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From SARS to COVID-19: The Singapore Journey

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Abstract

Abstract: Having experienced SARS in 2003, Singapore's healthcare system had drawn upon this experience to enhance its pandemic preparedness response. The emergence of COVID-19 has now put these preparations to the test. We describe the evolution of Singapore's outbreak response from the SARS crisis in 2003 to the current COVID-19 pandemic, focusing on public health measures as well as the clinical management and workflows at the National Center for Infectious Diseases, Singapore.

Introduction

Singapore is a densely populated city-state of 5.7 million and a global travel hub. These characteristics make it particularly susceptible to the importation of communicable diseases and consequent outbreaks. The 2003 severe acute respiratory syndrome (SARS) outbreak challenged the nation's public health system and now, the emerging Coronavirus Disease 2019 (COVID-19) pandemic is poised to present a greater challenge.

Since December 2019, the virus responsible for COVID-19, SARS-CoV-2, has spread to more than 150 countries and more than 200,000 cases have been reported. (1) Singapore diagnosed its first case on 23 January 2020.

Translating lessons from SARS to COVID-19

In 2003, SARS infected 238 people and killed 33 in Singapore, exposing the weaknesses of the epidemiological surveillance and healthcare system for emerging infectious diseases. (2) Learning from the outbreak, Singapore introduced several key measures to strengthen its pandemic management capabilities.

The Disease Outbreak Response System Condition (DORSCON) framework was established. This framework serves as the foundation for the national responses to any outbreak and is divided into four levels of incremental severity (Green, Yellow, Orange and Red), based on risk assessment of the public health impact of the disease and the current disease situation in Singapore (Table.1). The goal and extent of public health response measures are in response to the level of threat.(2,3)

Infrastructure for outbreak management was significantly augmented. Isolation facilities in public hospitals have been increased. The National Centre for Infectious Diseases (NCID), a 330-bed purpose-built infectious disease management facility with integrated clinical, laboratory and epidemiologic functions has replaced the 39 isolation-bed Communicable Disease Centre as the centrepiece of pandemic management in Singapore. (2,4) National stockpiles of personal protective equipment (PPE), critical medications and vaccines for up to 6 months have been established. (2)

Professional manpower and training of healthcare workers (HCW) in outbreak response were expanded, with the number of infectious disease physicians rising from 11 in 2003 to 73 in 2020. Since 2006, the Ministry of Health (MOH) has conducted regular scenario-based simulation exercises at all public hospitals to evaluate and provide feedback to their pandemic response plans.(5)

Public engagement and education were crucial components in the public health response to outbreaks. Consistent public communication was effected through press releases and media coverage of the epidemic while an education campaign was mounted to educate Singaporeans on the disease and appropriate behaviour to prevent transmission. (6)

It was apparent from SARS that clear leadership and direction was essential for a government-wide, coordinated response towards the outbreak. A ministerial committee first established during SARS to provide guidance and decisions on strategies for containment of the outbreak was convened in COVID-19 as a multi-ministry task force co-chaired by the Minister for Health and the Minister for National Development.(2,4) This taskforce had the ability to recommend and implement whole-of-government policies to deal with issues related to COVID-19.

Singapore's COVID-19 response

To reduce the transmission of SARS-CoV-2, Singapore has adopted a strategy of active case detection and containment through several means.

Surveillance and Containment

With the goal to identify every case of COVID-19, several complementary detection methods were employed. A local case definition for suspect cases of COVID-19 was first established on 2 January 2020 based on clinical and epidemiological criteria. (4,7) This definition was constantly updated to adapt to the evolving global and local situation. (7) Dissemination of the criteria to all physicians in Singapore was through text messages and emails, and criteria-based screening was implemented at all clinics and hospitals nationally. Persons fulfilling criteria were referred from primary care clinics to NCID while those that presented to hospital emergency departments were isolated in airborne isolation rooms and tested.

At NCID, an outbreak screening centre was set-up to evaluate suspect cases. Suspects were stratified into low and high-risk groups. (Fig. 1) High-risk suspects were admitted, isolated and tested for SARS-CoV-2. Low-risk suspects had a single nasopharyngeal swab test and were discharged with a written advisory to self-isolate at home. Phone surveillance for symptom progression was performed and patients with persistent symptoms or positive swab results were recalled for further evaluation or isolation. As of 16 March 2020, a total of 4,721 low-risk suspects had been evaluated, of whom 63 were recalled for positive test results.

Patients with confirmed COVID-19 underwent detailed interviews for activity mapping to guide contact tracing and cluster investigations. Identified close contacts were placed in quarantine either at home or government quarantine facilities while casual contacts were

placed on phone surveillance. (7,8) The Infectious Diseases Act was applied to enforce epidemiological investigations and containment measures.(9) To date, over 4000 contacts have been placed under quarantine.(4)

Beyond case definition, an enhanced surveillance system was implemented to test for SARS-CoV-2 among all cases of community-acquired pneumonia, severely ill patients in intensive care units (ICU) with possible infectious disease, deaths from possible infectious aetiology and influenza-like illness in sentinel primary care clinics. (4,7) Doctors have the liberty to test patients based on clinical or epidemiological suspicion. As of 29 February 2020, 16% of the first 100 COVID-19 cases were detected by enhanced surveillance while clinician-guided testing accounted for an additional 11% of cases. (7)

To support multiple testing sites, SARS-CoV-2 Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) laboratory testing capability was expanded from the National Public Health Laboratory (NPHL) to all public hospitals in Singapore, allowing 2,200 tests to be performed daily. (4)

Border Control Measures

Singapore had implemented border control measures to prevent importation of cases and consequent forward local transmission.(4) The earliest of these measures involved temperature and health screening for arrivals from Wuhan since 3 January 2020. Measures were progressively escalated in response to the global situation, with screening measures extended to all travellers at all ports of entry since 29 January, a travel ban for all visitors with recent travel to China since 1 February, which was extended to South Korea, Iran and Northern Italy on 4 March, and then the whole of Italy, France, Spain and Germany from 15 March.

As of 19 March 2020, travel bans have been imposed on visitors from 7 countries. All arrivals from ASEAN countries, Japan, Switzerland and the United Kingdom will have to serve a mandatory 14-day Stay-Home-Notice. Singapore residents have been advised to defer all non-essential travel.

Community and Social Measures

Drawing from the public engagement efforts in SARS, public education efforts in Singapore emphasised on social responsibility and appropriate behaviour. Messages on regular handwashing, appropriate use of masks only when unwell, seeking medical treatment early and staying home when unwell were conveyed through print and broadcast media as well as social media platforms.(4) The public was advised to obtain accurate and factual information from reliable sources including government websites, Facebook and Instagram. (4)

Daily updates on the COVID-19 situation with anonymised information on positive cases were shared publicly though MOH website while misinformation was quickly dispelled to prevent public anxiety and speculation.(4)

Singaporeans with respiratory symptoms were encouraged to seek treatment at Public Health Preparedness Clinics (PHPCs), a network of over 800 primary health clinics that provided subsidised care and extended medical leave of up to five days. This allowed possible mild COVID-19 cases to self-isolate at home and reduce community transmission. Those with progressive symptoms were advised to return to the same doctor for evaluation and further testing.(4)

At the workplace, employers were encouraged to conduct regular temperature and health monitoring for employees, as well as to implement business continuity plans, e.g. work from home or segregated teams to reduce mixing of workers.(4) Advisories against large scale events of more than 250 participants are currently in place. Thus far, schools and businesses have remained open, although most have implemented precautionary measures, including fever screening through thermal scanners at points of entry.(4)

Management of COVID-19 in NCID

Patients in NCID were placed in individual negative-pressure isolation rooms and reviewed daily by medical teams. Manpower was augmented by trained staff deployed from Tan Tock Seng Hospital (TTSH), a university teaching hospital. Business-as-usual operations at TTSH was scaled down to provide both clinical and non-clinical manpower for national outbreak response.

A structured just-in-time training programme was rolled out by the department of infection prevention and control to train newly deployed staff in donning and doffing of PPE. To standardise the collection of clinical and epidemiological data, and guide clinical management, COVID-19 clinical pathways were implemented.

All admitted suspects received an initial chest radiograph and were tested for SARS-CoV-2 by means of RT-PCR from respiratory specimens over 2 consecutive days. Clinicians were given the liberty to perform additional tests based on clinical or epidemiological grounds. Suspects were deisolated or discharged if they fulfilled the in-house discharge criteria.(10) To date, none of the discharged suspects have been readmitted and tested positive.

Patients who tested positive were managed inpatient until their symptoms had resolved and two nasopharyngeal swabs negative for SARS-CoV-2 on two consecutive days. The ViSi Mobile® (Sotera Wireless, San Diego, California, USA) wearable continuous patient monitoring system was used to monitor patient parameters to reduce exposure for HCW and PPE consumption. As standard of care, complete blood count, kidney and liver function tests, C-reactive protein and lactate dehydrogenase levels were performed. Respiratory samples were tested for influenza and other respiratory viruses with a multiplex PCR assay. All patients received supportive therapy, including supplemental oxygen when needed. Patients clinically suspected of having community-acquired pneumonia were administered empirical antibiotics and oral oseltamivir.(11) Agents with possible anti-viral effect on SARS-CoV-2 were offered to patients meeting in-house guidelines. Co-formulated lopinavir-ritonavir (200 mg/100 mg twice daily orally for up to 14 days) with or without interferon beta-1b (8 million units every other day for 14 days) were prescribed to selected patients after shared decision-making and provision of verbal informed consent.

Patients with risk factors for severe disease and requiring supplementary oxygen were referred to a multidisciplinary Intensive Care Unit (ICU) team, comprising Critical Care and Infectious Disease specialists.(12,13) Patients expected to deteriorate were pre-emptively transferred to the dedicated outbreak ICU for monitoring. Intubation, if required, was performed electively in full PPE whenever possible. Non-invasive ventilation was disallowed to reduce generation of aerosol. On-site Extracorporeal Membrane Oxygenation (ECMO) support was available for patients assessed to be suitable.(14)

Managing the Sick Healthcare Worker

Since the transmission of SARS-CoV-2 to HCW was reported on 20 January 2020 (15), twice-daily temperature monitoring was mandated for all front-line HCW in all public hospitals. HCW in direct contact with COVID-19 patients who developed fever or symptoms of acute respiratory infection were encouraged to declare their symptoms to their superiors and present themselves to the screening centre, where they would be managed based on their exposure risk (Fig.2). A HCW with protected exposure was defined as one who minimally was wearing a surgical mask and would be placed under phone surveillance for symptoms. Those with unprotected exposure would be quarantined. Those who present with symptoms would be managed as high-risk suspects. As of 15 March, a total of 569 HCW have been evaluated, of whom 35 had been admitted and none had tested positive.

Beyond COVID-19

These strategies aim to delay the peak in number of COVID-19 cases in Singapore and avoid overwhelming the healthcare system which may have contributed to higher case fatality rate in Hubei, China and Italy. (16) 'Flattening the curve' buys time for additional measures to be put in place. Adequate time is needed for purchase of equipment, manpower deployment, logistical arrangement and operational planning. In our experience, approximately 10% of patients were admitted to intensive care unit. Increase in requirement for intensive care unit beds is anticipated. Planning for such additional resources should be guided by experience and evidence, and adjustment made in an agile manner. To deal with the numbers of positive cases who are all admitted under current policy, those who have low risk and mild disease would be identified using predictive scores for subsequent safe transition of care to the outpatient setting to free up hospital resources to manage patients with severe disease.

As valuable medical resources are diverted to manage the pandemic, it is important to maintain acceptable level of care for patients with other medical conditions. Clinic sessions that were disrupted and elective surgeries that were delayed ought to be ramped up to clear the backlog of patients requiring care. COVID-19 had impacted the training of medical students and junior doctors as cross-institutional staff movement were restricted, and

lectures and bedside tutorials were cancelled. These were somewhat mitigated with online learning.

We are seeing the start of the pandemic. All countries must ramp up medical capabilities to deal with the surge in patients. Measures implemented in Singapore to reduce infections are laborious, time-consuming and costly. However, it is projected that these measures will be cost-effective in the long run and more importantly, life-saving. A whole-of-government concerted approach is paramount to combat COVID-19 as its impact is not just on human health. Social unrest, political instability, economic depression and food security are potential issues that may further threaten our wellbeing.

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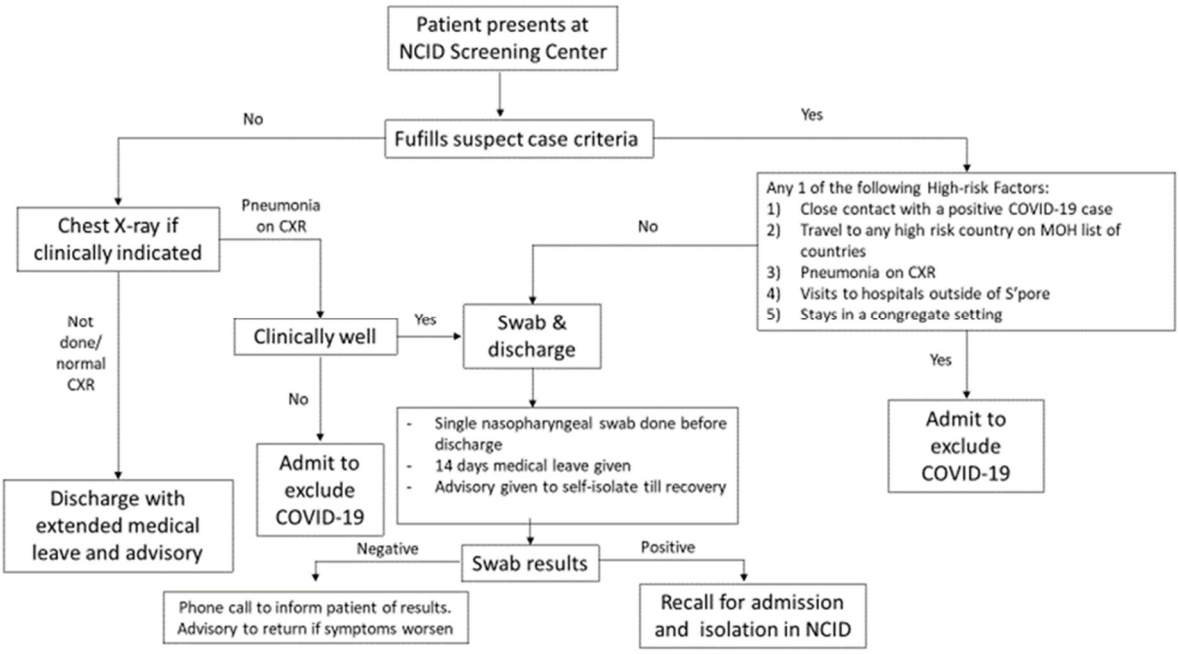
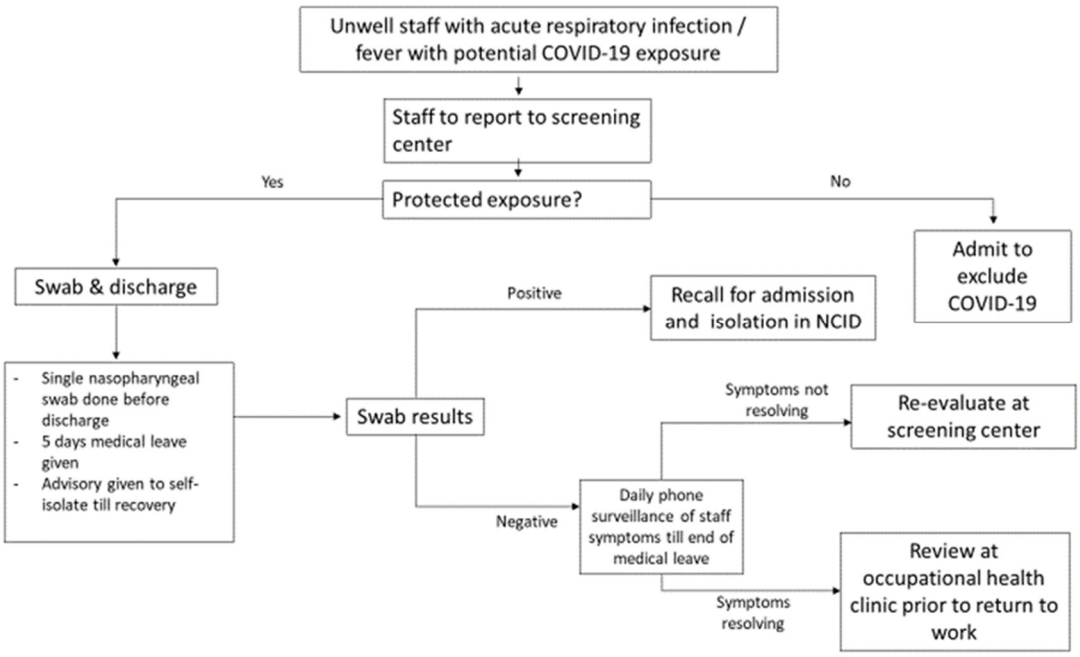

Patient presents at NCID Screening Center
Fufills suspect case criteria
No
Yes
Chest X-ray if clinically indicated
Pneumonia on CXR
Not done/ normal CXR
Discharge with extended medical leave and advisory
Clinically well
Yes
No
Admit to exclude COVID-19
Swab & discharge
- Single nasopharyngeal swab done before discharge
- 14 days medical leave given
- Advisory given to self-isolate till recovery
Swab results
Negative
Positive
Phone call to inform patient of results. Advisory to return if symptoms worsen
Recall for admission and isolation in NCID
No
Any 1 of the following High-risk Factors:
1) Close contact with a positive COVID-19 case
2) Travel to any high risk country on MOH list of countries
3) Pneumonia on CXR
4) Visits to hospitals outside of S'pore
5) Stays in a congregate setting
Yes
Admit to exclude COVID-19


Unwell staff with acute respiratory infection / fever with potential COVID-19 exposure
Staff to report to screening center
Protected exposure?
Yes
No
Admit to exclude COVID-19
Swab & discharge
- Single nasopharyngeal swab done before discharge
- 5 days medical leave given
- Advisory given to self-isolate till recovery
Swab results
Positive
Recall for admission and isolation in NCID
Negative
Daily phone surveillance of staff symptoms till end of medical leave
Symptoms not resolving
Re-evaluate at screening center
Symptoms resolving
Review at occupational health clinic prior to return to work

Possible scenarios	Applicable response phases	Border Control	Public Health Measures						
			Temperature screening in institutions	Social distancing	School closures	Contact tracing	Phone surveillance or quarantine	Antivirals	Vaccination
GREEN - Negligible to low publich health impact									
- High virulence - No or limited H-H transmission - Disease mainly overseas	Alert with containment of imported cases	Health Advisory Notices (HANs)	No	No	No	Yes, if imported cases	To implement depending on risk	Treatment of cases where necessary	No
- Similar of lower virulence and transmissibility as seasonal flu	Mitigation	No	Consider for implementation			No	No		Vaccination for high risk groups if available
YELLOW									
- High virulence but low transmissibility - Disease mainly overseas	Alert with containment of imported cases	- HANs - Health Declaration Card (HDCs) - Temperature screening of inbound passengers	No	No	No	Yes, if imported cases	To implement depending on risk	Treatment of cases where necessary	Procure and offer vaccines when available
- Local epidemic with low virulence but high transmissibility	Mitigation	HANs	Consider for implementation			No	No		
- High virulence and transmissibility but, vaccine available	Mitigation		No						Distribute vaccine to mitigate impact
ORANGE									
- High virulence and transmissibility - Disease mainly overseas	Alert	- HANs - Health Declaration Card (HDCs) - Temperature screening of inbound passengers	No	No	No	Yes, if imported cases	Quarantine	Treatment of cases, consider limited prophylaxis of personnel providing essential services	Procure and offer vaccines when available
- High virulence and transmissibility - Disease in Singapore	Containment		Yes, depending on risk	Yes, depending on risk	Yes, selective closure if cases or clusters detected in schools	Yes, as far as operationally feasible	Quarantine, as far as operationally feasible		
- High virulence and transmissibility - More cases in Singapore	Limited mitigation	- HANs - Health Declaration Card (HDCs) - Temperature screening of all passengers				No	No		
RED									
- High virulence and transmissibility - Widespread transmission	Mitigation	Temperature screening of all passengers	Yes	Yes	Yes	No	No	Treatment of cases and prophylaxis of personnel providing essential services	Procure and offer vaccines when available