution of the epidemic, including on when a threshold for herd immunity has been reached.

Testing has always been of paramount importance, **(WHO: Test, test, test; 16-03-20**) but testing on a massive, untargeted scale is not practicable.
A well-designed, effective testing strategy is needed that tests, tracks people infected and traces their contacts (TTT). This, combined with smart containment strategies, helps to reduce the spread of the virus and bringing its reproduction number below one will help to ensure that the contagion curve is flattened and the health system can operate within its capacity.

Interpreting a covid-19 result
Relies on understanding the accuracy of the test, and the pre-test probability or estimated risk of disease before testing. Positive RT-PCR test for covid-19 test has more weight than a negative test because of the test's high specificity but moderate sensitivity.

A single negative covid-19 test should not be used as a rule-out in patients with strongly suggestive symptoms

Expert guidance, analysis and opinion- Testing

World Health Organization

Coronavirus disease (COVID-19) technical guidance: Surveillance and case definitions[1]

The WHO supports a policy of widespread testing

This document covers:

- Surveillance strategies for COVID-19 human infection
- Contact tracing in the context of COVID-19
- Considerations in the investigation of cases and clusters of COVID-19
- Global Surveillance for human infection with coronavirus disease (COVID-19)

Laboratory testing strategy recommendations for COVID-19[2]

Guidance on the strategic use of diagnostic testing in different COVID-19 transmission scenarios

King's Fund

Testing times: the government's approach to Covid-19 testing[3]

An Explainer by David Buck, Senior Fellow, Public Health and Inequalities, setting out the different types of testing, the purpose of testing and the current UK government approach to delivering testing, acknowledging that there are some nuances to testing between the nations of the UK

CEBM Oxford

Molecular and antibody point-of-care tests to support the screening, diagnosis and monitoring of COVID-19[4]

Moving diagnostic testing for COVID-19 from laboratory settings to the point of care is potentially transformative in the rate and quantity of testing that could be performed. Eleven diagnostic tests that are potentially suitable for testing for COVID-19 at the point-of-care are described: six molecular tests, and five antibody-based tests. Some devices show high diagnostic accuracy during controlled testing, but performance data from clinical settings, and a clear understanding of the optimal population and role for these tests in the care pathway, are currently lacking.

Nato Centre of Excellence for Military Medicine

COVID STRATEGY: Systematic concentric circle testing methodology[5]

This paper proposes an effective combination of three imperfect testing methods as a solution for a testing strategy, and as a basis for rationalising and coordinating medical, social, economic and political measures. It has input from Imperial College, London.

Expert guidance, analysis and opinion- Testing

European Union

EU recommendations for testing strategies (18 March 2020)[6]

- *"As the epidemiological situation evolves, testing strategies must adapt in order to ensure an optimal use of resources and alleviate pressure on laboratories".*
- *"Priority should be given to invest in research and development for point-of-care diagnostics and serological tests in the guidelines for testing"*

Who to test in the EU?

The precise situation differs from one Member State to another. Testing in decreasing order of priority:

- Testing of hospitalised patients with Severe Acute Respiratory Infections (SARI) in order to inform appropriate clinical management, including isolation and PPE measures.
- Testing any cases of acute respiratory infection in hospitals or long-term care facilities in order to guide infection control and PPE use to protect both vulnerable persons and healthcare staff
- Testing of symptomatic healthcare staff, even with mild symptoms, to guide decisions on exclusion from and return to work; the aim is to protect health and social care services.
- Elderly people with underlying chronic medical conditions such as lung disease, cancer, heart failure, CVD, renal disease, liver disease, hypertension, diabetes, and immunocompromising conditions exhibiting signs of acute respiratory illness, given that they may more rapidly need respiratory support. Particular attention should be given to vulnerable populations, for example people living in homes for elderly persons.
- If the epidemic is local and resources allow, testing of all patients with respiratory infection. This can inform contact tracing especially in the containment phase. Testing of asymptomatic patients which have been identified as contacts to a COVID-19 case may be considered as part of the contact tracing.

Expert guidance, analysis and opinion-importance of contract tracing as part of overall testing strategies

Centers for Disease Control and Prevention (CDC)
Contact Tracing: Part of a Multipronged Approach to Fight theCOVID-19 Pandemic[7]
Basic principles of contact tracing to stop COVID-19 transmission

A Framework for Sustainable Contact Tracing and Exposure Investigation for Large Health Systems[8]
Argues that despite its challenges (e.g. labour-intensive), contact tracing is the cornerstone of communicable disease containment. It involves identifying, quarantining, and monitoring contacts of infected people.
A framework for feasible, scalable COVID-19 contact tracing in a large multi-state health system in the US is presented

BMJ: Covid-19 contact tracing: a briefing[9]
This briefing analyses what contact tracing involves, whether it is still effective when there is widespread infection, how other countries have utilised the method and the role of contact tracing apps, particularly in comparison with manual tracing methods

Expert guidance, analysis and opinion-importance of surveillance

Strategies for the surveillance of COVID-19[10]
This document proposes an updated strategy for COVID-19 surveillance at national and EU/EEA level that specifically aims to reconcile the data needs for effective pandemic response with what is still feasible in countries and within healthcare systems under siege, while taking into account guidance issued by the World Health Organization.

UK Position - 1
The Department of Health and Social Care published its testing strategy ***Coronavirus (Covid-19): scaling up our testing programmes***[11] on 4 April, setting out its plan across 5 "pillars".

1. NHS Swab testing
2. Commercial swab testing
3. Antibody testing
4. Surveillance testing
5. Diagnostics National Effort

This strategy is evolving and developing in the light of new knowledge about the virus
It is augmented by the government's *Our Plan To Rebuild: The UK Government's COVID-19 recovery strategy*[12] which gives limited detail of further testing and tracing plans pages 38-40

UK Position - 2
In public health practice, serological analysis can be useful for rapid case-identification[13] and the subsequent chain of events to actively identify close contacts, recommend quarantine, and define clusters of cases.
the government bought 3.5 million finger prick blood tests from China which failed to pass sensitivity and specificity tests[14]
An antibody test being pioneered by Oxford University[15] could be available by the end of May, according to Professor John Newton, the UK's national testing co-ordinator
Two tests for covid-19 antibodies have been assessed and validated by PHE, but the evidence on which the approvals were based has not been made publicly available:
- An antibody blood test for covid-19, which the manufacturer Abbott claims is 99% accurate[16], has been certified for use by the EU and has received its CE mark
- Scientists at Porton Down evaluated a test produced by Roche[17] in the last week and found it to be highly specific

Expert guidance, analysis and opinion-importance of surveillance

UK position- 3
Public Health England: Coronavirus (COVID-19): Using data to track the virus[18]
PHE is responsible for surveillance in England. To help understand the spread of COVID-19, PHE uses a wide variety of real-time data at both local and national level, and in order to keep the public health system informed about this data, there is now a weekly surveillance report and weekly infographic[19].

Major home testing programme for coronavirus will track levels of infection in the community[20]
A nationwide **surveillance study** to track the **prevalence of infection** with SARS-CoV-2 in the general population has been launched, involving **swab testing** and **serology testing** to look at both the current rates of infection and how many people are likely to have developed antibodies to the virus.
The government is inviting **UK households** to take part in the study, with the pilot survey including 10,000 households in England and expects **25 000 to take part in the first phase**.
It aims to extend this to **300 000 households** over the next **12 months**.
The trial is led by the Department for Health and Social Care and the Office for National Statistics. It is sponsored by the University of Oxford and supported by data science company IQVIA UK and the National Biosample Centre in Milton Keynes.

Initial findings from the first wave of the pilot phase of the Coronavirus (COVID-19) Infection Survey for England[21]
This analysis included swab tests from a total of 10,705 participants, with 33 individuals in 30 households testing positive for COVID-19.
Based on tests conducted between 27 April and 10 May 2020, it is estimated 148,000 people in England had COVID-19 (95% CI 94,000 to 222,000), equating to 0.27% (95% CI 0.17% to 0.41%) of the community population in England (excluding hospitals, care homes).
The rate of positive tests was higher in those who self-reported working in patient-facing healthcare roles or resident-facing social care roles (1.33%; 95% CI 0.39% to 3.28%) than in those not working in these types of roles (0.22%; 0.13-0.35%). There was no evidence of any differences in the proportions testing positive in different age categories.

Expert guidance, analysis and opinion-importance of surveillance

What is the UK's contact tracing strategy?[22]

Contact tracing has previously been used successfully to control outbreaks of Ebola and various sexually transmitted infections. But particularly with covid-19, contact tracing needs to be combined with widespread testing of the public to identify new outbreaks as they happen

The UK had been conducting contact tracing until the government decided to stop this on 12 March when it moved testing capacity exclusively to patients admitted to hospital. This position has been criticised by public health experts such as John Ashton, Allyson Pollock and others

Test and Trace Programme[23]

There is an expert team leading on the rapid nationwide roll-out of the coronavirus (COVID-19) test and trace programme, which has been designed to minimise the spread of coronavirus, by identifying people who may have been in contact with the virus.

Full details of the new contact tracing programme have not been made public, although there is some detail in *Our Plan To Rebuild: The UK Government's COVID-19 recovery strategy*

PHE has been asked to oversee the recruitment of 18,000 staff and volunteers, including 3000 healthcare staff, through a complex regional and call centre model. Workers are being recruited through private companies

Another element of this part of the testing strategy is a contact tracing app development overseen by NHSX, is being trialled on the Isle of Wight

Many people will need to use it; In the UK, experts advising the NHS say that 80% of smartphone users—roughly 56% of the total population, or 37 million people—would need to use the app for it to be effective[24]

The app, which was developed by private firm VMWare, has faced criticism[25] because of technical limitations and privacy protection

A report from the Joint Committee on Human Rights[26] on the contact tracing app concludes that, there are significant concerns regarding surveillance and the impact on other human rights that must be addressed

Some expert commentators have said that local authorities must be at the heart of contact tracing[27] because covid-19 is best understood as a pattern of local outbreaks rather than a national pandemic.

Expert guidance/ analysis/ opinion - International testing strategies

International testing strategies - Description

World Economic Forum: Strategic Intelligence[28] suggests that:

Policy on testing differs from country to country, region to region and even city to city – it depends on what stage that community has reached in the pandemic curve and the level of preparedness in the specific context.

Different countries are pursuing very different strategies[29] with policies around the world varying. There seem to be arguments in support of the different approaches – largely due to supplies, shortages and priorities. Whilst the first priority will be the state of the epidemic in the country or community, second is the availability of testing resources - both the test kits themselves (or the swabs) and PPE for health workers, who are required to wear these in order to take the sample from patients

Testing strategies fall on a spectrum from limited and delayed to aggressive and early action on testing:

Italy, UK and the US have principally been testing patients with severe symptoms and have largely withheld testing asymptomatic individuals.

By contrast Germany, Iceland and South Korea have quickly expanded testing regimens to mildly symptomatic cases, and to asymptomatic individuals who work in jobs where, should the become infected, have a high chance of spreading the virus to many others e.g. healthcare staff and workers in transportation hubs

Specific details on individual countries can be found at:

COVID-19 OECD Health System Response Tracker[30] - details the latest in OECD countries' responses to the COVID-19 pandemic, including plans for testing

WHO health system monitor[31]

International testing strategies - Analysis

Different approaches in testing strategies may have been dictated by different logistical constraints, yet it is clear those countries that have employed intelligent testing and contact tracing strategies have in turn been more successful in containing COVID-19.

Countries which persisted with expanded and rigorous testing and tracing programmes, such as Germany, South Korea, Hong Kong, Singapore, and New Zealand, have fared better with lower deaths rates than those which did not, such as Belgium, France, Italy, Spain, UK and the USA. This is probably because contact tracing and testing can identify asymptomatic infections and isolate them faster than systems relying on the development of symptoms.

The Lancet: Are high-performing health systems resilient against the COVID-19 epidemic?[32]

This article explores how different testing strategies, combined with other measures, have contributed to disease control

Expert guidance, analysis and opinion- Testing strategies for coming out of lockdown

Independent SAGE[33]

This first report of the independent scientific advisory group for emergencies (iSAGE) focuses on the priorities for measures to support a gradual release from social distancing measures through a sustainable public health response to Covid-19. Many concerns about the UK's testing strategy have been raised in this report which can be summarised:

The government should refocus its ambition on ensuring sufficient public health and health system capacities to ensure that we can identify, isolate, test and treat all cases, and to trace and
quarantine contacts with quarantine for 14 days and not seven.

In order to underpin our recommendations, the future long-term management of the pandemic should be based on an integrated and sustainable public health infrastructure. The government has adopted a top-down approach with vertical structures for test and trace programmes. The overdependence on outsourcing of key operational functions limits the sustainability of this approach. A more appropriate infection control response will require adaptation for local needs. A 'find, test, trace' policy should be linked to GPs and to local public health.

Expert guidance, analysis and opinion- Testing strategies for coming out of lockdown

The Organisation for Economic Co-operation and Development (OECD)[34]
This policy brief discusses the role of **testing for COVID-19** as part of any plan to **lift confinement restrictions** and **prepare for a possible new wave of viral infections**.
If all confinement restrictions are lifted before a vaccine or effective treatments are developed without other measures to suppress new infections, the infection rate is expected to rebound rapidly. Crucially, quick suppression of infections requires testing more people to identify who is infected; tracking them to make sure they do not spread the disease further; and tracing with whom they have been in contact. This brief discusses how testing strategies can be used to achieve three main goals: 1) suppressing the resurgence of local outbreaks;
2) identifying people who have developed some form of immunity and can safely return to work
3) gaining intelligence on the evolution of the epidemic, including on when a threshold for herd immunity has been reached.
The brief discusses what tests can be used for each goal, as well as practical implementation issues with testing strategies, including the opportunities and risks of using digital tools in this context

Expert guidance, analysis and opinion- Testing strategies for coming out of lockdown

Lancet Public Health: COVID-19: extending or relaxing distancing control measures[35]

- New COVID-19 country-specific models should incorporate testing, contract tracing, and localised quarantine of suspected cases as the main alternative intervention strategy to distancing lockdown measures, either at the start of the epidemic, if it is very small, or after the relaxation of lockdown
- Modelling such a strategy for the UK would be extremely useful to guide when such measures could be lifted—i.e., at what proportion of the population tested (and, given asymptomatic and pre-symptomatic transmission, how regularly) could we be confident that we are controlling the epidemic sufficiently to considerably delay or even prevent resurgence if lockdown were to be lifted.
- Emerging data from South Korea, which adopted a widespread testing strategy early (in conjunction with an innovative digital crowd-sourced contact tracing strategy) and has so far avoided the need for widespread lockdown, would prove very useful in this regard. As would data from Italy, which is now attempting to use such a strategy as a way out of lockdown
- The contributions of testing, contact tracing, and localised quarantine on reductions in contacts and COVID-19 transmission could be determined via a model that simulates localised clusters throughout the country and estimates their likely coverage by testing, given the number of tests kits made available nationally per day. Promising pooled testing methods, whereby multiple samples (eg, from a household, or local cluster of up to 64 people—the limit of pool sample accuracy) are pooled 7 and all individuals are quarantined if the sample comes back positive, could be useful to multiply the effect of restricted testing capacity.
- **Professor Julian Peto FRS, statistician and epidemiologist at the London School of Hygiene and Tropical Medicine and fellow authors**
- Universal weekly testing as the UK COVID-19 lockdown exit strategy[36]
- Recommends evaluation of weekly SARS-CoV-2 antigen testing of the whole population in an entire city as a demonstration site (preferably several towns and cities), with strict household quarantine after a positive test.

Individual empirical studies (not peer-reviewed)- What Strategies Make COVID-19 Testing Effective?

Imperial College London: Report 16 - Role of testing in COVID-19 control[37]

Reports a simple mathematical model to investigate the potential effectiveness of alternative testing strategies for COVID-19 control.

Model found that testing is most useful when targeted at high-risk groups such as healthcare and care home staff and other at-risk groups, where weekly screening using PCR or point-of-care tests for infection irrespective of symptoms in addition to testing of symptomatic individuals may prevent an additional 25-33 % of their contribution to transmission in hospital and the community.

This is dependent upon test results being delivered quickly (less than 24 hours after the swab is taken)

Widespread PCR testing of the general population is essential for pandemic surveillance but this report suggests its direct contribution to the prevention of transmission is likely to be limited to patients, HCWs and other high-risk groups.

Immunity passports - using infection testing or antibody testing to demonstrate that someone has had and recovered from Covid-19 and now has immunity - could help people return to work but these face significant technical, legal and ethical challenges.

Periodic COVID-19 Testing in Emergency Department Staff[38]

Picking up on the idea of periodic testing for HCW, in this study a mathematical model was generated to predict the impact of periodic COVID-19 testing in asymptomatic members of the emergency department staff in regions affected by COVID-19 infection.

The model predicts that after 30 days, with a transmission constant of 1.219e-4 new infections per person2, weekly COVID-19 testing of healthcare workers (HCW) would reduce new HCW and patient infections by 5.1% and bi-weekly testing would reduce both by 2.3%. At a transmission constant of 3.660e-4 new infections per person,2 weekly testing would reduce infections by 21.1% and bi-weekly testing would reduce infections by 9.7-9.8%. For a lower transmission constant of 4.067e-5 new infections per person2, weekly and biweekly HCW testing would result in a 1.54% and 0.7% reduction in infections respectively.

Periodic COVID-19 testing for emergency department staff in regions that are heavily-affected by COVID-19 and/or facing resource constraints may reduce COVID-19 transmission significantly among healthcare workers and previously-uninfected patients.

Individual empirical studies (not peer-reviewed)- What Strategies Make COVID-19 Testing Effective?

A workable strategy for Covid-19 testing: Stratified periodic testing rather than universal random testing[39]

Proposes that 'stratified periodic testing'(based on at-risk groups, and 'periodic' as everyone in the group is tested at regular intervals) is better use of scarce testing resources than 'universal random testing'.

Finds that universal testing would require checking over 21 % of the population every day to reduce the effective reproduction number of the epidemic down to 0.75. This rate of testing using a corrected method for calculating the impact of an infectious person on others, where testing and isolation takes place, and where there is self-isolation of symptomatic cases. We also find that any delay between testing and the result being known significantly increases the effective reproduction number and that one day's delay is equivalent to having a test that is 30 percent less accurate.

Effectiveness of isolation, testing, contact tracing and physical distancing on reducing transmission of SARS-CoV-2 in different settings[40]

Study aiming to understand what combination of measures - including novel digital tracing approaches and less intensive physical distancing - may be required to reduce transmission.

Model of individual-level transmission stratified by setting (household, work, school, other) based on BBC Pandemic data from 40,162 UK participants was used to simulate the impact of a range of different testing, isolation, tracing and physical distancing scenarios.

Under optimistic but plausible assumptions, it was estimated that combined testing and tracing strategies would reduce transmission more than mass testing or self-isolation alone (50-65% compared to 2-30%).

If limits are placed on gatherings outside of home/school/work (e.g. maximum of 4 daily contacts in other settings), then manual contact tracing of acquaintances only could have a similar effect on transmission reduction as detailed contact tracing.

In a scenario where there were 10,000 new symptomatic cases per day, it was estimated in most contact tracing strategies, 140,000 to 390,000 contacts would be newly quarantined each day. Analysis estimates that a high proportion of cases would need to self-isolate and a high proportion of their contacts to be successfully traced to ensure an effective reproduction number that is below one in the absence of other measures. If combined with moderate physical distancing measures, self-isolation and contact tracing would be more likely to achieve control.

Individual empirical studies (not peer-reviewed) What Strategies Make COVID-19 Testing Effective?

Multi-Tiered Screening and Diagnosis Strategy for COVID-19: A Model for Sustainable Testing Capacity in Response to Pandemic[41] (NB Published; peer-reviewed review)

- *Delayed testing deployment has led to uncertainty surrounding overall disease burden and community spread, severely hampering public health containment and healthcare system preparation efforts.*
- *A multi-tiered testing strategy incorporating rapid, host immune point-of-care tests can be used now and for future pandemic planning by effectively identifying patients at risk of disease thereby facilitating quarantine earlier in the progression of the outbreak during the weeks and months it can take for pathogen specific confirmatory tests to be developed, validated and manufactured in sufficient quantities.*
- *The ability to triage patients at the point of care and support the guidance of medical and therapeutic decisions, for viral isolation or confirmatory testing or for appropriate treatment of COVID-19 and/or bacterial infections, is a critical component to our national pandemic response and there is an urgent need to implement the proposed strategy to combat the current outbreak.*

Evidence-based, cost-effective interventions to suppress the COVID-19 pandemic: a rapid systematic review[42]

Countries vary in their response to the COVID-19 pandemic. Some emphasise social distancing, while others focus on other interventions. This review provides a comprehensive summary of the evidence on epidemic control, with a focus on cost-effectiveness, from 34 studies.

Higher-quality evidence was only available to support the effectiveness of hand washing and face masks. Modelling studies suggested that these measures are highly cost-effective.

For other interventions, only evidence from observational and modelling studies was available. A cautious interpretation of this body of lower-quality evidence suggests that: (1) ***the most cost-effective interventions are swift contact tracing and case isolation****,* ***surveillance networks****, protective equipment for healthcare workers, and early vaccination (when available); (2) home quarantines and stockpiling antivirals are less cost-effective; (3) social distancing measures like workplace and school closures are effective but costly, making them the least cost-effective options; (4) combinations are more cost-effective than single interventions; (5) interventions are more cost-effective when adopted early and for severe viruses like SARS-CoV-2.*

A cautious interpretation of this body of evidence suggests that for COVID-19: (1) social distancing is effective but costly, especially when adopted late and (2) adopting as early as possible a combination of interventions that includes hand washing, face masks, swift contact tracing and case isolation, and protective equipment for healthcare workers is likely to be the most cost-effective strategy.

Individual empirical studies (not peer-reviewed) What Strategies Make COVID-19 Testing Effective?

COVID-19: PCR screening of asymptomatic health-care workers at London hospital[43]

COVIDsortium, a bioresource focusing on asymptomatic health-care workers at Barts Health NHS Trust collects data through 16 weekly assessments (unless ill, self-isolating, on holiday, or redeployed) with a health questionnaire, nasal swab, and blood samples

Data reinforce the importance of epidemic multi-timepoint surveillance of HCWs and also suggest that a testing strategy should link population-representative epidemiological surveillance to predict prevalence, with adaptive testing for symptomatic individuals at times of low prevalence, and rapidly expanding to include the asymptomatic HCWs during possible new infection waves.

First experience of COVID-19 screening of health-care workers in England[44]

Similarly, a case study from Newcastle Hospital shows that a testing protocol of HCW has enabled 1414 health-care workers to return more rapidly to NHS service in the past 3 weeks, the vast majority returning to direct patient care

A Spatiotemporal Epidemic Model to Quantify the Effects of Contact Tracing, Testing, and Containment[45]

A epidemic model based designed to assess the impact of TTT strategies

Model makes use of data gathered by a variety of contact tracing technologies and can quantify the effects that different testing and tracing strategies, social distancing measures, and business restrictions may have on the course of the disease

Experiments using real COVID-19 data and mobility patterns from Tübingen, a town in the southwest of Germany, demonstrate that our model can be used to quantify the effects of tracing, testing, and containment strategies at an unprecedented spatiotemporal resolution.

Open-source implementation of the framework is here[46]

Individual empirical studies (not peer-reviewed)-
Group testing/ pooled testing

Capacity issues do not allow high-throughput and community level scans of COVID-19 infections. Various studies have supported the principle of "group testing" or "pooled testing" to overcome this issue.
This approach means that the swabs of multiple patients are grouped together and tested.
There is evidence suggesting that this may be a feasible and promising approach when the resources are scarce, but different pooling protocols are needed depending on estimated prevalence, target specificity, and high- vs. low-risk population.

Group Testing Performance Evaluation for SARS-CoV-2 Massive Scale Screening and Testing[47]
Employed group testing with a sparse random pooling scheme and conventional group test decoding algorithms both for exact and inexact recovery. Our simulations showed that significant reduction in per case test numbers (or expansion in total test numbers preserving the number of actual tests conducted) for very sparse prevalence regimes is available. Currently proposed COVID-19 group testing schemes offer a gain up to 10X scale-up. There is a good probability that the required scale up to achieve massive scale testing might be greater in certain scenarios. We investigated if further improvement is available, especially in sparse prevalence occurrence where outbreaks are needed to be avoided by population scans.

Pooled testing with replication: a mass testing strategy for the COVID-19 pandemics[48]
This study proposes this technique in conjunction with a combinatorial replication scheme in which each patient is allocated in two or more groups to reduce total numbers of tests and to allow testing of even larger numbers of people. Under mild assumptions, a 13x average reduction of tests can be achieved

Individual empirical studies (not peer-reviewed)-
Group testing/ pooled testing

Group testing for SARS-CoV-2 allows for up to 10-fold efficiency increase across realistic scenarios and testing strategies[49]

This analysis compares general strategies for group testing and highlights significant efficiency gaps between different group testing strategies in realistic scenarios for SARS-CoV-2 testing, highlighting the need for an informed decision of the pooling protocol depending on estimated prevalence, target specificity, and high- vs. low-risk population.
For example, all 1.47 million inhabitants of Munich, Germany, could be tested using only around 141 thousand tests if an infection rate up to 0.4% is assumed. Using 1 million tests, the 6.69 million inhabitants from the city of Rio de Janeiro, Brazil, could be tested as long as the infection rate does not exceed 1%. For comparative visualization and querying of the precomputed results an interactive web application is provided.

Evaluation of Group Testing for SARS-CoV-2 RNA[50]

This modelling study suggests that when most tests are negative, pooling reduces the total number of tests up to four-fold at 2% prevalence and eight-fold at 0.5% prevalence. At current SARS-CoV-2 prevalence, randomized group testing optimized per country could double the number of tested individuals from 1.8M to 3.6M using only 672k more tests. This strategy is well-suited to supplement testing for asymptomatic and mild cases who would otherwise go untested

Efficient prevalence estimation and infected sample identification with group testing for SARS-CoV-2[51]

Mathematical models for epidemic spread, incorporating empirically measured individual-level viral kinetics to simulate changing viral loads in a large population over the course of an epidemic were used to construct representative populations and assess pooling strategies for community screening, accounting for variability in viral load samples, dilution effects, changing prevalence and resource constraints.
Group testing frameworks were confirmed through pooled tests on de-identified human nasopharyngeal specimens with viral loads representative of the larger population.
Group testing designs can both accurately estimate overall prevalence using a small number of measurements and substantially increase the identification rate of infected individuals in resource-limited settings.

Individual empirical studies (not peer-reviewed)-
Group testing/ pooled testing

Efficient high throughput SARS-CoV-2 testing to detect asymptomatic carriers[52]

Describes the development of P-BEST - a method for Pooling-Based Efficient SARS-CoV-2 Testing, using a non-adaptive group-testing approach, which significantly reduces the number of tests required to identify all positive subjects within a large set of samples.

Samples are pooled into groups and each pool is tested for SARS-CoV-2 using the standard clinically approved PCR-based diagnostic assay.

Each sample is part of multiple pools, using a combinatorial pooling strategy based on compressed sensing designed for maximizing the ability to identify all positive individuals.

In this proof-of-concept study, 384 patient samples were pooled into 48 pools providing an 8-fold increase in testing efficiency. Five sets of 384 samples, containing 1-5 positive carriers were screened and all positive carriers in each set were correctly identified.

Analysis and Applications of Adaptive Group Testing Methods for COVID-19[53]

This paper proposes non-adaptive and adaptive group testing strategies based on generalized binary splitting (GBS) where the group test is restricted to the largest group that can be used.

The method starts by choosing a group from the population to be tested, performing a test on the combined sample from the entire group and progressively splitting the group further into subgroups.

Compared to individual testing at 4% prevalence, 74% are saved; at 1% ,91% are saved and at 1%, 97% of tests are saved.

This approach is particularly applicable to vulnerable confined populations such as nursing homes, prisons, military ships and cruise ships.

Poolkeh Finds the Optimal Pooling Strategy for a Population-wide COVID-19 Testing (Israel, UK, and US as Test Cases)[54]

A data-driven tool is presented that allows decision-makers to assess the spread of the virus among the world population.

Our framework allows health agencies to maximize the throughput of COVID-19 tests among the world population by finding the best test pooling that fits the current SIR-D status of the nation.

Individual empirical studies (not peer-reviewed)-
Group testing/ pooled testing

Optimization of group size in pool testing strategy for SARS-CoV-2: A simple mathematical model [54](NB Published; peer-reviewed)

A simple mathematical model to estimate the optimum number of pooled samples according to the relative prevalence of positive tests in a particular healthcare context, assuming that if a group tests negative, no further testing is done whereas if a group tests positive, all the subjects of the group are retested individually.

The model predicts group sizes that range from 11 to 3 subjects. For a prevalence of 10% of positive tests, 40.6% of tests can be saved using testing groups of four subjects. For a 20% prevalence, 17.9% of tests can be saved using groups of three subjects. For higher prevalences, the strategy flattens and loses effectiveness.

Boosting test-efficiency by pooled testing strategies for SARS-CoV-2[55]

A formula to estimate the optimal pooling size, the efficiency gain (tested persons per test), and the expected upper bound of missed infections in the pooled testing, all as a function of the population-wide infection levels and the false negative/positive rates of the currently used PCR tests.

Assuming an infection level of 0.1 % and a false negative rate of 2 %, the optimal pool size is about 32, the efficiency gain is about 15 tested persons per test. For an infection level of 1 % the optimal pool size is 11, the efficiency gain is 5.1 tested persons per test. For an infection level of 10 % the optimal pool size reduces to about 4, the efficiency gain is about 1.7 tested persons per test. For infection levels of 30 % and higher there is no more benefit from pooling.

Sequential informed pooling approach to detect SARS-CoV2 infection[56]

A two-step sequential pooling procedure is suggested that could identify positive subjects, ensuring at the same time significant benefits of costs and time. Simulation data are used to assess the efficiency, in terms of number of required tests, both for random assignment of the subjects to the pools and for situations when epidemiological and clinical data are used to create an "informed" version of the pooling. Different scenarios are examined in the simulations to measure the effect of different pool sizes and different values for the virus frequency. Results allow to customize the pooling strategy according to the specific characteristics of the cohort to be tested.

Individual empirical studies (not peer-reviewed)-
Group testing/ pooled testing

Assessment of Specimen Pooling to Conserve SARS CoV-2 Testing Resources[57]

Results indicate that when the incidence rate of SARS-CoV-2 infection is 10% or less, group testing will result in the saving of reagents and personnel time with an overall increase in testing capability of at least 69%.

Group Testing for SARS-CoV-2: Forward to the Past?[58]

This expert commentators paper debates the evidence relating to whether group testing should become a key component of the strategy to combat COVID-19

"We conclude that group testing has the potential to substantially reduce constraints in availability of diagnostic tests for SARS-CoV-2. In many circumstances, it could enable limited numbers of diagnostic tests to be used more efficiently, testing more patients without increasing operational delays. The sensitivity of existing and future tests at different group sizes therefore deserves urgent consideration. Group testing should be a forethought not an afterthought."

Individual empirical studies (not peer-reviewed)-
Testing strategies on release from lockdown

Suppressing the impact of the COVID-19 pandemic using controlled testing and isolation[59]

Strategies to significantly relax lockdowns, while still controlling the spread of the virus are needed. This analysis uses active feedback to control testing for infection by actively testing individuals with a high probability of being infected. An active testing strategy is proposed to achieve this goal. It is suggested it would have success in controlling the spread of the virus on one million people, using 3; 000 tests per day. Results show up to a 50% reduction in quarantine rate and morbidity rate in typical settings as compared to existing methods.

Frequency of routine testing for SARS-CoV-2 to reduce transmission among workers[60]

How often is routine testing needed among workers returning to workplaces after lockdown? This simulation found that testing strategies less frequent than twice weekly (e.g. weekly testing or testing once prior to returning to work) are unlikely to prevent workforce outbreaks. Even given unlimited testing capacity, the impact of frequent testing may not be sufficient to reliably relax shelter-in-place policies without risking continued epidemic propagation, unless other measures are instituted to complement testing and self-isolation.

Containing Covid-19 outbreaks with spatially targeted short-term lockdowns and mass-testing[61]

Efficacy of spatially targeted lockdown or mass-testing and case-isolation in individual communities, as a compliment to contact-tracing and social-distancing was tested using the UK as a case study. A stochastic branching process model for the virus transmission was embedded on a network interaction model encoding mobility patterns in the UK.

For outbreak scenarios where contact-tracing and moderate social distancing alone provide suppression but do not contain the spread, targeted lockdowns or mass-testing interventions at the level of individual communities (with just a few thousand inhabitants) can be effective at containing outbreaks.

For spatially targeted mass-testing, a moderate increase in testing capacity would be required (typically<40000 additional tests per day), while for local lockdowns only a small fraction (typically<0.1%) of the population needs to be locked down at any one time (assuming that one third of transmission occurs in the home, at work or school, and out in the wider community respectively).

Individual empirical studies (not peer-reviewed)-
Testing strategies on release from lockdown

Modeling serological testing to inform relaxation of social distancing for COVID-19 control[62]

An SEIR-like compartmental model that accounts for serological test status was used to examine if widespread serological testing can reduce the adverse effects of relaxing social distancing measures, in terms of total deaths and health system burden.
In our model, social distancing measures are relaxed to a greater extent for those who test positive compared to those who have not been tested or test negative, allowing a return to work and partial restoration of other social contacts to pre-pandemic levels. All individuals preferentially interact with those who have tested positive, such that seropositive individuals act as immunological shields.
Although relaxing social distancing interventions increases total deaths, serologic testing as a part of this strategy can reduce population risk.
If social distancing restrictions are relaxed by 50% in tandem with monthly serological testing of the general United States (US) population, 174,000 deaths would be averted and 67% of the US population would be released from social distancing after 1 year, as compared to a scenario without serological testing.

Modeling Exit Strategies from COVID-19 Lockdown with a Focus on Antibody Tests[63]

Two epidemiological models investigate the potential effects of a combination of measures such as large-scale use of antibody tests in addition to continuation of hygienic constraints after leaving lockdown, isolation of infectious persons, repeated and adaptive short-term contact reductions.
Based on the modeling assumptions, it can be expected that repeated short-term contact reductions will be necessary in the next years to avoid overload of the health system and that on the other side herd immunity can be achieved and antibody tests are an effective way to mitigate the contact reductions for many.

Individual empirical studies (not peer-reviewed)-

Testing strategies on release from lockdown

Exit strategies: optimising feasible surveillance for detection, elimination and ongoing prevention of COVID-19 community transmission[64]

Australia's surveillance strategy on exit from lockdown

System requirements for increasing testing to allow exhaustive identification of all transmission chains, and then enable complete follow-up of all cases and contacts within each chain, were assessed per million population.

Screening all syndromic fever and cough primary care presentations, in combination with exhaustive and meticulous case and contact identification and management, enables appropriate early detection and elimination of community transmission of COVID-19. If testing capacity is limited, interventions such as pooling allow increased case detection, even given reduced test sensitivity. Wider identification and testing of all upstream contacts, (i.e. potential sources of infection for identified cases, and their related transmission chains) is critical, and to be done exhaustively requires more resources than downstream contact tracing.

The most important factor in determining the performance of such a surveillance system is community participation in screening and follow up, and as such, appropriate community engagement, messaging and support to encourage presentation and compliance is essential. Operational guidance on implementing such a system is given

Individual empirical studies (not peer-reviewed)-
Digital technology

STeCC: Smart Testing with Contact Counting Enhances Covid-19 Mitigation by Bluetooth App Based Contact Tracing[65]
Complementary mitigation strategies relying on virus-RNA testing to detect and quarantine both, symptomatic and asymptomatic cases are evaluated. Epidemic dynamics modeling shows that stopping the pandemic by mass testing alone is unrealistic, as we lack enough tests. However, realistic numbers of tests may suffice in a smart-testing strategy, e.g. when biasing tests towards people with exceptionally high numbers of contacts. These people are at particularly high risk to become infected (with or without symptoms) and transmit the virus. A mitigation strategy combining smart testing with contact counting (STeCC) and contact tracing in one app would reduce R0 by 2.4-fold (e.g. from R0=2.4 to R0=1) with realistic test numbers (≈166 per 100'000 people per day) when a realistic fraction of smartphone owners use the app (≈72%, i.e. ≈50% in total population). Thereby, STeCC expands the portfolio of mitigation strategies and may help easing social distancing without compromising public health.

Individual empirical studies (not peer-reviewed)- Impact of testing on the case fatality rate

Impact of virus testing on COVID-19 case fatality rate: estimate using a fixed-effects model[66]

In France, testing policies are determined locally. All contiguous department pairs located on the opposite sides of a region border were compared. The increase of one percentage point in the test rate is associated with a decrease of 0.001 percentage point in the death rate. For each additional 1000 tests, one person would have remained alive.

Extensive testing may reduce COVID-19 mortality: a lesson from northern Italy[67]

Lombardy, Emilia-Romagna, and Piedmont had an extremely steeper increase in mortality with increasing number of tests performed than Veneto, which applied a policy of broader swab testing. This suggests that the strategy adopted in Veneto, similar to that in South Korea, is effective in containing COVID-19 epidemics and should be applied in other regions of Italy and countries in Europe.

Making sense of the Global Coronavirus Data: The role of testing rates in understanding the pandemic and our exit strategy[68]

The number of diagnostic tests performed in proportion to the number of cases and subsequently deaths were analysed across different countries.

Analysis was according to the number of tests performed as the main denominator.

Country wise population level pandemic projections were extrapolated utilising three models - 1) inherent case per test and death per test rates at the time of obtaining the data (4/4/2020 0900 BST) for each country; 2) rates adjusted according to the countries who conducted at least 100000 tests and 3) rates adjusted according to South Korea.

It was found that that countries with the highest testing rates per population have the lowest death rates and give an early indication of an eventual COVID-19 mortality rate.

How many lives can be saved? A global view on the impact of testing, herd immunity and demographics on COVID-19 fatality rates[69]

This analysis assesses the global impact of COVID-19 showing how demographic factors, testing policies and herd immunity are key for saving lives.

*A standard epidemiological SEIR model is extended in order to: (a) identify the role of demographics (population size and population age distribution) on COVID-19 fatality rates; (b**) **quantify the maximum number of lives that can be saved according to different testing strategies**; (c) different levels of herd immunity, and specific population characteristics; and (d) infer from the observed case fatality rates (CFR) what the true fatality rate might be.*

A Bayesian Melding method in the calibration strategy enables accounting for data limitation on the total number of deaths.

Individual empirical studies (not peer-reviewed)-
Impact of testing on the case fatality rate

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Individual empirical studies (not peer-reviewed)-
Testing in a vulnerable setting

How best to use limited tests? Improving COVID-19 surveillance in long-term care[71]

Long-term care facilities (LTCFs) are particularly vulnerable to outbreaks of COVID-19 with high rates of transmission and mortality. This study suggests improving COVID-19 surveillance can alert healthcare institutions to emerging outbreaks before they escalate

An individual-based transmission model was used to simulate COVID-19 spread along inter-individual contact networks in the LTCF setting.

A range of surveillance strategies were evaluated for their ability to detect simulated outbreaks, assuming limited availability of standard RT-PCR tests.

Various epidemiological scenarios were considered

A median delay of 7 (95% uncertainty interval: 2-15) days from importation of an asymptomatic COVID-19-infected patient to first presentation of COVID-19 symptoms among any patients or staff, at which point an additional 7 (0-25) individuals were infected but did not (yet) show symptoms. Across a range of scenarios, the reference surveillance strategy (testing individuals with COVID-like symptoms with signs of severity) took a median 11-21 days to detect an outbreak.

Group testing patients and staff with any COVID-like symptoms was both the most timely and efficient strategy, detecting outbreaks up to twice as quickly as the reference, and more quickly than other considered strategies while using fewer tests. Maximizing use of available tests via testing cascades was more effective than group testing only when substantial testing resources were available (on the order of 1 test/20 beds/day). Including not merely those with symptoms but also newly admitted patients in group tests and testing cascades reduced delays in outbreak detection for LTCFs actively admitting patients potentially already infected with COVID-19

Individual empirical studies (not peer-reviewed)- Limitations

Severe underestimation of COVID-19 case numbers: effect of epidemic growth rate and test restrictions[72]
Accurate numbers of cases?
Limited COVID-19 test capacities in many countries are restricting the amount of testing that can be done which can lead to the implementation of testing policies that restrict access to COVID-19 tests, and to testing backlogs and delays.
This means confirmed case numbers can be significantly lower than the actual number of infections
This study examines the quantitative relation between infections and reported confirmed case numbers for two different testing strategies, "limited" and "inclusive" testing, in relation to the growth rate of the epidemic.
Results indicate that confirmed case numbers understate the actual number of infections substantially; during rapid growth phases where the daily growth rate can reach or exceed 30%, as has been seen in many countries, the confirmed case numbers under-report actual infections by up to 50 to 100-fold.

"No test is better than a bad test": Impact of diagnostic uncertainty in mass testing on the spread of Covid-19[73]
Implications of uncertainty in testing.
This analysis uses a modified SIR model to understand the implication and magnitude of misdiagnosis due to false positives and false negatives of even highly accurate tests in the context of ending lock-down measures.
Results indicate that increased testing capacity alone will not provide a solution to lock-down measures in the UK. The progression of the epidemic and peak infections is shown to depend heavily on test characteristics, test targeting, and prevalence of the infection. Antibody based immunity passports are rejected as a solution to ending lockdown, as they can put the population at risk if poorly targeted.
Similarly, mass screening for active viral infection may only be beneficial if it can be sufficiently well targeted, otherwise reliance on this approach for protection of the population can again put them at risk. A well targeted active viral test combined with a slow release rate is a viable strategy for continuous suppression of the virus.

Keep up to date

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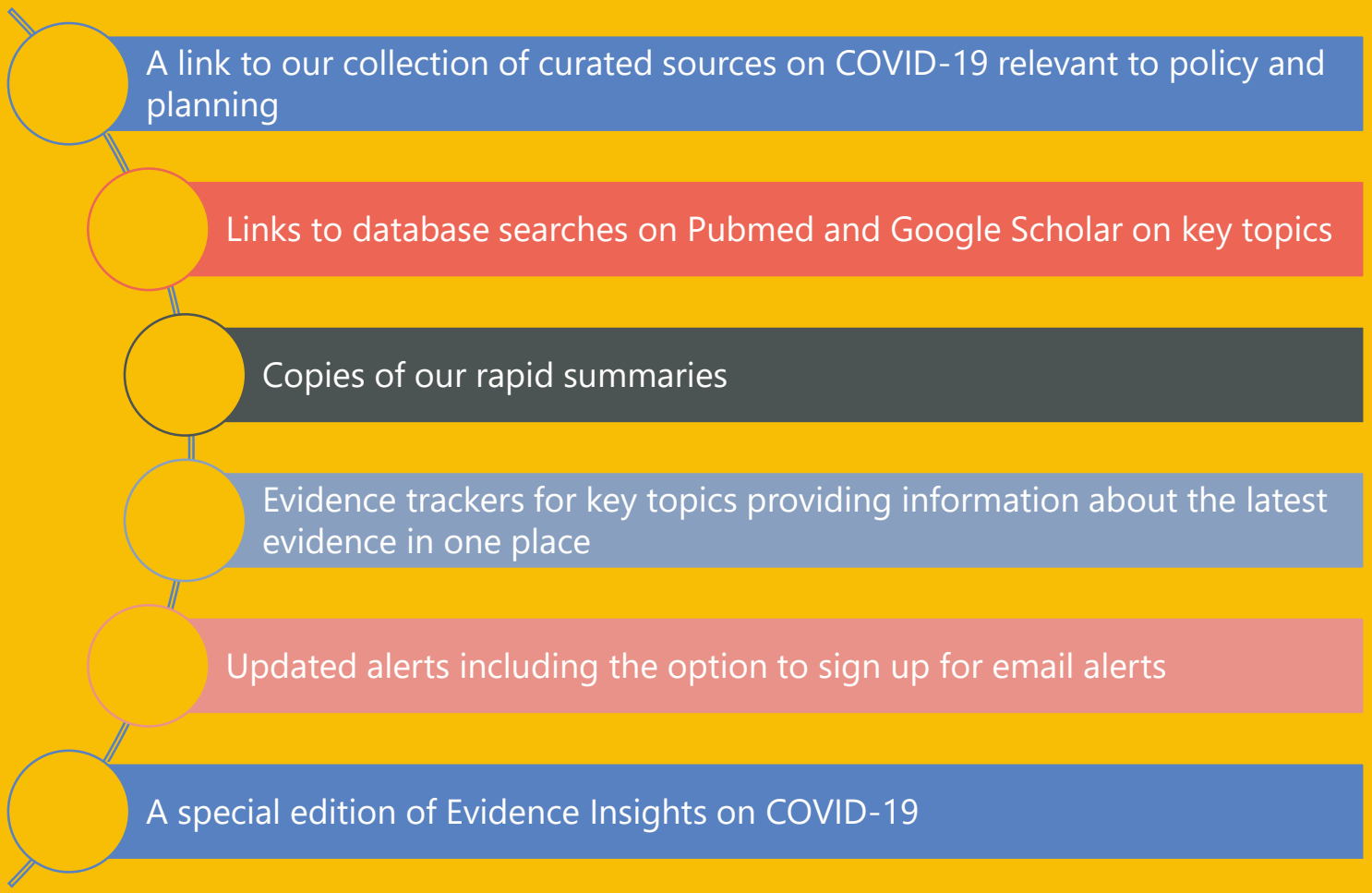
https://www.strategyunitwm.nhs.uk/COVID-19-and-coronavirus



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60. https://www.medrxiv.org/content/10.1101/2020.04.30.20087015v1

61. https://www.medrxiv.org/content/10.1101/2020.05.05.20092221v1

62. https://www.medrxiv.org/content/10.1101/2020.04.24.20078576v1

63. https://www.medrxiv.org/content/10.1101/2020.04.14.20063750v1

64. https://www.medrxiv.org/content/10.1101/2020.04.19.20071217v1

65. https://www.medrxiv.org/content/10.1101/2020.03.27.20045237v2

66. https://www.medrxiv.org/content/10.1101/2020.04.26.20080531v1

67. https://www.medrxiv.org/content/10.1101/2020.04.24.20078709v1

68. https://www.medrxiv.org/content/10.1101/2020.04.06.20054239v1

69. https://www.medrxiv.org/content/10.1101/2020.04.29.20084400v1

70. https://www.medrxiv.org/content/10.1101/2020.04.29.20084400v1

71. https://www.medrxiv.org/content/10.1101/2020.04.19.20071639v1

72. https://www.medrxiv.org/content/10.1101/2020.04.13.20064220v1

73. https://www.medrxiv.org/content/10.1101/2020.04.16.20067884v2

Appendix - Methodology

Scoping the review

Geography	International
Settings	All care settings – secondary, primary, community, independent – unless specified
Language/s	No language restrictions but please note there is no budget for translation. Therefore, we will prioritise translated materials where available and will source translations within existing resource.
Dates	We may limit evidence relating to earlier pandemics/major incidents to the last 10 years, should the volume of results be high, to focus on contemporary literature.

Search sources and locations

Bibliographic databases:

- Pubmed
- Google Scholar
- Cochrane Library
- CINAHL
- Global Health
- Disaster Lit

Aggregators and search engines:

- NHS Evidence
- TRIP (using Covid filters)

Grey literature:

via our curated collection of resources on COVID-19 and Coronavirus [28]