

## Perspective

# Interrupting transmission of COVID-19: lessons from containment efforts in Singapore

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## Introduction

As of 23 April 2020, almost 3 million COVID-19 cases with almost 200 000 deaths have been reported globally.<sup>1</sup> Countries are now facing emerging outbreaks that threaten to develop into local epidemics if not well contained. China, which had initiated the largest community containment effort in history, has been successful at containing the outbreak, and since mid-February, the daily number of new COVID-19 cases has been declining in China.<sup>2</sup> In the Republic of Korea (ROK) with one of the highest number of infections outside China, the outbreak also appears to have stabilized after application of rigorous measures such as strict contact tracing and large-scale quarantine.

Singapore, a city-state and global travel hub in Southeast Asia, was one of the first countries to be affected by COVID-19, and for a while was the country with the highest COVID-19 numbers outside of China from 5 February 2020 to 18 February 2020. This was in part due to Singapore's strategy of using a comprehensive surveillance system to detect as many cases as possible, and to contain them at the individual level. Despite early importations resulting in local chains of transmission, the rise in the number of cases has been steady without the exponential growth observed elsewhere. This suggests that this strategy, coupled with community-based measures proportionate to the transmission risk, has been effective in containing spread, and could be considered in countries in the early stages of the outbreak where it is not possible to mount massive community-wide containment efforts.

## Singapore's Approach

Singapore was one of the worst affected areas in the 2003 severe acute respiratory syndrome (SARS) outbreak, and since then

Singapore has steadily built up its outbreak preparedness, including developing a national pandemic preparedness plan based on risk assessment and calibration of response measures that are proportionate to the risk. This includes holding regular exercises, and building the National Centre for Infectious Diseases (NCID), a 330-bed purpose built infectious diseases management facility with integrated clinical, laboratory and epidemiological functions.

One of the lessons learnt from SARS is that clear leadership and direction is critical to ensure co-ordinated response across all sectors. Therefore, a Multi-Ministry Task Force was set up before Singapore had its first COVID-19 case to provide central co-ordination for a Whole-of-Government handling of the crisis.

## Surveillance and containment measures

Singapore's surveillance for COVID-19 aimed to identify as many cases as possible using complementary detection methods. First, a case definition to identify suspect cases, at healthcare facilities or through contact tracing, was established based on clinical and epidemiological criteria, and evolved over time as more information became available. To identify cases in the community that do not fulfil the case definition, an enhanced surveillance system was set up to detect COVID-19 among all cases of pneumonia in hospital and primary care, severely ill patients in hospital intensive care units and deaths with possible infectious cause and influenza-like illness (ILI) in sentinel primary care clinics. Finally, doctors were also allowed to test patients whom they viewed with suspicion for clinical or epidemiological reasons. To support the surveillance system, SARS-CoV-2 RT-PCR laboratory testing capacity was scaled up rapidly to all public hospitals in Singapore and is able to handle 2200 tests a day for a population of

5.7 million. Similarly, ROK has also quickly expanded testing capacities, including setting up drive-through testing stations, and has conducted over 200 000 tests to date (Table 1).<sup>3</sup>

All suspected and confirmed cases were immediately isolated in hospital to prevent onward transmission. Contact tracing was also initiated to determine their movement history 14 days prior to symptom onset to isolation to determine possible sources of infection and also to prevent onward transmission among close contacts. Any contact with current or recent symptoms after exposure to the case was referred to hospitals for isolation and testing as part of active case finding. Close contacts who were well were placed under mandatory quarantine for 14 days from their last date of exposure, whereas other lower-risk contacts were put on phone surveillance.

As of 10 March 2020, >4000 close contacts had been placed under quarantine, and eight cases developed symptoms while under quarantine and tested positive. To facilitate compliance and reduce hardship, the Quarantine Order Allowance Scheme provides economic assistance. At the same time, the Infectious Diseases Act provides legal power to enforce contact tracing and quarantine, and to prosecute those who do not comply.

### Healthcare measures

A network of >800 Public Health Preparedness Clinics (PHPCs) was activated to enhance management of respiratory infections in the primary care setting, with subsidies extended to Singapore residents to incentivize them to seek care at these PHPCs. As early COVID-19 disease is mild and undifferentiated, medical practitioners were instructed to provide extended medical leave of up to 5 days for patients with respiratory symptoms. This allowed possible COVID-19 cases to self-isolate at home to reduce the number of undetected cases seeding community transmission. Those with persistent or worsening symptoms are advised to return to the same doctor for evaluation and referral for testing.

At the hospitals, infection control measures were strengthened, including strict visitor controls, cohorting of patients with pneumonia or respiratory infection and maintenance of strict infection control practices across all settings with personal protective equipment levels appropriate for the patient care setting. Movement of patients and doctors between healthcare institutions was also limited to prevent multiple institutions from being affected at the same time.

### Border control measures

Apart from detecting cases and containing spread, prevention of imported cases is important to reduce the force of infection from external sources. In Singapore, temperature and health screening of incoming travellers from Wuhan since 3 January 2020, and extended to all travellers since 29 January 2020, is in place at all ports of entry. Travellers who meet the suspect case definition are conveyed directly to hospital.

Singapore has, as of 4 March 2020, advised Singaporeans to defer non-essential travel to mainland China, ROK, Northern Italy and Iran and imposed entry restrictions on visitors from the

same areas. Returning residents and long-term pass holders with travel history to these affected regions are subject to a 14-day quarantine.

### Community and social measures

The community-level approach in Singapore was focused on social responsibility while life continued as usual with precautions. Public education is a key strategy to empower the public and is done through traditional print and broadcast media, as well as social media. This includes messages on regular hand-washing and seeking medical treatment early and staying at home when unwell. The use of masks was only encouraged for ill persons to prevent them from infecting others, and the government distributed four masks to every household. Detailed anonymized information on COVID-19 cases is shared publicly to prevent speculation, whereas misinformation is quickly debunked and clarified on a government website.

In the workplace, employees are encouraged to monitor their temperature and health regularly, and institutions to step up their business continuity plans, including allowing employees to telecommute where possible and having segregated teams. Advisories to avoid large-scale events of >1000 people are in place, whereas ongoing events are advised to take precautions such as health screening and turning away ill individuals. Schools have remained open, and have implemented precautionary measures such as reduction of mass assemblies, inter-class and inter-school activities and staggered meal times. Mass fever screening through thermal temperature scanners is widely instituted at entry to public buildings, such as offices, hotels, community centres and places of worship.

Although these precautions are implemented, relative normalcy of day-to-day life has been maintained in Singapore. Notably, Singapore has not implemented school closures or other major social-distancing measures, as there is no evidence of widespread community transmission, and rates of COVID-19 infection among children remain low.<sup>4</sup> School closures and social distancing have been performed in China and Hong Kong, where containment is also successful. However, Singapore's experience suggests it is possible to avoid major social disruptions and contain the spread of COVID-19, as a sustainable approach over the long term.

### Success and Challenges

With the combination of measures, Singapore has been able to interrupt transmission to contain the outbreak. The majority of cases were detected through application of the case definition at the point of medical consult or through contact tracing.<sup>5</sup> Statistical modelling of the effective reproduction number has shown it to be consistently below 1, suggesting that containment efforts are successful (unpublished data).

However, several challenges lie ahead. Firstly, the longer the outbreak persists, the more chains of community transmission and missed cases are present, and the more difficult it will be to link cases and contain spread. Contact tracing and quarantine are resource-intensive activities and may not be sustainable in the long run. Secondly, some individuals who continue to work or attend social functions while symptomatic are driving disease

**Table 1.** Summary of measures taken for COVID-19 in Singapore and other countries (as of 10 March 2020)

Measure	Singapore	Other countries (selected)
Surveillance and containment measures		
Case detection	Case definition was established based on clinical and epidemiological criteria, and continuously updated as the COVID-19 situation evolved. Surveillance was enhanced to test COVID-19 in all pneumonia patients, ICU patients and deaths from possible infectious cause and ILI in sentinel primary care sites. Doctors were also allowed to test patients whom they viewed with suspicion for clinical or epidemiological reasons	Affected countries instituted various case-finding activities using WHO's case definition or a modified version. <sup>6</sup> Malaysia, ROK and the UK incorporated COVID-19 testing for severe acute respiratory illness (SARI) and ILI surveillances. In Japan, ROK and the USA, doctors were allowed to test patients at their discretion
Quarantine and phone surveillance	Symptomatic contacts were referred to hospital. Asymptomatic close contacts were placed under compulsory quarantine for 14 days, whereas lower-risk contacts were put on phone surveillance	Mandatory quarantine was required by law in several countries/regions, including Brunei, Hong Kong, Israel, mainland China and ROK
Laboratory testing	PCR testing for COVID-19 is available at all public hospital laboratories to increase national diagnostic capacity, and other healthcare institutions can send samples for testing at these facilities. Serological tests were used to investigate linkages between cases and clusters	In Japan and the USA, COVID-19 testing was extended to non-public health laboratories. Serological testing using IgM and IgG antibodies was described in mainland China
Healthcare measures		
Clinical management in primary care	Medical practitioners were instructed to provide extended medical leave of up to 5 days for patients with respiratory symptoms, and to refer them for further testing if they do not recover. Patients were advised to return to the same doctor if symptoms persist	In the UK, primary care practitioners were advised to avoid face-to-face assessment of suspected cases. Instead, patients should be immediately isolated and referred to the local health authorities via a hotline. <sup>7</sup> General practitioners in Australia were similarly advised to refer patients to dedicated health services, undertake remote telemedicine consultation or make safe arrangements to assess possible COVID-19 patients <sup>8</sup>
Infection prevention and control	Infection control measures were strengthened at healthcare institutions, including strict visitor controls, cohorting of patients with pneumonia or respiratory infection and maintenance of strict infection control practices across all settings. Inter-institution movement of patients and doctors was limited	Infection control measures recommended by the US Centres for Disease Control to healthcare institutes included limiting points of entry to facilities, prioritizing triage of patients with respiratory symptoms, exploring alternatives to face-to-face triage, limiting visitor access and movement within facility and managing exposed healthcare workers <sup>9</sup>
Healthcare services	Over 800 PHPCs were activated to enhance management of respiratory infections in the primary care setting, with subsidies extended to Singapore residents	Australia and China set up 'fever clinics' to assess large volume of people for COVID-19 while minimizing risk of transmission to other patients
Designated hospital	Majority of cases were isolated and treated at the NCID, a 330-bed purpose built infectious diseases management facility	While most countries managed their cases in existing hospitals, China established at least 14 temporary medical facilities designated to treat COVID-19 patients. Two new hospitals with at least 1000 beds each were also built in Wuhan city
Border control measures		
Temperature screening	Temperature and health screening for inbound travellers is being conducted at all land, air and sea checkpoints	Countries including China are conducting temperature screening of incoming passengers at air, land and sea checkpoints
Travel advisories and border restrictions	Singaporeans are advised to defer non-essential travel to mainland China, ROK, Northern Italy and Iran, and entry restrictions are imposed on visitors from these regions. Returning residents with travel history to these areas are subject to a 14-day quarantine	At least 45 countries or regions issued partial or complete travel bans on mainland China, Iran, Italy, ROK or other countries

(Continued)

Table 1. Continued

Measure	Singapore	Other countries (selected)
Community and social measures		
Schools	Schools have remained open, but implemented precautionary measures such as reduction of mass assemblies, inter-class and inter-school activities, and staggered meal times	Country/region-wide school closures were announced in Albania, Bulgaria, Iran, Iraq, Italy, Japan, mainland China, Hong Kong, Saudi Arabia, Spain and ROK
Workplaces	Employees are encouraged to monitor their temperature and health regularly, and institutions are encouraged to step up their business continuity plans, such as telecommuting where possible and having segregated teams	Hong Kong's Centre for Health Protection encouraged companies to develop comprehensive policies that include business continuity and operational plans to maintain core services. <sup>10</sup> In the USA, employers were recommended to develop contingency plans for situations that may arise during outbreaks <sup>11</sup>
Public communications	Public education was done through traditional print and broadcast media, as well as social media. Public are advised to practise social responsibility while life continues as usual with precautions. Misinformation is debunked and clarified on a government website	Most countries delivered public-service announcements promoting social responsibility and set up telephone hotlines for public enquiries. In mainland China, several provinces mandated mask wearing in public spaces
Lockdown of affected areas	No areas have been locked down to date	Massive lockdowns were reported in mainland China, Palestine, Saudi Arabia, and Italy. Smaller scale lockdowns were reported in ROK, Cyprus and Vietnam

spread, leading to substantial community transmission. Thirdly, with global spread, the force of infection from imported cases will be substantial, leading to new waves of infection.

As Singapore is a travel hub with high reliance on trade, sustained border control measures may not be practical with global disease spread, and it may not be feasible to completely shut a country's borders for a prolonged duration. These factors may result in a rise in cases, and additional measures will be required to achieve a balance between containing disease spread and reducing the overall health and socioeconomic impact due to community transmission.

## Conclusion

Early detection of cases through surveillance and aggressive contact tracing around known cases has helped to contain spread of the outbreak in Singapore. Together with other healthcare, border and community measures, they allow the COVID-19 outbreak to be managed without major disruption to daily living. Countries could consider these measures for a proportionate response to the risk of COVID-19.

## Conflict of interest

None declared.

## Authors' Contributions

All authors contributed equally to the literature review, data collection and writing of the manuscript.

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