SUCCESSFUL FIND-TEST-TRACE-ISOLATE-SUPPORT SYSTEMS: HOW TO WIN AT SNAKES AND LADDERS

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Summary: In order to ease lockdown restrictions and prevent a second wave of infections, countries must be able to find, test, trace, isolate and support new COVID-19 cases. The simplicity of the 'test, trace, isolate' mantra dramatically understates the multitude of time-dependent processes that must occur seamlessly for the strategy to work effectively. We reconceptualise the way out of lockdown as a Snakes and Ladders boardgame. To succeed, countries must ensure that people with COVID-19 progress through the board as quickly as possible by putting in place measures that enhance their public health capacity (i.e. landing on ladders) and prevent setbacks caused by having insufficient capacity (i.e. avoiding snakes).

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Introduction

Any country thinking of easing COVID-19 lockdowns must be confident that they have a robust system in place to find, test, trace, isolate, and support (FTTIS) new cases. This is essential if they are to minimise the risks of a second wave going out of control. The theory is simple. Anyone with symptoms is tested and, if positive, their contacts are traced and advised or instructed to isolate. The reality is somewhat different. It requires a complex system with many interlinking components, demanding rapid and effective communication between different organisations, some of which are newly created, while others may be combining their day to day work with a major expansion in capacity. Even the best resourced public health system would struggle given the scale of the pandemic. For many, especially those whose capacity has been diminished as a consequence of sustained underinvestment, the challenges are enormous. To help those who are facing these challenges, we have examined what countries across Europe are doing, seeking where possible lessons that can be learned from their experiences.

This analysis uses information gathered from the COVID-19 Health System Response Monitor (HSRM), created by the European Observatory on Health Systems and Policies.[1] A network of national correspondents from over 50 countries has prepared a series of structured reports on national responses to the pandemic, regularly updating them as events develop.

Conceptually, we can consider a FTTIS programme as a complex adaptive system, with the individual being tested passing along a non-linear route involving multiple paths, each with feedback loops and with their speed and direction influenced by a multiplicity of factors, many outside their control. Practically, however, if we are to help the busy policymaker, we must simplify this considerably, something that we have done by portraying the main elements of the system as a Snakes and Ladders boardgame (image). Snakes and Ladders is remarkably well suited to this exercise. To be successful (i.e. to win the game) countries must ensure that those with COVID-19 progress as quickly as possible from the start to the finish. If this does not happen, new cases will appear, and another lockdown will be needed. They can do this most effectively by putting in place measures that enhance their ability to find, test, trace, isolate, and support (i.e. landing on ladders) and by avoiding setbacks that occur due to insufficient capacity in the health system and beyond (i.e. avoiding snakes). We now run through the boardgame, pointing out many of the steps that policymakers should be mindful of, highlighting approaches that countries are currently taking to implement a FTTIS system and thereby "win the game". Before doing so, however, it is important to note an important difference from the real game, in which players land on squares at the throw of a dice. In this case, countries that went into the pandemic with strong public health systems and systems of governance are more likely to land on ladders because the capacity is already in place.

Producing and procuring enough testing materials

The game starts with procurement, with a focus on molecular testing supplies for nose and throat RT-PCR swabs, the gold standard test recommended [2] by the World Health Organization (WHO) to identify COVID-19 cases. Testing requires reliable supplies of a range of materials, including swabs, transport media, reagents, primers, assays, and PCR machines. Many of these are also used to test for other infections but, during a pandemic, countries face supply constraints, a 'snake' that inhibits FTTIS before it has a chance to get started.

> "a complex system with many interlinking components

Equipped with the genetic sequence from China, Germany and the United Kingdom managed to manufacture some of the earliest COVID-19 tests outside Asia and Germany quickly purchased millions of them. Germany also published a blueprint that the WHO could share with other countries to support their use of the newly developed test. However, large scale testing is only possible if laboratories have all of the items required, from glassware to PCR machines. This requires very well-functioning procurement and distribution systems, something that many countries have struggled to achieve, and even Germany, widely praised for its ability to scale up testing capacity rapidly, has experienced periods when demand has exceeded supply. Countries that do not manufacture these items themselves initially struggled to obtain them in a global market where they were competing against others with greater purchasing power. Some countries such as Norway, have developed and manufactured their own tests [3] to minimise dependence on those produced elsewhere. Rather like printers, where cartridges are specific to particular brands, PCR machines are often licensed for use with specific reagents, with global stocks of many of them rapidly depleted in the early stage of the pandemic. In response, some countries, including Belgium, the UK, and Canada eased regulations to enable more flexible use of reagents, drawing on South Korea's earlier response to MERS.

Once procured and warehoused, supplies need to be distributed to testing sites and laboratories. Failure to do so effectively creates a snake because testing sites cannot administer tests without the right supplies. Countries offering home testing faced logistic challenges, especially as postal services were often weakened because of staff shortages and working with social distancing. Some countries also faced particular early challenges in getting tests to certain high risk settings, such as care homes, as in the UK.[4] A failure to distribute test kits to individuals or test sites where they are most needed will delay access to testing, thus enabling new cases to remain undetected and transmission to continue.

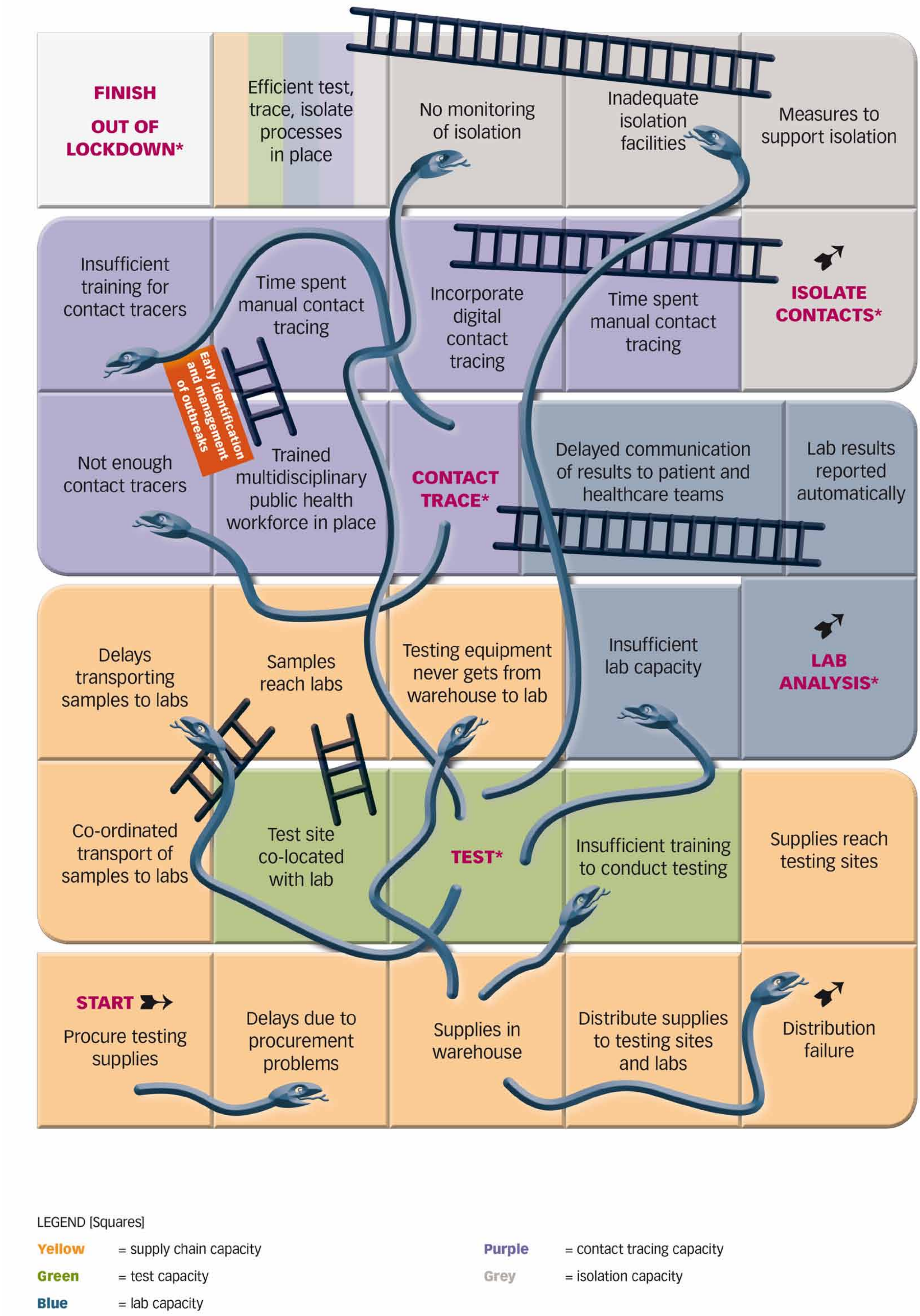
Developing sufficient skills and facilities to meet testing needs

While few countries were conducting tests outside of hospitals early in the pandemic, most now do so, for example by building drive-through or mobile testing units, with many others, including Austria, the UK, and Estonia also starting home testing. Some governments have outsourced some components of this work to private companies, for example in Finland, Estonia, and the UK, although with varying degrees of success.

Although these measures can increase the volume of testing they also present enormous logistical challenges as testing supplies must be distributed to a large number of testing sites, while testing on a large scale depends on recruitment of staff who are unlikely to have experience in taking samples. Taking a nasopharyngeal swab does require some degree of training about how and (critically) when to test to reduce the risk of false negative results.[5] Without proper training, tests will be wasted and need to be repeated, which in turn erodes limited capacity (another snake). Recent advances have shown great promise for the use of saliva tests, which can avoid this trade-off between availability of trained staff and quality assurance.

After taking a swab, samples should reach the laboratory rapidly. Otherwise they may have to be discarded and repeated. Thus, it is important to ensure that there is a well-coordinated system to ensure transport of samples from test sites to laboratories. Ideally, testing sites and

Figure 1: Win the game



Source: Authors' compilation

laboratories would be co-located, as in hospitals and in some South Korean drive-through testing sites. This is a ladder, although one that is rare in community testing sites in Europe. The ultimate goal is to develop a test that does not require a laboratory, using a point of care test that can produce immediate results, particularly for those without symptoms, but those that have been developed so far have not performed sufficiently well to depend on at population scale. This approach also removes the need for laboratories, which are a critical rate limiting step in any pathway at population scale. So far, cases that are confirmed through rapid testing usually have to be verified through PCR swab testing and so this approach is still only likely to be feasible at a low prevalence. Estonia has also offered an innovative approach, using drones to deliver some samples directly to laboratories. In the UK, most testing takes place in just seven commercial mega-laboratories, creating transport bottlenecks and reports of discarded samples.

Given the evidence that symptomatic testing alone is likely to miss a large proportion of infectious presymptomatic and asymptomatic cases,[6] [7] there has also been a move more recently towards regular mass testing in high risk settings such as in health and social care settings and areas of increased transmission in Lithuania and England. It remains unclear how regular such testing needs to be to be effective but some studies suggest an interval of two days is required,[8] which is likely unfeasible for RT-PCR testing. Others, including Estonia, France, Iceland and Germany have also instituted testing for incoming travellers, although their testing policies and capacity differ. A secondary but important concern for asymptomatic screening is that it does not help to identify which of the cases will be most likely to transmit the virus to others, given that very few cases seem to be responsible for a large proportion of transmission, otherwise known as clustering [9] and that RT-PCR can pick up both infectious and non-infectious cases. Germany and Portugal are also now testing samples in batches, so called pooled sampling,[10] taking lessons from the population screening programme in Wuhan and from HIV testing strategies.[11] Any mass testing in high risk settings must also be done under the strictest of infection control precautions to prevent cross contamination, which can lead to falsely positive results. A second type of pooling is surveillance sampling of wastewater, which has also been shown to be a useful early warning system to monitor outbreaks [12] and the utility of this approach is now being studied by the European Commission in a number of European countries.

Strengthening lab capacity to rapidly analyse samples and immediately report the results

The ability to scale up testing will be easier in countries that have had sustained investment in health infrastructure, including laboratory equipment, technicians, logistics systems, and information technology. Germany [13] entered the pandemic with a strong diagnostics and chemicals industry, which allowed it to implement large scale testing rapidly.[14] In contrast, the UK did not. Thus, a lack of sufficient laboratory capacity is another snake that will create severe delays in processing tests, possibly requiring substantial re-testing which exacerbates an already difficult situation.

Where laboratory capacity is insufficient, three types of response can be seen. One involves expanding existing medical laboratories or repurposing others, such as those involved in veterinary surveillance in universities, as in Croatia, Cyprus, Estonia, France, Germany, Lithuania, and Norway, among others. Thus, Germany [13] rapidly commissioned testing in 300 local laboratories and Sweden also used existing laboratories in all but 2 of its 21 regions. A second involves creation of a few centralised mega-laboratories. In the UK, outsourcing companies, many with little or no experience of running laboratories, were contracted to construct a few large lighthouse laboratories, creating a highly centralised system. A third approach, seen in Ireland and Finland, involved samples being sent abroad for testing, although as the UK has found, if samples are sent abroad at the wrong temperature they cannot be processed and will be voided. Other measures that also contribute include accelerated training of laboratory technicians, as in Israel, or use of robots, as in Denmark.

While there is widespread agreement that tests should be conducted within a country, where possible, debate continues as to the other approaches. Countries adopting the first one do generally appear to have been successful and although Germany has struggled to meet demand more recently rationalising its testing programme of all incoming travellers to those from high risk countries, demand for tests in the UK is reported to be many times capacity as laboratories have struggled to keep pace, with the Prime Minister calling on university laboratories to redeploy staff to the lighthouse laboratories once again, and resorting to sending more samples abroad.

contact tracing is a core component of public health

Once samples are processed, automated reporting can create a ladder, helping to deliver results quickly to cases and contact tracers who will be able to initiate tracing sooner. There are numerous examples of countries where this is working, including Belgium, Estonia, Iceland, Turkey and Lithuania. Rapid initiation of contact tracing will reduce the risk of further transmission. It also increases the likelihood that suspected cases will agree to isolate while they wait for their results. Without an automated system, results have to be telephoned individually to cases, which is resource intensive and can delay notification and isolation. Some countries such as the UK are also planning to implement mass point of care testing and it is unclear how this critical component of automating results will be factored in.

Self-evidently, there must be a system to monitor test performance to ensure false positives and negatives are minimised. This may create logistic challenges for quality assurance where new or repurposed laboratories have come on stream, although there are examples, such as those in Italy and Ireland, that can offer lessons. Further guidance is now required on how to standardise laboratory testing in different labs using different assays and machines. Quality assurance is critical and mechanisms to monitor this were implemented in Italy and Ireland.

Building a large, well-trained workforce to conduct contact tracing (even in countries using digital technologies)

Despite renewed attention, contact tracing is a core component of public health departments, which have long experience in preventing transmission of other communicable diseases such as tuberculosis, hepatitis, and sexually transmitted infections. Contact tracing requires a well-resourced existing public health infrastructure, with a trained workforce that is well connected with local services. Such a system will enable clusters and complex outbreaks to be detected early. This is an important ladder that will help to strengthen the FTTI process and is crucial for any containment or mitigation strategy. Various strategies have been used to trace contacts, outlined elsewhere [15] (also see the article by Hernández-Quevedo, et al. in this issue) but each case must be interviewed to ensure that they isolate, identify, and risk assess their contacts, providing sufficient information to locate and engage with them. An inadequate number of contact tracers creates a snake as manual contact tracing is time consuming, demanding a large workforce. Any delays will lead to increased transmission. Modelling suggests that around 80% of non-household contacts would have to be traced and isolated within 48 hours of the first person experiencing symptoms, with strict adherence to self-isolation and there are few examples of countries in Europe where this is happening systematically.[16]

To avoid this snake, several countries have recruited paid contact tracers to work in call centres, including France (>8,000), the UK (18,000) and Germany (up to five contact tracers per 20,000 inhabitants), although an early survey in Germany showed that only 24% of departments were able to meet this target in mid-May and it is unclear what proportion will be experienced contact tracers. There are various ways to boost the contact tracing workforce. They include inviting experienced environmental health officers, sexual health specialists, and retired doctors and nurses, as the UK has done (although uptake is unknown and in reality this kind of redeployment can only ever be temporary to avoid neglecting other serious health problems). Others have recruited military personnel (as in Germany and Israel) and medical students (as in Finland), or recruited volunteers (as in Cyprus). However, in all cases, there can be challenges in ensuring that they are all adequately trained.

> “digital solutions do not offer a panacea

There has been considerable attention on digital technology, specifically apps as a potential ladder, given their potential to identify and notify contacts quickly. Countries where they have been implemented include Austria, Belgium, Bulgaria, Canada (Alberta), Denmark, Finland, France, Georgia, Iceland, Ireland, Italy and Germany, where the Corona-Warn-App has been downloaded 18 million times since mid-June. England have had to redesign its app over the summer, following a pilot in the Isle of Wight and launched in late September, 4 months after it was anticipated and 2 months after the launch in Northern Ireland. However, while apps may deliver speed, there is little evidence they are effective;[17] coverage and compliance are not guaranteed, and only 3% of the population have downloaded it in France, compared to 30% in Finland. This means that considerable time is still required to manually trace all contacts. Recognising that digital solutions do not offer a panacea, Belgium and France opted for manual contact tracing initially. To support the required increase in capacity, the German Ministry of Health committed €50 million to support necessary upgrades in hardware and software and France has also invested in improved contact tracing software. In contrast, 16,000 cases were recently missed in the UK because of a reliance on outdated Microsoft Excel templates to transfer data. In many countries, (including Austria, Belgium, Croatia, Estonia, France, Greece and Ukraine) primary care services are also involved in the test, trace, isolate process and can monitor and support cases more effectively.

Supporting people in isolation (unless you want to start the game again)

Isolation is arguably the most important part of the test, trace isolate process according to recent evidence.[18] A team of community volunteer contact tracers in the UK published data [19] from a pilot in which it took approximately 80 minutes to manage each case, with many contacts were unwilling to isolate. Cross-sectional data from May also suggested that only 25% of those with household symptoms of COVID-19 in the UK actually adhered to isolation guidance.[20] Measures to support isolation are therefore an important ladder and in Denmark, Finland and Lithuania, people who cannot isolate are accommodated elsewhere (albeit for a fee in Finland). The same approach has also been used successfully to prevent outbreaks in care homes in South Korea. Without facilities to support vulnerable individuals to isolate, and especially to minimise any loss of income, it is likely that transmission will rise, another snake that could set back the entire process. Enforcing isolation is also critical [15] and many countries, such as Lithuania and the UK, impose fines but this risks penalising marginalized populations disproportionately. Some countries, including Hungary, Iceland, Italy, Lithuania, Norway and Ukraine [15] use geolocation data to monitor the movements of cases, but such efforts still require a dedicated workforce to enforce it. This requires resources and connections to local service providers who know the local populations. Some groups [21] have suggested that community health workers could be trained for this purpose.

Successful 'test, trace, isolate' depends on having adequate capacity in many areas of the public health system

The resources required to successfully find, test, trace, isolate and support cannot be underestimated. Each step requires complex management and logistics and a well-resourced public health infrastructure and workforce. Setbacks can be encountered at any stage, but many can be anticipated. Many countries have developed innovative measures that can boost capacity rapidly. However, it is important to focus on the outcome of FTTIS rather than the amount of activity. Increasing the number of tests, will have limited value without a well-resourced system to trace and isolate cases. In addition to scale, speed is essential. Delays at any stage will allow more cases to remain under the radar, silently spreading the infection to others. Ultimately, the success of FTTI is to get countries out of lockdown. This will depend critically on their ability to be co-ordinated, flexible, and prepared.

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