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# COVID-19 in Singapore: Our Experience as a Country, and at Singapore General Hospital's Department of Emergency Medicine

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COVID-19 has changed our lives as we knew it. The world is not naive to infectious disease outbreaks, having experienced pandemics such as the H1N1 outbreak in 2009 with up to 400,000 deaths, and the "Spanish flu" in 1919 with up to 50 million deaths worldwide respectively (https://www.euro.who.int/en/health-topics/ communicable-diseases/influenza/pandemic-influenza/past-pandemics). However, this outbreak caused by the severe acute respiratory syndrome coronavirus-2 has taken the world by storm since it was first reported in end 2019. With the numbers of confirmed cases of COVID-19 and death toll rising every day, it raises the question of when will we be fully equipped to handle a pandemic of such a mammoth scale. A multi-pronged approach has to be undertaken by not only healthcare organisations and pharmaceuticals, but also government agencies and legislation in order to overcome the repercussions and mitigate the effects of an infectious disease outbreak. In this article, we share our experience in Singapore and Singapore General Hospital against COVID-19 and our ongoing efforts to keep the virus at bay.

Key words: infectious diseases, outbreak, pandemic, emergency medicine

### Introduction

The year 2020 has been plagued by the coronavirus disease 2019 (COVID-19) which is probably the latest buzzword across all countries. The disease, caused by the severe acute respiratory syndrome coronavirus virus 2 (SARS-CoV-2), first documented in December 2019, has affected over 33 million people in 213 countries and contributed to over a million deaths worldwide.<sup>1</sup> COVID-19 was declared a Public Health Emergency of International Concern on January 30, 2020; then later, a pandemic on March 11, 2020, by the World Health Organization.<sup>2</sup> Singapore, the small city-state of approximately 721 km<sup>2</sup> and a population of 5.7 million, is no exception to the profound effects of the pandemic.

### **Lessons From Previous Outbreaks**

In modern-day Singapore, our experiences with pandemics include SARS in 2003 with 33 fatalities,<sup>3</sup> Influenza A (H1N1) in 2009 with 21 fatalities,<sup>4</sup> and Middle Eastern Respiratory Coronavirus Syndrome (MERS-CoV) with 0 cases.<sup>5</sup>

SARS had affected Singapore greatly as it occurred at a time when the government and healthcare system were not anticipating an emerging infectious disease outbreak (DO). It served as a stepping stone for a better whole-of-government consolidated effort in managing such a situation. In anticipation of future pandemics after SARS, all restructured government hospitals expanded their fever and isolation facilities in their respective emergency departments (EDs)

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as well as inpatient locations to accommodate an increase in such infectious cases. Since then, much progress, including technological advancements, has been made as a country, to better deal with infectious DOs.

For example, the National Centre for Infectious Diseases (NCID), a 330-bedded, multidisciplinary infectious disease management facility, was officially opened on September 7, 2019. In the 2003 SARS outbreak in Singapore, only one general hospital was designated as the "SARS hospital" also treating pediatric patients,<sup>6</sup> while currently, all hospitals are managing COVID-19 independently after ramping up infection control efforts and services. Furthermore, to provide adequate specialist services for emerging infectious DOs and disasters, the number of emergency physicians has risen from 34 in 2003 to at least 212 currently and infectious disease physicians from 16 in 2003, to at least 87 currently.<sup>7,8</sup> In terms of resources, stockpiling of at least 3-6 months of personal protective equipment (PPE) and powered air-purifying respirators (PAPRs) for all hospitals and clinics was undertaken to ensure adequate supplies during outbreaks.9

Infection prevention and control measures at hospitals were heightened and new standards were put in place to promote and sustain infection control in healthcare institutions.<sup>10</sup> During SARS in 2003, healthcare workers (HCWs) had contributed to 40% of the total SARS cases and healthcare institutions were the source of infection in 73.5% of cases<sup>11</sup> whereas a cross-sectional study conducted earlier in 2020 studying the epidemiology of HCWs infected with COVID-19 reported that HCWs contributed to a mere 1.7% of the total infections during the tenure of the study.<sup>12</sup> Furthermore, none of these HCWs had contracted COVID-19 in healthcare institutions,<sup>13</sup> which was contributed by restrictions on the inter-hospital movement of staff, suspension of teaching of medical students, and postponement of courses, events, and certain post-graduate specialist medical examinations.

In order to ramp up testing for COVID-19 in a timely fashion, the Health Sciences Authority, Singapore, set up a provisional authorization process to hasten the production and availability of COVID-19 testing kits.<sup>14</sup> The importance of research and development in medical science and technology is clear when comparing the fact that no diagnostic testing kits were available during the first several weeks of the SARS outbreak in 2003<sup>11</sup> to the rapid production of test kits during the current COVID-19 outbreak. Diversifying sources of testing kits and local production has enabled testing and prompt management of larger numbers of suspect patients.<sup>15</sup> Testing capability was also extended from the National Public Health Laboratory at NCID to include all hospital laboratories in order to increase the rate of case detection.<sup>8</sup> Currently, Singapore is within reach of its target of conducting 40,000 tests per day.<sup>16</sup>

# Suspect-Case Definition and Isolation Facilities

The Ministry of Health (MOH), Singapore, defined "Suspect Cases" to assist healthcare professionals in identifying and testing individuals at high risk of the virus. The initial case definition included travel history to Wuhan City, China, within 14 days of developing respiratory illness. It was then updated to persons who had traveled to any country abroad as the situation escalated worldwide. Adopting these strict criteria enabled timely detection and management of the positive cases and helped to prevent further community spread. In addition to the MOH case definition, physicians were given the autonomy to perform swab tests on patients who, based on risk stratification, could not be safely ruled out as being disease-free. This flexibility allowed more positive cases to be picked up and quickly isolated as was evident when a new cluster of COVID-19 was unveiled due to the vigilance of the attending physicians at Singapore General Hospital (SGH) ED when a patient had persistent symptoms despite not meeting the MOH suspect case definition at the time of presentation in February 2020-the patient did not have a travel history to Wuhan, China, but was working in a souvenir shop patronized by many tourists from China.<sup>17</sup> All patients presenting to primary healthcare who met the definition of suspect cases were sent to hospitals via dedicated ambulances for testing and isolation, while low-risk patients with acute respiratory illnesses were given five-day medical leave and required by law to stay home.

All positive COVID-19 cases in the community were admitted to isolation wards in hospitals across the island. Also, there are a total of 974 Public Health Preparedness Clinics that offer treatment and swab tests for COVID-19 via the Swab-and-send-home (SASH) protocol.<sup>18</sup> The SASH protocol aims to identify individuals at risk of the virus early and reduce the workload at the hospital's EDs.

As part of scaling up facilities and to manage the surge of positive COVID-19 cases, Community Care Facilities, for example, at the Singapore Expo with 8,000 beds, were set up by the government to isolate positive cases who were clinically well and stable. In addition, military camps were converted to Community Recovery Facilities for those recovering from COVID-19, and Swab Isolation Facilities were set up to house suspect cases who could not isolate themselves while waiting for the swab results.<sup>19</sup>

# DORSCON (DO Response System Condition) and Circuit Breaker

DORSCON (DO Response System Condition) system was developed as part of Singapore's national response strategy and planning for a pandemic after our previous experiences with outbreaks. DORSCON is a color-coded framework developed by MOH, Singapore, as a means of characterizing a DO in terms of the threat of infection to the general public, the condition of the DO overseas, and the impact of the DO on the local community. The color-codes range from green, corresponding to a negligible public health impact, to red, reflecting a high public health impact.<sup>20</sup> As a result of several unlinked cases of COVID-19 with no travel history, the surveillance level was raised from Yellow to Orange on February 7, 2020, in Singapore. A Multi-Ministry Taskforce which included the MOH, Ministry of Defence, and the Ministry of Home Affairs was set up to ramp up efforts to contain the virus and mobilize resources to stop the community spread of the disease.

As the number of unlinked COVID-19 cases was rising and more local clusters were being discovered, the Multi-Ministry Taskforce announced the "circuit breaker" on April 7, 2020. The circuit breaker consisted of enhanced safe distancing measures to reduce the interactions between members of the public. The Circuit Breaker period was initially planned to be for 1 month but was extended till June 1, 2020, due to rising numbers of COVID-19 cases in the community. At the same time, there was an increase in the number of positive cases among migrant workers that lived in dormitories. Students and teachers were affected during this period as learning moved from the school to home-based learning via the virtual classroom. The circuit breaker also meant only organizations and companies providing essential services were available for business-as-usual while the rest began working from home. Reusable masks were distributed to all households and everyone was required to wear masks when going outdoors. The elderly were discouraged from going outdoors as they were epidemiologically more vulnerable to the effects of COVID-19 and faced a higher threat of mortality.

In addition, a new Bill was introduced in Parliament, called the COVID-19 Temporary Measures Act,<sup>21</sup> which provides legal grounds to enhance safe distancing measures, prevent social gatherings, ensuring the safety of the community. Contact tracing was also emphasized to track the paths of positive COVID-19 cases and identify other individuals at risk. Contact tracing is a multi-ministry effort comprising the Singapore Police Force, security officers, hospitals, volunteers from government statutory boards and is managed by MOH, Singapore. MOH also collaborated with other government agencies such as GovTech to create a new mobile app called TraceTogether,<sup>22</sup> which uses Bluetooth and timestamps to identify other nearby phones with the same app installed. It enables contact tracing to be done more easily and aims to ease the workload of human contact tracers.

Subsequently, as the outbreak was under control and local spread was limited, the government took a three-phased approach to ease restrictions in the community. Phase 1, which took effect on June 2, 2020, saw amongst others, most manufacturing and production companies and essential services such as hairdressers resuming business with safety measures in place and graduating students returning to school daily while other levels alternated between homebased learning and school-based lessons. Currently, as of October 2020, we are in Phase 2 with more activities resuming back to normal and looking forward to Phase 3 with the re-opening of borders.<sup>23</sup>

## **Command and Control at SGH**

With an inpatient bed capacity of 1,785 beds and staff strength of 9,888, SGH is Singapore's largest and oldest tertiary hospital which had its beginnings in 1821. The SGH campus also houses five National Specialist Centres.<sup>24</sup>

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The SGH Campus Command and Control Centre was officially set up in 2007 to coordinate emergency management and operational responses during outbreaks and disasters. In addition, the Disaster Outbreak Taskforce is specifically appointed to streamline the campuses' efforts to manage resources and provide guidance during DOs. The SGH Campus Command and Control Centre is led by the Chief of Staff, who is appointed by either the Chief Executive Officer or Chairman Medical Board of SGH.

# ED's Outbreak Roster and Adapting to a New Norm

SGH's Department of Emergency Medicine (DEM) sees more than 122,000 ED visits per year, which amounts to approximately 340 patients per day.<sup>25</sup> Operations and screening efforts at the DEM were heightened in January 2020 with the outbreak alert and suspect case definition set forth by the MOH.

The DEM transitioned into an outbreak roster on February 8, 2020, to cope with the threat and demands of COVID-19. The outbreak roster was initiated in anticipation of staff contracting COVID-19 and to mitigate the subsequent effects on manpower. The doctors and nurses in the department were split into teams—each team of doctors comprised approximately 15 juniors and seniors in total and did a 12-hour shift each time. We also identified at least one senior doctor within each team as a peer support leader to provide advice and help to other staff members during the functioning period of the outbreak roster. We have transitioned out of the outbreak roster at the time of writing.

As part of a unified effort, all of the DEM staff were strongly recommended to shower after shifts, before leaving the hospital, and safe distancing was ensured at all rest areas. Furthermore, transparent plastic shields were placed on the tables in the staff pantry to prevent droplet transmissions between staff during break and mealtimes. Posters were placed at rest areas to remind staff to keep a safe distance from one another.

We also expanded and modified our clinical areas to manage the suspect cases and non-suspect cases separately. Our ED has a fever area which was constructed after the 2003 SARS epidemic (Fig. 1). The area has high-efficiency particulate air filters built into the ventilation system resulting in a negative-pressure system. The fever area consists of three consultation rooms, four cubicles for observation, four cubicles for trolleys which can be used for resuscitation, including endotracheal intubation (Fig. 2). Additionally, there are two toilets, X-ray facilities, and one ultrasound machine. We also adapted our usual clinical work area and treatment rooms to allow more space to manage high acuity cases who were suspects for COVID-19





Fig 1. (A) Facilities within Fever Area in the Department of Emergency Medicine. (B) X-ray room. (C) Dedicated toilets.

and to safely board suspect cases waiting for inpatient beds. In addition, the Ambulatory Surgery Centre (ASC) which is part of the Division of Surgery, was converted to manage suspect COVID-19 cases within the ED. Dedicated toilets, a portable X-ray machine, and an ultrasound machine were added to the ASC to enable it to be as self-sufficient as possible to avoid patient movement and cross-contamination. The use of portable plastic screens in place of curtains ensures privacy for patients and facilitates terminal cleaning (Fig. 3).

In our main resuscitation area, fever area, and ASC, staff attending to suspect cases were required to don PPE while those involved in aerosol-generating procedures such as tracheal intubation were required to wear the PAPR. Minimum PPE included mask-fitted N-95 or equivalent, disposable gowns, gloves, and face shield or eye protective gear. All oropharyngeal and nasopharyngeal swabs were obtained by trained staff at a dedicated swab booth outside of the department to minimize aerosolization of particles.

Working closely with the Infection Prevention and Epidemiology (IPE) and Infectious Diseases specialists, emergency physicians at SGH DEM devised internal screening-criteria on top of the MOH suspect case definition to cast a wider net on the suspected cases. This allowed us to identify more individuals at risk of COVID-19, test them early, and treat them accordingly to prevent unnecessary community spread.

# Surge Response at SGH

As part of SGH's DO preparedness plan, suspect



Fig. 2. Fever Area Cubicle. The area can be used to perform resuscitation and endotracheal intubation.





Fig 3. (A) Converting Ambulatory Surgery Centre to see suspect COVID-19 cases. (B) Portable X-ray machine.

cases were to be screened at a designated area separate from the non-suspect patients. In anticipation of large numbers of suspect cases of COVID-19, a peacetime multi-storey car park was converted to a Flu Screening Area (FSA) to manage the expected surge (Fig. 4). It was officially operational for the COVID-19 pandemic on March 20, 2020. Planning for this mega-scale transformation began as early as 2013. In 2015, validation of the building itself and workflow simulations were conducted and is continually reassessed with regular tabletop exercises.<sup>26</sup> SGH's Preparedness and Response Unit and Department of IPE are involved in these efforts, together



Fig 4. Transformation of multi-storey car park to Flu Screening Area. (Courtesy of Singapore General Hospital)

with specialists and staff from the DEM. Support from hospital administration and senior management has been crucial to the success of this endeavor.

The building is suitable for managing suspect infectious cases as it is large, spanning 12 decks, and located about 400 m away from the main hospital building but accessible by well-connected roads. This allows decanting of suspect cases who met the definition set out by the MOH and hospital to the FSA, as part of SGH's surge response. Infrastructural modifications such as the addition of a staircase, only for staff use, to minimize unnecessary contact with suspect patients were also undertaken. A turnaround time of approximately 3 days is required to convert the MCSP into an FSA, complete with IT equipment, patient care areas, resuscitation area, X-ray facilities, and also a swab-booth (Fig. 5). Additional staff members from various disciplines throughout the SGH campus assisted with the operation of the FSA which saw between 5% and 15% of the monthly total ED patient load during the height of the pandemic in Singapore, from March 20, 2020 to May 13, 2020.<sup>27</sup> The successful transformation of the MSCP into an FSA is a result of a multidisciplinary, campus-wide effort and meticulous planning.

At SGH, in addition to the FSA, an open-air car park was converted into an Isolation Ward with a capacity of up to 50 purpose-built container isolation rooms replete with X-ray facilities and WiFi (Figs. 6

and 7). Construction of the 3,200 m<sup>2</sup> facility, named Ward@Bowyer, took 6 weeks to complete and was officially opened on July 15, 2020. The clever use of technology has made monitoring of patients seamless as they are given a biosensor to wear on their wrists that can transmit patient vital signs to alert the clinical team of potentially sick patients. Furthermore, SGH's Nursing Division collaborated with Integrated Health Information Systems to create a new mobile app called MyCare Lite that enabled video conferencing between patients and medical staff (Fig. 8).<sup>27</sup>

# **Re-organization and Re-training**

Radiology departments across all hospitals also modified their workflows to accommodate the needs and demands during this pandemic. Radiology departments adopted spatial and temporal segregation contingency-plans depending on their staff capacities respectively. Spatial segregation included staff working in teams and even the ability to report via satellite sites to minimize interactions with each other. Temporal segregation meant they worked shifts to provide timely reporting services. At SGH, there was a 1-hour turnaround time of chest radiograph reporting to help clinical staff treat make critical decisions as to whether the patients should be isolated. "Portable if possible" was the mantra as portable radiology equipment was increasingly used to minimize patient movement,



Fig 5. Swab booth. Patients are first briefed on the swab procedure outside of the swab booth.



Fig 6. Ward@Bowyer: Purpose-built isolation container facility for COVID-19 patients. (Courtesy of Singapore General Hospital)



Fig 7. Ward@Bowyer: Purpose-built isolation container facility for COVID-19 patients. (Courtesy of Singapore General Hospital)



Fig. 8. MyCare Lite telecommunication between COVID-19 patients and medical staff.

and the picture archiving and communication systems allowed electronic transmission of data which helped avoid physical handling of cassettes and enabled rapid transmitting of images for reporting purposes. Enhanced infection prevention was undertaken for terminal cleaning of computed tomography scanners with sodium hypochlorite and ultraviolet light.<sup>28,29</sup>

All elective surgeries hospital-wide were scaled down and the inpatient wards were separated into Acute Respiratory Ward (ARI) and non-ARI wards to accommodate the rising numbers of suspect cases (Fig. 9). The staff were reorganized to augment manpower in areas such as the ED and the FSA to meet the demands of the rising numbers of COVID-19 suspects.

To protect all staff from infectious droplets and particles, several mask-fitting sessions were aggressively conducted throughout the hospital to ensure every single HCW and even support staff such as security officers and porters were appropriately mask fitted. These sessions were organized by the Department of Infection Prevention and Control. All staff were also required to key in their temperature twice daily on an online government-linked form and advised to seek medical attention if they fell ill. Visitors were not allowed to enter the wards unless in exceptional circumstances; however, they were subject to strict screening measures and had to adhere to restrictions such as only the same person being allowed to visit.

# **Forging Ahead**

COVID-19 has caused much grief throughout the world. It is still ongoing and some countries are still battling the disease at its height. No country or system is perfect in dealing with an infectious DO that threatens our economies and livelihoods. In Singapore, the wearing of facemasks amongst the general public was only encouraged in early April 2020 after international guidance from WHO and evidence from a local experiment proved that wearing masks reduces the spread of respiratory droplets.<sup>30</sup> With that said, Singapore safely and successfully held its General Elections on July 10, 2020, during the height of the pandemic worldwide, with additional safety regulations and even passing the Parliamentary Elections (COVID-19 Special Arrangements) Act.<sup>31</sup> There was no community spread of infection as a result of the elections.

Moving forward, Singapore is looking to enter Phase 3 of reopening from the Circuit Breaker restrictions. A strategic, multi-pronged approach including early access to COVID-19 vaccine is planned to ensure a safe transition. Singapore is co-chairing an international effort for developing a vaccine for COVID-19, recognizing that a multilateral approach is required for this mammoth task.<sup>32</sup> Being a busy travel hub, Singapore is also planning safe reopening of international travel. In the coming months, Sin-



Fig. 9. Adapting the inpatient wards to manage suspect COVID-19 cases. In this five-bedded ward, for example, two beds were removed, partitions added and patients were instructed not to cross over to other rooms. There is also an en-suite toilet. (Courtesy of Singapore General Hospital)

gapore Changi Airport will be starting a new testing laboratory at the airport itself to boost the number of tests being conducted on passengers to revive air travel safely.<sup>33</sup>

As healthcare providers, we hope for the betterment of the community and especially our loved ones. We hope that our experience in Singapore and SGH will provide insights to the international stage to better deal with outbreaks in the future. By sharing our experiences and lessons learned, we hope that there will be a collaborative approach to come up with better strategies and innovation for everyone to emerge stronger.

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