Test, Trace, Isolate

This work was carried out rapidly in May 2020 so that an early version could inform discussions at SAGE. It may be revisited as further scientific evidence becomes available.

transmission include infection control in institutional settings where social distancing may not be possible (e.g., hospitals, care homes, prisons), increased hand washing, respiratory hygiene and use of masks and other personal protective equipment. Measures that reduce the number of contacts between all individuals in the population include social distancing (e.g., working from home, avoiding meetings with friends and family), bans on mass gatherings and closure of schools, shops and restaurants. Importantly, the latter greatly reduce inter-household and community transmission, but do not much affect intra-household transmission, a major source of secondary infections. Contact tracing can therefore be seen as complementary to social distancing and infection control in the context of COVID-19, insofar as it is able to either drive within-household infection prevention efforts (i.e., self-isolation), or provide a gateway to extra-household isolation if required.

Countries that have managed to, at least temporarily, control their COVID-19 epidemics have almost all enacted and maintained substantial testing and contact tracing efforts from early in their epidemics. These countries include China, Iceland, New Zealand, Singapore, South Korea and Taiwan (see summary in Technical Document 4). There are several commonalities in these countries' TTI approaches:

8. Comprehensive TTI was started early in the epidemic, when the number of contacts needing tracing, and thus of follow-on tests, were small;
9. Testing provision was widespread, decentralised and accessible in both traditional and novel locations, including primary healthcare settings;
10. Turnaround times from symptom reporting to test result provision were short. For example, it takes around 5 hours from swab collection to test result provision in Vietnam[2] as a result of the government ramping up laboratory analysis capacity. Similarly, in Taiwan[3], tests results can be provided in 4 hours and in South Korea[4], tests results are provided through automated text messages within 24-48 hours of swab collection.
11. Contact tracing was conducted rapidly, ensuring contacts were reached before they became infectious. South Korea, for instance, uses an information communications technology (ICT) system that integrates GPS data, credit card information and CCTV footage to create a moving history (i.e. transmission route) of the confirmed case in 10 minutes, which is matched with the patient interview, and contacts are then identified and informed via text messages on the same day. The whole process of testing, contact tracing and isolation advice for contacts takes approximately 2-3 days in South Korea.
12. Compliance with isolation was high due either to tailoring to homes (where physical separation was feasible) or through physical separation in institutions (e.g., hotels) or enforcement through fines on violation (South Korea and Taiwan)[5,6];
13. Traditional manual tracing strategies were supplemented with app-based approaches for efficiently notifying contacts of cases and conducting follow-up symptom checks.

However, it is not yet possible to quantify the independent effect TTI has on COVID-19 epidemic control, since these countries generally also had strong early social distancing and infection control procedures.

3. Increasing speed of testing and tracing

The speed at which TTI can move along transmission chains is determined by two quantities: the time between an index case reporting symptoms and their test results being available, and the time required to trace their contacts. COVID-19 combines a short serial interval (5-6 days on average) and substantial pre-symptomatic transmission (up to 2 days prior to symptom presentation).[14] This provides a short window within which infected contacts need to be reached by a TTI system to avoid onward transmission. Between January and March in the UK, the time taken to obtain a test result averaged 3 days, and the time to find a contact 2 days.[15] This amounts to the entire pre-symptomatic period of the average secondary case, meaning that by the time contacts were found, half of their onward transmissions to tertiary cases had already occurred. Our simulation model finds that reducing the overall turnaround time from five days to three leads to 60% improvement in effectiveness of the test-based TTI system (in terms of reduction in R_e), due to the quarantining of infected contacts just as they are expected to be most infectious. For now, we assume that point-of-care testing is not imminent, although a high-quality, immediate test became available should provide a small additional benefit.

A key element of TTI effectiveness is system speed at breaking transmission chains. While the testing and tracing process can be sped up by asking secondary contacts to quarantine at the point where either their index case tests positive or even shows COVID-19 symptoms, these approaches have very large economic consequences in terms of days lost to quarantine (see section 6). Speeding up testing and tracing processes is thus vital. App-based contact tracing can reduce the time needed for manual tracing. However, the effectiveness of app-based tracing is determined by overall smartphone usage and willingness to install and use the app. Smartphones and app use may be lower among children, the elderly and lower socioeconomic status populations, there may be ongoing concerns around privacy and centralised vs decentralised tracing systems, and the population may uninstall the app as the epidemic wanes.

Some ways in which each delay in the system might be addressed are suggested below. Achieving substantial increases in speed is likely to require a system-wide approach utilising existing public health infrastructure and capacity, with greater linkage with primary and community care and local authorities. This decentralised approach is likely to enable faster test turnaround and improve on tracing delays.

1. Time from symptom onset to patient self-reporting. This can be helped by a well-designed, clear public information campaign on how and where to report symptoms which provide access appropriate to all (e.g., via the NHS COVID 19 App, NHS 111 or GP. Apps that also track symptoms may also be able speed up reporting, at least for a subsection of the population.
2. Time from symptom reporting to test taking place. This requires multiple access points and channels to testing, but any appointment systems must have minimal delays (at home or at a test centre). These systems could integrate the use of apps, as used recently for a chlamydia testing and risk assessment system.[16] Self-swabs may increase speed but delivery would need to be rapid - one potential approach would be pick-up from central community points (e.g., pharmacies, community centres, GP hubs).
3. Time from testing to lab. Courier services are likely to be central here, but pharmacies as collation points for pick up within communities could also help, as might local NHS specimen collection.