CHAPTER 3

THE VIRUS INFILTRATES THE COMMUNITY

ON FEBRUARY 7, 2020, MOH RAISED SINGAPORE'S DORSCON LEVEL FROM YELLOW TO ORANGE, SIGNALLING THAT THE VIRUS WAS SEVERE AND COULD SPREAD EASILY.

HEALTHCARE workers dressed in full personal protective equipment (PPE) were deployed to the National Centre for Infectious Diseases' (NCID) screening centre, filled with tables and chairs that were arranged in examination hall-like neatness – spaced at least 1m apart.

In the seats were people waiting anxiously for their turn to get swabbed and checked. Since the Ministry of Health (MOH) confirmed the first cases of local transmission on February 4, 2020 – where four women with no travel history to Wuhan tested positive for the virus – more and more people had been turning up at the centre.

The virus had spread across the globe, and as more Singaporeans returned from overseas, it was inevitable that COVID-19 would creep into the community. On February 7, 2020, MOH raised Singapore's Disease Outbreak Response System Condition (DORSCON) level from yellow to orange, signalling that the virus was severe and could spread easily.

Inter-school and external activities were suspended until after the March school holidays, while event organisers were urged to cancel or defer non-essential large-scale events.

"New information is emerging daily; we expect that this is likely to take time to resolve...Life cannot come to a standstill but we should take all the necessary precautions and carry on with life," said then-Minister for Health Mr Gan Kim Yong at a media briefing. But life was not the same anymore.

DORSCON ALERT LEVELS

GREEN	YELLOW	ORANGE	RED
Disease is mild or severe but does not spread easily	Disease is severe and is spreading easily outside Singapore, or spreading in Singapore but typically mild (except in vulnerable groups)	Disease is severe and spreads easily but is being contained	Disease is severe and spreading widely

ENTERING A NEW STATE OF UNCERTAINTY

RAISING the Disease Outbreak Response System Condition (DORSCON) from yellow to orange in February 2020 was not an easy decision, revealed then-Minister for Health Mr Gan Kim Yong.

"It is something we need to do so that we are able to mobilise the whole country to respond, but it is going to have a severe impact on the economy, on the way we live, study, play," shared Mr Gan, currently the Minister for Trade and Industry.

He made the announcement on February 7, 2020 during a press conference, which inadvertently sent Singapore residents into a state of panic buying at supermarkets.

Asked how he felt when he made that announcement, he said: "The sense is that we are entering into a new state, filled with uncertainties and unknowns. At that time, we knew very little about the virus. But we knew we had to mobilise the nation."

Shoppers at the Fairprice Finest outlet in Bukit Timah Plaza reaching out for toilet paper even before it got stocked on the shelves, after the Disease Outbreak Response System Condition (DORSCON) was raised from yellow to orange on Feb 7, 2020. Politicians and supermarket chain representatives urged shoppers to remain calm as shelves started emptying at unprecedented rates.

PHOTOS: TAN TOCK SENG HOSPITAL

Tan Tock Seng Hospital constructed tents outside the Screening Centre at the National Centre for Infectious Diseases in Apr 2020, to increase screening capacity to meet the rising demand of COVID-19 cases (far left and centre).

It also set up an extended facility at the Emergency Department to create more screening spaces, as part of ramped-up efforts in Sep 2021 (far right).

A CAPACITY ISSUE TO BE ADDRESSED

With no way to test for the virus at polyclinics and general practitioner clinics yet, anyone with signs of respiratory tract infections was being sent to hospitals – with NCID shouldering the bulk of cases as the first response site. But the team faced three challenges.

First, the massive number of people with runny nose and other respiratory tract infection symptoms, which made testing all of them unfeasible. "Did we have this kind of testing capabilities right from the beginning, during the first wave? We did not," shared Professor Leo Yee Sin, Executive Director of NCID*.

Second, the issue of isolating individuals exhibiting symptoms while they waited for the results of their test, which at the time were solely Polymerase Chain Reaction (PCR) tests. These tests took around three hours to process and up to 48 hours for corresponding reports to be generated.

Third, the possibility of false negative and false positive PCR test results. For every false negative case, it could potentially infect five to six others, and set off a chain effect that could remain undetected. "It meant that for every person that we miss, someone may die down the road," said Permanent Secretary for Health Mr Chan Yeng Kit. The fatality rate at the time was 2 to 5 per cent.

On the flipside, false positives would further exacerbate the shortage of isolation wards. Even though other public hospitals, besides Tan Tock Seng Hospital, were also opening their isolation facilities to suspected cases, the sheer numbers were overwhelming.

MOH held nightly meetings with international and local public health and infectious disease experts, deliberating on how to scale up hospital capacity to meet demand. Eventually, they concluded that the current approach was simply not practical.

They had to find creative ways to keep people out of the hospital without compromising their well-being and the safety of others. This would also buy time for the country to ramp up its testing capabilities.

* PROFESSOR LEO YEE SIN STEPPED DOWN AS EXECUTIVE DIRECTOR OF NCID ON JULY 1, 2023, AND WAS APPOINTED SENIOR CONSULTANT AT MOH AND SENIOR ADVISOR AT THE NATIONAL HEALTHCARE GROUP.

RAPID EXPANSION OF TESTING CAPABILITIES

AT THE NATIONAL CENTRE FOR INFECTIOUS DISEASES' NATIONAL PUBLIC HEALTH LABORATORY, the team went from monitoring influenza and food-borne outbreaks to screening suspected COVID-19 cases.

Changes had to be made overnight, from setting up a separate space within the lab with a higher biosafety level, to adding personal protection equipment and double gloves to their daily uniform.

To boost the lab's testing capacity, the team extended their working hours and took on shifts. Automation, such as automated extractors, was also introduced to speed up the process, said Ms Nataline Tang, a Senior Medical Technologist at the laboratory.

Together, these measures allowed them to maximise the number of Polymerase Chain Reaction (PCR) tests conducted per hour.

But the most challenging part for Ms Tang was the time pressure to complete everything quickly. Contact tracers and medical staff were waiting on the results that would decide their next step.

The efforts of such laboratories would help to increase Singapore's daily testing capacity from mere hundreds to 70,000 by May 2021 – just in time as the Delta variant started its rampage.

PHOTO: DIGITALVISION VIA GETTYIMAGES/TANG MING TUNG

"THE TRICKY THING WITH COVID-19 PATIENTS WAS THAT THEY DID NOT ALWAYS APPEAR SEVERELY ILL IN THE INITIAL STAGES EVEN WHEN THEIR CONDITION WAS DETERIORATING."

– DR SAPNA SADARANGANI, INFECTIOUS DISEASES CONSULTANT AT THE NATIONAL CENTRE FOR INFECTIOUS DISEASES

LIGHTENING THE LOAD ON HOSPITALS

Bringing every person with a runny nose to NCID was not efficient and would take resources and attention away from patients who required closer monitoring and critical care. Thus, it became a common practice to place patients with mild symptoms and unconfirmed diagnoses on five days of sick leave to allow self-monitoring at home.

Only patients who did not recover after five days, or were linked to COVID cases, were referred to NCID for further medical assessments and tests.

Most patients who showed respiratory symptoms (fever, cough, sore throat, runny nose) tested negative for COVID-19, noted MOH. But the Ministry also recognised that extra precautions were necessary, and Singaporeans had to be socially responsible.

The Ministry stressed in its press release: "Patients must recognise the importance of staying home when unwell. Mixing in large crowds, or continuing to go to work or school when ill, even with mild symptoms, will put others at risk."

At the same time, MOH also reactivated its network of more than 900 general practitioner clinics to provide subsidised treatment, investigations and medications for patients with respiratory symptoms.

Later, in April 2020, swab isolation facilities comprising over 4,000 beds would be set up to house patients awaiting the results of their swab test overnight, further easing the strain on medical facilities.

The various solutions lightened the burden on hospitals, allowing doctors and nurses to focus on confirmed cases, especially those who had severe symptoms – which were prevalent in the pre-vaccine days.

Recalling the prognosis of the first 30 patients, Professor Benjamin Ong, then the outgoing Director of Medical Services at MOH, said they had terrible outcomes. "Anytime you see patients over 60, we were very worried because the rate of mortality was so high," he said.

The tricky thing with COVID-19 patients was that they did not always appear severely ill in the initial stages even when their condition was deteriorating, shared Dr Sapna Sadarangani, an infectious diseases consultant at NCID. Moderate to severe COVID-19 causes a mismatch in how the lungs exchange air and how the blood vessels extract oxygen. This is known as ventilation-perfusion mismatch, and is different from how bacterial pneumonia may cause low oxygen when air sacs and airways are filled with mucous and pus.

"The patients didn't always look

Within hospitals, medical staff had to gown up in full personal protective equipment (PPE) at all times, even having to change their PPE in between tending to different patients to ensure the highest safety levels. Hospitals were also well-equipped with medical equipment like ventilators, and still had sufficient isolation wards, intensive care units and beds at the time, especially after private hospitals started taking in COVID-19 patients.

that bad initially. They weren't gasping and didn't appear too breathless, but when you checked their oxygen, it was so low. If you didn't address it, they would have gotten even worse. We had to be vigilant," she added.

WORKING AS ONE TEAM IN THE HOSPITALS

"Clean" and "dirty" zones had to be clearly demarcated at the NCID patient care areas to prevent cross contamination, as every patient suspected to have COVID-19 was treated as potentially infectious until a negative result was received and the patient was deemed safe to be de-isolated by the assessing physician. Housekeeping staff would also clean the premises several times a day.

There were moments when the screening centre would get so busy that infectious diseases doctors like Dr Sadarangani would also head down to offer her emergency department colleagues extra support. "Obviously if they are busy down there, the busyness is going to come to us anyway. We were in this together and we all had to work together," she said with a smile.

By March 2020, the public hospitals found their beds filling up faster than they could discharge patients. Private hospitals had to be roped in, with Mount Elizabeth Hospital becoming the first to take in COVID-19 patients.

Almost overnight, the hospital's 29-bedded Ward 5E was transformed into a COVID-19 ward. Assistant Nurse Clinician Ms Lee Ann Aquino Carino and her fellow ward colleagues were quickly trained to perform PCR swab tests, suited up in full PPE, and split into two teams to ensure care continuity should one team get infected.

The nurses would work in pairs. Once the swab was completed, the swab stick would be passed to the next nurse who would triple pack it in plastic zipper bags, disinfect the bag, and then send it off for testing. It also became a requirement to change their PPE between patients, which meant having to gown up multiple times a day.

Donning the PPE was one of the biggest tests of Ms Carino's resilience as it often left her feeling dehydrated because of the heat. "I would drink water if I had the

PHOTO: NATIONAL UNIVERSITY HEALTH SYSTEM

choice. But the worry was that I would then need to use the toilet, which would mean removing the gown. Putting it back on was not easy as it had to be done carefully, and I also had to get somebody to recheck that it was done properly," she said.

While hospitals were well-equipped with medical equipment such as ventilators, and still had enough isolation wards, ICU facilities and beds, the wild card was manpower. "You can never quite estimate when workers will get exhausted and won't be able to function properly," noted Permanent Secretary for Health Development Mr Ng How Yue.

On the research end, scientists like Professor Lisa Ng, Executive Director at the A*STAR Infectious Diseases Labs, tried to understand how the virus behaves, the cells it infects, and whether it causes mild or severe disease. Samples were also taken from patients to study their immune response and how factors like age affect the progression of COVID-19.

"We had weekly workgroup meetings with the Ministry and various healthcare institutions like NCID to update each other on the latest findings," she said.

Still close to a year away from a vaccine, the approach then was to keep the number of cases from exploding and overwhelming the healthcare system. This was done by tracking down potential cases, and preventing others from getting infected.

Gowning up and down became a regular affair for healthcare workers at hospitals. Here, a healthcare worker helps a colleague with the gown at the Intensive Care Unit of the Ng Teng Fong General Hospital.

PHOTO: NATIONAL UNIVERSITY HEALTH SYSTEM

"GOLD STANDARD"

Tucked away in a lecture room at MOH was the first contact tracing centre, where 40 to 50 people sat in front of computers with telephones in hand, asking patients on the other end of the line to retrace their steps in the days before they tested positive.

The contact tracers would then draw up comprehensive activity maps – essentially large electronic spreadsheets – to visualise the various potential points of spread.

The pioneer team consisted mainly of staff from the MOH's Communicable Diseases Division (CDD) and "reservist" staff with concurrent appointments in other parts of MOH, who were called in to beef up the team.

Describing contact tracing as both a science and an art, CDD's Senior Director Professor Vernon Lee* said it was not only important to understand how the virus spreads, but also know how to ask the right questions in the right manner.

"If I go to you demanding that you tell me all that you've done in the past fourteen days, you will get really flustered as it's difficult to recall, right?" he said with a laugh.

* IN ADDITION TO HIS CURRENT ROLE AS SENIOR DIRECTOR OF MOH'S COMMUNICABLE DISEASES DIVISION, PROFESSOR VERNON LEE WAS APPOINTED EXECUTIVE DIRECTOR OF NCID ON JULY 1, 2023.

Professor Vernon Lee, Senior Director of the Communicable Diseases Division at the Ministry of Health, describes contact tracing as both an art and a science. Understanding how the virus spreads was important. But it was equally crucial to ask the right questions of people to gather information about their activities, to determine how far the virus had reached, to control transmission.

> "IT WAS NOT ONLY IMPORTANT TO UNDERSTAND HOW THE VIRUS SPREADS, BUT ALSO KNOW HOW TO ASK THE RIGHT QUESTIONS IN THE RIGHT MANNER."
>
> – PROF VERNON LEE, SENIOR DIRECTOR OF THE COMMUNICABLE DISEASES DIVISION (CDD) AT THE MINISTRY OF HEALTH

The team had a way of getting people to recall their past activities and to open up. They started by asking about daily routines, whether they have kids, and if they send them to school. And in the process, they would latch on to any changes in patterns, say a special birthday celebration.

"Of course, some individuals, unfortunately, were a bit shifty. And they didn't want to tell us things. That's why we have the Infectious Diseases Act, which is the legal instrument and the law by which we work," shared Prof Lee. "We have the legal powers to get information from individuals and if they do not comply, they can be charged."

One such individual in fact sparked off the SAFRA Jurong cluster. Fearful that people might misinterpret her actions, Case 94 did not tell contact tracers various important details, and was eventually charged in court for the offence. The cluster grew to 47 cases before it was officially closed in April 2020.

"By the time we actually figured out who spread to whom, it was already such a big cluster, which took us a long time to rein it in," said Prof Lee. But he pointed out that such irresponsible individuals make up less than 1 per cent of all people contacted.

Then there was the mystery of the Grace Assembly of God Church cluster, which had contact tracers scratching their heads over who seeded the infection there. Eventually, it took a serology test developed by researchers at Duke-NUS Medical School and much sleuthing by MOH's epidemiology team to crack the case.

The contact tracing team's success in the first few months of the pandemic was well-known, with Harvard University researchers describing Singapore's contact tracing as "gold standard".

But contact tracing alone was insufficient. It had to be combined with sound quarantine measures. For instance, high-risk individuals would be placed in dedicated quarantine facilities, the low-risk ones on phone surveillance, and the very low-risk are asked to self-monitor their health.

Over the course of the pandemic, the contact tracing team grew to over 1,000 during the peak of the infection wave, before stabilising at about 200. Staff from the Singapore Police Force and Singapore Armed Forces also joined the team at critical times to bolster its capabilities.

But even with Singapore's rigorous contact tracing efforts in early 2020, the rate of infection increased exponentially. The seven-day moving average spiked from one to 53 cases in March 2020. Singapore also recorded its first two deaths on March 21, 2020 – both were patients at the NCID.

More trouble was also brewing – Singapore was starting to see infected cases in migrant worker dormitories by April 1, 2020, and was discovering the presence of asymptomatic carriers. This was a "game-changing moment", said Professor Kenneth Mak, Director of Medical Services at MOH.

"In the past, when we could identify people who were infectious, or people who were potentially infectious because of close contacts, our policy then was to isolate them," he noted. But this process would miss out the asymptomatic carriers, who would go on to infect many more. Something drastic had to be done, urgently.

EVEN WITH SINGAPORE'S RIGOROUS CONTACT TRACING EFFORTS IN EARLY 2020, THE RATE OF INFECTION INCREASED EXPONENTIALLY.

In the first few months of the pandemic, Singapore's contract tracing success was well-known worldwide, with Harvard University researchers lauding it as "gold standard".

SAF'S HAND IN FIGHTING THE COVID-19 WAR

PHOTO: MINISTRY OF DEFENCE

As cases burgeoned, contact tracing capacity had to be scaled up urgently. The Singapore Armed Forces (SAF) roped in personnel from across its ranks to do so, including full-time National Servicemen, the SAF Volunteer Corps, and service personnel from the Singapore Army, the Republic of Singapore Navy and the Republic of Singapore Air Force.

TRY AS IT MIGHT, MOH could not fight the COVID-19 war on its own.

"In mid-March 2020, there were about 25 cases a day. By then, the need to scale up was already clear. That was when they asked the Singapore Armed Forces (SAF) for help with contact tracing in addition to health surveillance efforts," Brigadier-General (BG) Lee Yi-Jin recalled.

In hindsight, the Ministry might have roped in the SAF at just the right time. After receiving training from the professionals at MOH, SAF then set up its first contact tracing centre (CTC) within Mandai Hill camp by the end of March.

However, with the accelerating spread of the virus around the nation, what started as a target to double or triple contact tracing capacity ended up with the SAF running a total of seven CTCs in just two weeks. And with each centre being larger than the original one at MOH, it increased the capacity tenfold.

"To scale up that fast meant that you were running people very thin. The first batches were working pretty much without breaks," BG Lee said.

Eventually, the SAF was able to scale up with personnel from across its ranks. They included full-time National Servicemen, the SAF Volunteer Corps, service personnel from the Army, the Republic of Singapore Navy and the Republic of Singapore Air Force (RSAF).

Another source of manpower came from the then-dormant travel industry. The strong customer service skills of air crew made them perfect hires as callers at the CTCs.

Tapping technology made the entire process more efficient. The Army, RSAF, Defence Science and Technology Agency and even volunteer coders from the National University of Singapore came together to create SwiftCobra, a digital activity mapping tool to assist contact tracers.

But even with the increased manpower and the help of technology, the stress and anxiety levels of contact tracers and activity mappers were still high. With the long hours, fatigue was a big challenge too. Fortunately, many food vendors showed their support in tangible ways for those working hard in Singapore's fight against COVID-19.

BG Lee recalled how "when bubble tea stores shut down, it was like a national disaster" as many consumers were deprived of their daily fix. But those working in the CTCs got to enjoy the sweet beverage as a treat from the SAF.

"We made sure that there was some kind of morale booster every day. These simple pleasures – usually food – kept the soldiers going."

It might not have been a battle the SAF were trained for, but the troops rose to the occasion and cut down the average contact tracing time for a case by half. This was a feat that greatly helped to slow the spread of the virus.

WORLD'S FIRST COVID-19 ANTIBODY TESTS THAT LINKED TWO CLUSTERS

CONTACT TRACERS WERE STUMPED. A new cluster had emerged at the Grace Assembly of God Church, but none of the first two cases had links to Wuhan or any other existing clusters. And in just two days, it had grown to more than six times its size to 13 cases.

The usual means of contact tracing was not sufficient. Out of options, the team turned to what was then an experimental method – a novel COVID-19 serology test developed by Duke-NUS Medical School scientists. This proved to be the key that would unlock the mystery.

On February 25, 2020, 13 days after the first cases were detected, a link was finally established between the Grace Assembly of God cluster with the Life Church and Missions Singapore cluster, which was seeded by tourists from Wuhan in January 2020.

The serology tests – which look for COVID-19 antibodies in blood samples – managed to belatedly detect two cases of COVID-19. The couple (Case 83 and 91) did not fit the definitions of suspected cases as they had exhibited symptoms earlier and hence were not tested.

But after tracing their earlier whereabouts, contact tracers found that the couple had been at the Life Church and Missions on the same day as two Wuhan tourists (Cases 8 and 9), and had attended the same Chinese New Year gathering as a Grace Assembly of God staff (Case 66), who then seeded the Grace Assembly cluster at a staff meeting.

Such a test is particularly effective in handling a disease like COVID-19, which can be spread by asymptomatic patients, said Professor Wang Linfa of the Programme in Emerging Infectious Diseases at Duke-NUS Medical School, who led the development of the test.

"You might have been infected two weeks ago, had a little bit of a sore throat but did not think it was COVID-19. Two weeks later, Polymerase Chain Reaction (PCR) or rapid antigen tests will not be able to diagnose the infection anymore because your body has cleared the virus," he explained.

"During that process, your body induced what we call the antibody molecule. So we devised this test to detect a specific antibody in your serum, also known as blood."

Known commercially as cPass, the test also cuts down the traditional antibody detecting process from three to five days, to just 60 minutes.

"What we did is use protein engineering, using a biochemical simulation of that process. And now it's purely just protein-based, and we can do it in a normal lab," said Prof Wang.

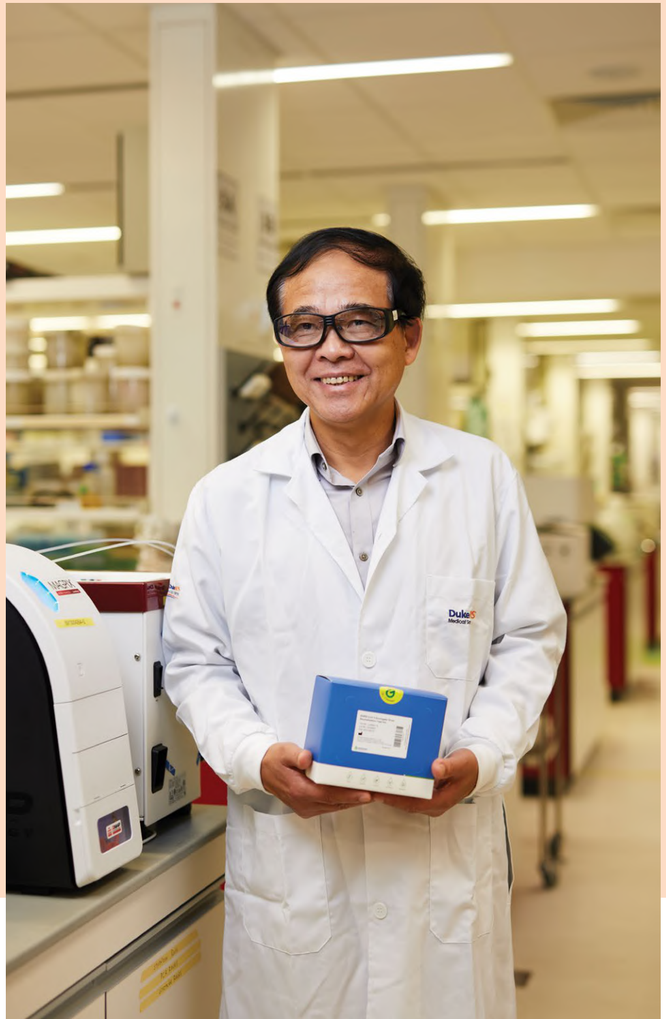
Previously, the process – mixing a blood sample with the virus and placing it on cells – could only be conducted in a highly contained biosafety level three lab by highly skilled scientists.

cPass is the first such test to be approved by the United States Food and Drug Administration, and it is now used across 80 to 90 countries for various research studies.

But the test has to be constantly updated to keep pace with the mutation of the virus. So far, the team has developed 22 different cPass-like tests to detect different variants. With just five millilitres of serum (blood) from a fingertip prick, scientists are able to use the test to check for immunity to any of the 22 variants through what is called a multiplex test.

The team is currently creating tests for variants of the virus that have not yet jumped to humans.

"We are already working towards the potential SARS three and SARS four, because these viruses are already circulating in bats, pangolins and civets. We have developed tests for these future viruses, as there is a high risk of them jumping to humans," said Prof Wang.



Professor Wang Linfa, one of the world's leading zoonotic disease experts, worked with his team to develop cPass, a serology test that can assess within an hour if a person had been previously infected with COVID-19.

HOW CONTACT TRACING WORKS

POSITIVE CASE CONFIRMED

ACTIVITY MAPPING

Patient is interviewed to determine who he/she has been in contact with

CONTACTS ARE CALLED UP

Information obtained through interviews with the case are corroborated against other sources of information (e.g. travel records, SafeEntry records, etc.)

AT-RISK INDIVIDUALS EXPOSED TO THE CASE ARE IDENTIFIED AND PLACED ON APPROPRIATE PUBLIC HEALTH FOLLOW-UP ACTIONS

Close contacts are quarantined for up to 14 days. If they have symptoms suggestive of infection, they are medically assessed and tested

Contacts who are of lower risk are monitored via phone surveillance for up to 14 days