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DR ANGELA CHOW LI PING  
Head, Department of Clinical Epidemiology (DCE)

## TEST. TRACE. TREAT: MANAGING THE OUTBREAK

The race to contain the then unknown novel coronavirus outbreak began in Singapore on 31 December 2019. This was the day the World Health Organization (WHO) received news from health authorities in China about a cluster of viral pneumonia cases of unknown cause in Wuhan, Hubei Province.<sup>1</sup>

Singapore’s public health response was swift. It cancelled all inbound flights from Wuhan; imposing strict quarantines and restricting the movement of individuals who had recently been in affected areas; taking immediate steps to map the transmission of the novel coronavirus through polymerase chain

*Lab technicians and technologists working 24/7 non-stop to churn out swab test results at TTSH Lab (pictured) and NCID Lab.*



All ready at TTSH Emergency Department to receive visitors for screening, at the start of COVID-19.

reaction (PCR) testing and tracing of contacts of people found to be infected; and amplifying campaigns to promote safe distancing, as well as personal and public hygiene strategies designed to reduce transmission.<sup>2</sup>

“We have had a highly coordinated effort, involving not just the health sector but many other sectors, all contributing based on their expertise,”<sup>2</sup> says Dr Angela Chow Li Ping, who heads TTSH’s Department of Clinical Epidemiology (DCE).

### TEST-TRACE-TREAT TOTAL APPROACH (PRE-VACCINATION)

On 2 January 2020, screening for patients suspected of having novel coronavirus began at the TTSH Emergency Department fever screening area. Very promptly, at the national level on 22 January 2020, the Multi-ministerial Task Force was formed to direct the national pandemic preparedness protocols. On the same day, DORSCON Yellow was declared. The hospital immediately issued a Staff Advisory – disallowing staff from travelling to Wuhan and requiring them

to observe safety precautions, such as health monitoring.

On 24 January 2020, one day after the first SARS-CoV-2 case landed in Singapore, TTSH extended screening to its ED Decontamination (ED Decon) Facility with an additional 24 seats. On 29 January 2020, as ED’s screening numbers were close to capacity, the new Screening Centre (SC) at NCID was activated to scale up operations. Meanwhile, NCID had opened its first three outbreak wards, ICU and two contingency wards for suspect cases.

January 2020 marked the start and escalation of roll out of measures and protocols to ensure adequate testing and

treatment capacity, while island-wide tracing efforts were carried out in earnest. Seeing how SARS-CoV-2 spread so rapidly throughout Wuhan, leading to a total lockdown – in fact, a walling in – of the Chinese city, Singapore was focused fully on preventing such a worst-case scenario.

TTSH-NCID steadfastly assume a heightened state of readiness to any sort of outbreak. It had experience most recently with MERS-CoV in 2018. Nonetheless, with respect to COVID-19, there were more questions than answers. It needed to understand what it was up against. No outbreak is ever the same, so the level of vigilance must be kept high.



A doctor speaking with a visitor waiting to be screened at the Screening Centre at NCID.



As the number of people seeking to be screened escalated, the fully equipped tentage extension at the Screening Centre at NCID managed the overflow.

On 7 February 2020, DORSCON Orange was declared, following the first local transmission on 4 February 2020. TTSH began to initiate twice daily temperature monitoring of all staff and entrance screening for all visitors and patients; any travel, fever and respiratory symptoms had to be declared.

The outbreak battle strategy is clear (pre-vaccination): *test, trace* and *treat*. Testing for positive cases and segregating them; tracing where those cases have been and who might have been exposed; and treating patients and helping them recover. Each of these steps is crucial and involves a wide range of personnel, from lab technicians and researchers; infectious disease experts, doctors and nurses, to allied health professionals, estate and security officers, tracers and many more. The epidemiological risk of COVID-19 increases when any of the three steps is compromised.

## TEST

The first line of defence in managing any outbreak is screening for and testing suspected cases. TTSH has spared no effort in scaling up its screening and testing capacity, while augmenting the necessary manpower to support the escalation. *Capacity, speed* and *precision* – these three imperatives guide TTSH-NCID in planning for COVID-19

screening at the SC, and in conducting tests in its two laboratories.

On 16 March 2020, when the purpose-built 494-capacity SC at NCID was reaching its limit, construction of an outdoor tent for screening adjacent to it began. The construction of the expanded SC – featuring a high-ceiling tent equipped with IT access to EMR, RTLS and X-ray – was completed in just three days, and was opened on 20 March 2020. More than 500 people arrived to be tested on that “Most Terrible Monday”, 23 March 2020. A temporary tent had to remain open till 3am to meet demand.

The push to scaling up testing was persistent, with pressure mounting on all sides since TTSH not only tested cases within the hospital but also swabs from polyclinics and other sources.



Long queue of people waiting to be screened for COVID-19.

“With a new virus, you need to go back to basic ingredients . . . You have to get the eggs, flour, butter instead of a packet of cake mix, to make a cake ■

DR PARTHA DE  
Head, Department of Laboratory Medicine

The TTSH Lab runs 24/7, even before the pandemic. The PCR (polymerase chain reaction) test is the standard measure for COVID-19 that is over 99 percent accurate. But it is a multi-step process, each of which must be performed accurately. This takes time. Since SARS in 2003, the TTSH Lab has been gearing up for an outbreak like COVID-19. The testing capacity during peace time was 300 tests a day, and the Lab team had committed to MOH a maximum of 500 tests within a 24-hour period. But the coronavirus spread so rapidly, especially

in March and April 2020, that the Lab found itself facing a demand of up to 3,000 tests a day.

“The thing with a new virus is, you need to go back to basic ingredients,” explains Dr Partha De, Head, Department of Laboratory Medicine. He compares creating a test to baking a cake. “When you have a new virus, you don’t have a ready-made kit. So you have to get the eggs, flour, butter instead of a packet of cake mix, to make a cake.”

Each batch of tests takes about three hours to complete, requiring multiple



*Specimens collected from the swabs being tested at TTSH Lab for COVID-19.*



*Collecting a swab specimen (left) and a staff seen transporting the specimen from NCID to the Lab.*

steps and various machines; not to mention the number of lab technicians and PCR-trained personnel that needed to be boosted quickly. It wasn’t easy in the least, but in the true spirit of innovation that runs through all of TTSH, even as the Lab was racing to process swabs and blood tests faster, a solution to speed up this “cake-baking” procedure was being concurrently worked on.

While “cake-baking” was much slower than using a “pre-mixed” packet, with more experience, and in collaboration with biotech companies bent on getting

up to speed, the Lab hoped to see a novel “cake mix” concocted and placed in a packet more quickly.

The Fortitude Kit was made possible by a team of Singapore’s leading scientific minds, namely A\*STAR scientists, Dr Maurer-Stroh and Dr Masafumi Inoue; as well as CEO of the Diagnostics Development (DxD) Hub Dr Sidney Yee, and TTSH’s Dr Timothy Barkham, Senior Consultant, DLM. Each expert brought their own specialised set of skills to the table in the fight against COVID-19.<sup>3</sup> Given the massive effort required to develop a diagnostic test,



A lab staff working on a test at TTSH Lab.

it was remarkable that A\*STAR and TTSH managed to successfully do so in less than a month. The test kit comprises a pre-packed mix of reagents to test patient samples, which are then fed into a machine that analyses the results. The procedure saves time by allowing other hospitals and laboratories to conduct their own tests.

In Singapore, the Fortitude Kit has been in routine use in 13 public and private hospitals and laboratories since February 2020. To date, the kit has been deployed in more than 20 countries.

“It was 24-hour testing for over six months,” said Dr Partha. “How could we have coped? We thought at the beginning maybe it would be for a few weeks! You ask us how we keep going? We see the need. We’re all in this together. We can’t *not* do it. It was absolutely necessary. And when you see the TTSH CEO and other senior management also not having a break – that’s inspiring.”

Singapore’s testing capacity increased from about 2,000 a day in February 2020 to more than 50,000 by December 2020.

“COVID-19 is much more transmissible, and the way it rapidly moves has meant that information changes by the day, which makes it very challenging to keep pace with contact tracing ■

DR ANGELA CHOW LI PING  
Head, Department of Clinical Epidemiology

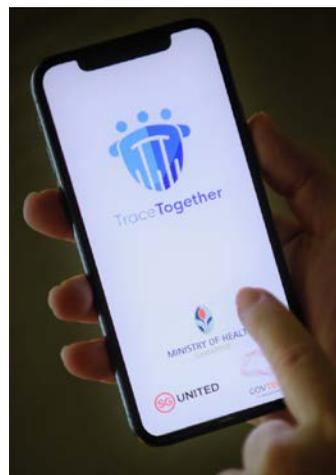
## TRACE

From the onset of Singapore’s first COVID-19 case on 23 January 2020, a multi-agency team has been working non-stop to curb the spread of the coronavirus through contact tracing, a process which identifies individuals who may have been exposed to those confirmed to have the virus. These individuals are then closely monitored and directed to be quarantined in dedicated facilities for 14 days. The aim is to ensure that infected persons are treated early and do not expose others to the infection. While contact tracing is overseen by MOH, the elaborate operation also involves many other players, including hospitals, the police, volunteers from statutory boards, Certis security officers, paramedics and the Government Technology Agency (GovTech). The elaborate operation involves activity mapping, analytic tools, surveillance footage, door-to-door inquiries and a newly developed smartphone app, called TraceTogether

(TT), launched on 20 March 2020, followed by TT tokens launched on 14 September 2020.<sup>4</sup>

Both the TT app and token identify those in close contact with people who tested positive for COVID-19, by using proximity data collected via Bluetooth technology. Market research firm Gartner crowned TraceTogether as the Asia-Pacific winner of its inaugural 2020 Government Eye on Innovation award.<sup>5</sup>

All said, contact tracing begins in the hospital.



Photos: Smart Nation and Digital Government Group

## How Contact Tracing Is Done

### Interview

Hospital maps the patient's movements and contacts for the last 14 days.



### Investigation

Contact tracing team calls all the people he has interacted with to verify and get more details of interaction.



### Identification

Decision made as to whether a person is a close contact and hence at risk of getting an infection. The team also checks if the close contact is well or not.



### Notification

If the close contact is **WELL**  
The person has to be quarantined for 14 days from the last contact with patient.



If the close contact has **CORONAVIRUS SYMPTOMS**  
The person has to be treated as suspect case and hospitalised.



Data from all patients is analysed for any possible links not known to them. These are checked out to see if more people might be at risk of infection or to identify source of infection. (Source: MOH)

TTSB initiated its contact tracing protocol with an Activity Map, produced by its DCE, based on the movement history obtained from interviews with patients by its augmented multidisciplinary team of doctors, dentists, nurses, epidemiologists, data analysts, biostatisticians, and research fellows and assistants. Next, DCE conducts hospital contact tracing to determine if the index patient had close contact with the staff, visitors and other patients. TTSB staff who have had protected contact with the confirmed case would be monitored closely as a precaution. Lastly, details are then passed on to MOH Contact Tracing team which follows up with expanding contact tracing in the community, and quarantine of unprotected close contacts identified by the DCE team. Such surveillance is made possible by the data collected from patients and visitors entering the hospital premises and undergoing strict entrance screening. All this serves to ring-fence infectious patients and stop the spread.

Dr Chow observes that, "COVID-19 is much more transmissible (than SARS), and the way it rapidly moves through countries and throughout the globe has meant that information changes by the day, which makes it very challenging to keep pace with the contact tracing and activity mapping during the containment phase."<sup>6</sup>



NCID isolation ward team tending to a patient.

She adds, "We work to ensure that our frontline colleagues remain well and adequately protected with the required PPE while attending to patients, for the safety of staff, patients, and visitors." Her team also performs active fever and health surveillance on more than 10,000 staff (including part-timers and contract workers) at the hospital – referring those who are sick and need medical attention and, where necessary, screening for COVID-19 – along with telephone surveillance follow-up until the staff's recovery and return to work.

"What we're doing now requires long hours of painstaking work, particularly when we are following up on every

activity and person our patients have been in contact with, but there is tremendous satisfaction in knowing that this work will prevent people from getting infected," Dr Chow concludes.

## TREAT

Singapore has the lowest case fatality rate in the world at 0.05 percent, which is significantly lower than the WHO's global case fatality rate of 4.34 percent. Worldwide, two years on, COVID-19 continues to rage.

The figures will remain grim even as vaccination programmes are being rolled out worldwide.



Staff working round the clock at the Contact Centre.

Early on, researchers and clinicians rushed to find the right mix of therapeutics to treat patients with COVID-19. In Singapore, a COVID-19 Therapeutic Workgroup chaired by NCID Clinical Director Dr Shawn Vasoo and comprising multi-disciplinary members from different institutions was formed on 1 March 2020 to evaluate evidence as it emerged on how existing (repurposed drugs) and novel therapeutics could be used to treat patients with COVID-19 infection. At NCID, before the availability of vaccines, researchers conducted trials

on promising treatments like the antiviral remdesivir and immunomodulators such as baricitinib.

Apart from remdesivir, which was the first antiviral approved by the US FDA for the treatment of COVID-19, and which Singapore also uses, few other treatments have seen positive results across the board. One major advance however was data on the use of steroids in COVID-19 which was shown to decrease mortality in patients with severe COVID-19, who needed oxygen supplementation. This evidence was generated by the UK Recovery Trial, and the Therapeutic Workgroup incorporated guidance for its use when this data emerged, and continues to update its recommendations in a living document as new data emerges.<sup>7</sup>

Apart from drugs, excellent supportive care is critical for optimal outcomes for patients with severe COVID-19. These strategies include supplementary oxygen therapy (e.g. high-flow nasal oxygen), prone positioning to allow their lungs to open up, as well as the use of mechanical ventilation and other more advanced cardio-respiratory support such as ECMO (extra-corporeal membrane oxygenation) if needed.



A TTSH staff receiving her vaccination.

## ROLL-OUT OF VACCINES

Beyond treatment, vaccination is a vitally crucial step in the fight to control COVID-19. At the time of writing, several vaccines have been authorised for use by various national health regulatory bodies. These include Pfizer-BioNTech-Comirnaty and Moderna – both mRNA vaccines – AstraZeneca, Janssen, SinoPharm and Sinovac.

On 21 December 2020, Singapore became the first nation in Asia to receive doses of the Pfizer-BioNTech COVID-19 vaccine, just 11 months after the arrival of its first COVID-19 case.<sup>8</sup> On 3 February 2021, the Government Health Sciences Authority (HSA) authorised Moderna's COVID-19 vaccine for use in Singapore, with its first shipment made in March.<sup>9</sup>

Apart from the two mRNA vaccines and Sinovac – a non-mRNA vaccine – rolled out under the National Vaccination Programme, HSA also grants the use of two other non-mRNA vaccines – SinoPharm and AstraZeneca – via the Special Access Route (SAR). All individuals who have been inoculated with a WHO-approved vaccine are considered fully vaccinated individuals and shall be accorded vaccination-differentiated safe management measures and travel concessions.<sup>10</sup>

As of 21 January 2022, over 10 million doses of vaccines have been administered under the National Vaccination Programme, where 90 percent of the population have received their first dose, 88 percent are fully vaccinated and 55 percent have had their booster shots.<sup>11</sup>

## WHAT NEXT?

The regimen of *test*, *trace* and *treat*, bolstered by *vaccinate*, will go on until Singapore becomes safe again. With the rollout of vaccinations not just across Singapore but in many countries, a critical preventive strategy is now in place. It protects residents and allows the country to open up to allow for trade and business to resume. While the understanding is that the pandemic could last another half a decade,<sup>12</sup> there is now hope that Singapore and the world will see the end of this coronavirus eventually. ■



Preparing the Pfizer-BioNTech vaccines for administration.

Strengthening of the resilience of the healthcare infrastructure is first and foremost . . . we need to build-in modularity and scalability

ER. GOH MIA SIANG  
Director of Facilities Management Office

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## ONE STEP AHEAD: REIMAGINING CARE

At TTSH, we learn that outbreak management at the hospital level has to be nimble; we need *speed* and *agility* to quickly take on various postures and effectively tackle the fast-evolving situation, in tandem with public health efforts at each phase of the outbreak. We have to be ready, respond, and recover, only to be ready again,” observes Dr Eugene Fidelis Soh, CEO TTSH & Central Health.<sup>1</sup>

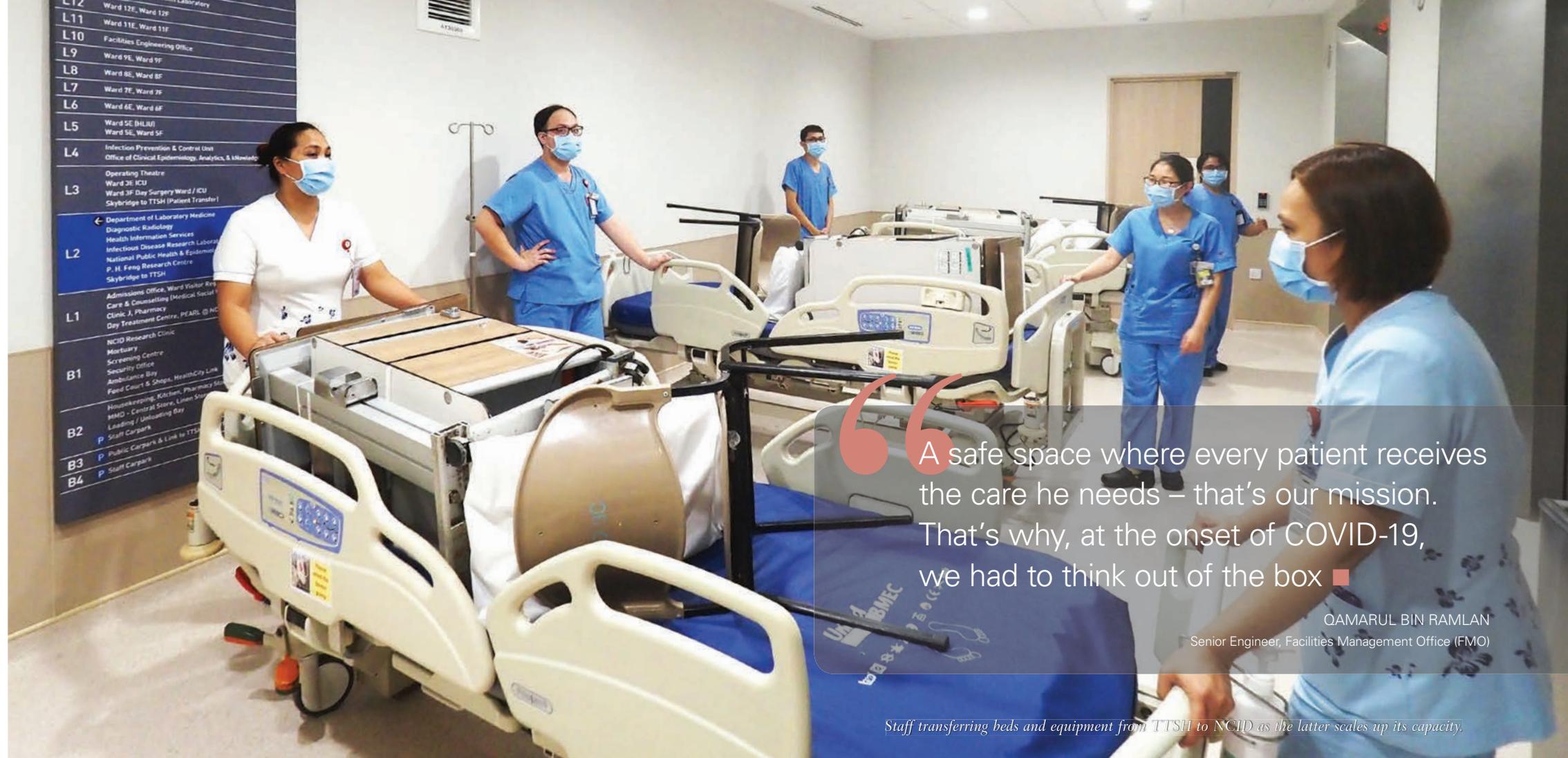
These – “nimble”, “speed”, “agility” – are key words that define TTSH’s battle-ready state of mind, in outbreak or peace time. This is how TTSH stays one step ahead of any scenario.

*The entire TTSH campus – comprising TTSH, NCID and CH (Centre for Healthcare Innovation) – is integrated to respond to outbreaks and business-as-usual demands.*

“A safe space where every patient receives the care he needs – that’s our mission. That’s why, at the onset of COVID-19, we had to think out of the box. We couldn’t afford to think that only a concrete four-walled space can administer care; we had to move fast,” says Qamarul Bin Ramlan, Senior Engineer at the Facilities Management Office (FMO), who oversaw the opening of NCID wards and expansion of the Screening Centre.

### READYING FOR OUTBREAK

When SARS arrived on Singapore’s shores in 2003, it forever changed the way TTSH dealt with outbreaks. The deadly virus took the lives of 33 Singaporeans, among them two staff members of TTSH, Medical Officer Ong Hok Su and Nurse Hamidah Ismail. But it wasn’t until 17 years later that a virus of even greater magnitude reared its head. There was an urgent need to craft a robust model that could adequately manage any threat levels.



The building of the newly opened National Centre for Infectious Diseases (NCID) was a vigorous response to this need. It replaces the old Communicable Diseases Centre (CDC). The 14-storey purpose-built NCID works closely with TTSH to deliver patient care using a multidisciplinary approach, both in its service and its infrastructure.

NCID’s key responsibility is protecting the people of Singapore from infectious diseases.<sup>2</sup> Barely four months after its opening, it found itself at the forefront of the national outbreak efforts. As Singapore was among the first countries in Asia to report a case after China, it was crucial to guide how the disease was managed and prevented with research conducted here.<sup>3</sup>



*The exterior of the old Communicable Diseases Centre (CDC).*

“Never was the opening of a medical facility so timely and fortuitous . . . It was the result of years of planning and hard work by government agencies, medical and research institutions, and healthcare partners ■

LEE HSIEN LOONG  
Prime Minister

The arrival of COVID-19 on 23 January 2020 put the freshly-minted NCID to its ultimate test. All that the TTSH teams had been preparing for was put into action. The slew of stringent thought processing and preparation paid off – NCID together with TTSH, was ready to serve its purpose during the pandemic, responding at the pace and scale of the outbreak as it unfolded.

In marking NCID’s first anniversary on 7 September 2020, Prime Minister Lee Hsien Loong said, “Today marks one year since the official opening of the National Centre for Infectious Diseases (NCID) at Tan Tock Seng Hospital (TTSH). Never was the opening of a medical facility so timely and fortuitous, as NCID found itself at the forefront of our fight against COVID-19 just a few months later. We were lucky that NCID was up and running before COVID-19 hit us, but this did not happen by chance. It was the result of years of planning and hard work by government agencies, medical and research institutions, and healthcare partners. Without this, our response to the pandemic would have been very different.”<sup>4</sup>

At the peak of COVID-19 infections in May 2020, 1,475 beds were filled in both buildings. This was on top of the 729 beds for TTSH BAU patients.<sup>5</sup>



The two-storey skybridge connecting NCID (left) and TTSH Emergency Department, symbolising the “double bond” the twin institutions share.

## NCID-TTSH Integrated Care<sup>6</sup>

The 14-storey purpose-built NCID is linked with TTSH Emergency Block through the two-storey skybridge, pedestrian underpass and service underpass link. It features 17 wards and 330 inpatient beds (including two ICU wards with 38 beds and one high level isolation ward with four high level isolation units [HLIU] for treating high-risk pathogens and eight negative pressure beds, plus five isolation wards with 100 beds), a ventilation system that ensures air flow only from the clean areas to the dirty, passing through a high-efficiency particulate air filter before being decontaminated with ultraviolet radiation and circulated out of the building. This number of beds could be quickly scaled up to over 586 in times of an outbreak. The design concept behind TTSH-NCID, as part of the HealthCity Novena campus, is to allow the twin institutions to work hand in hand, supporting and complementing one another during peacetime and outbreaks.



NCID seen from the rooftop of TTSH Main Building.

## REPURPOSING CARE

In 2019, only 150 beds by TTSH BAU patients in NCID were occupied.<sup>7</sup> By the end of January 2020, NCID had to scale up to 330 beds, which were all filled by 7 February 2020, when MOH declared DORSCON Orange. It soon reached its maximum capacity of 586 beds by mid March. Manpower had to be significantly augmented, when eventually 1688 additional staff from TTSH and public healthcare institutions were transferred to buttress NCID operations.

When that proved insufficient, TTSH quickly opened up floors of wards in the main hospital to cope with the patient

count: wards on Levels 6, 7 and 11, along with Ward 2A, were converted into COVID-19 wards.

“We had to work fast to convert the normal wards into COVID-19 wards,” recalls Othman Bin Yusop, Senior Engineer, FMO. “We had to move fast to set up the wards i.e. installation of exhaust fans and others. Good thing was that we managed to get our vendors to work with our in-house staff to get the wards ready. We’ve never achieved so much in such a short a time.” On 14 April 2020, TTSH opened its COVID-19 wards.

When the numbers kept climbing, primarily cases from the migrant worker



Staff preparing the original CDC to house patients waiting for their swab test results.

dormitories, the original CDC was reopened to house these patients who were waiting for the results of their swab tests.

“We were given one week to re-activate and reopen the dormant CDC

– to swiftly meet the rapidly rising cases among the migrant workers’ community. It was nothing short of a herculean task. But we had to get it done. Apart from readying additional COVID-19 wards, we also had to ensure timely procurement



Contracted workers worked long hours to get the CDC “operational” again.



“We were given one week to re-activate and reopen the dormant CDC – It was nothing short of a herculean task. But we had to get it done ■

VINCENT TANG BENG ONG  
Deputy Director, Facilities Engineering

of equipment and resources. All of this had to be thought through and acted upon in double quick time,” added Vincent Tang Beng Ong, Deputy Director, Facilities Engineering, who managed the conversion of CDC wards into a pre-Community Isolation Facility and Holding Facility for COVID-19 patients.

It wasn’t only buildings, wards and beds that were repurposed to meet needs. When the Screening Centre at NCID was overflowing with people coming for testing, tents were built in a very short time so that screening could spill over to the carpark. Screening Centre staff received reinforcements from other departments. The ICU at the main hospital was also reorganised to support the NCID ICU Wards 3E and 3F in the event all the ICU beds were filled. Meanwhile, TTSH’s community partners stepped up in a timely fashion to ease its

BAU load, providing continuing care for these transferred patients. More details are covered in Chapter 13.

All in, it was a true test of flexibility on the part of the infrastructure as well as the staff. United by a spirit of serving patients whatever it took, staff and structure were stretched to the maximum.



Staff and contracted workers installing exhaust fans as part of the ward conversion efforts – turning BAU Wards into COVID-19 Wards at TTSH.

“We had to work fast to convert the normal wards into COVID-19 wards ... i.e. installation of exhaust fans and others ... We’ve never achieved so much in such a short a time ■

OTHMAN BIN YUSOP  
Senior Engineer, FMO

#### CARE IN THE “NEW NORMAL”

If there is one encouragement that has come out of COVID-19, it is the reassurance that Singapore and its public health institutions like TTSH-NCID have successfully evolved and poised to be 24/7 ready for the next outbreak. Nevertheless, it requires relentless vigilance, ingenuity and efforts.

“NCID stands at the vanguard of Singapore’s outbreak response, with the main hospital as its hinterland of support and never a bridge too far away,” wrote CEO Dr Soh in the *Academy of Medicine Annals*.<sup>8</sup> “Today, we are better prepared and have a purpose-built facility that allows us to better manage surges in an outbreak. While there are limits to what NCID can achieve as a



Senior Engineer Othman Bin Yusop conferring with his colleague on a technical matter in a workshop.

facility, she has been built flexible for the known unknown.”

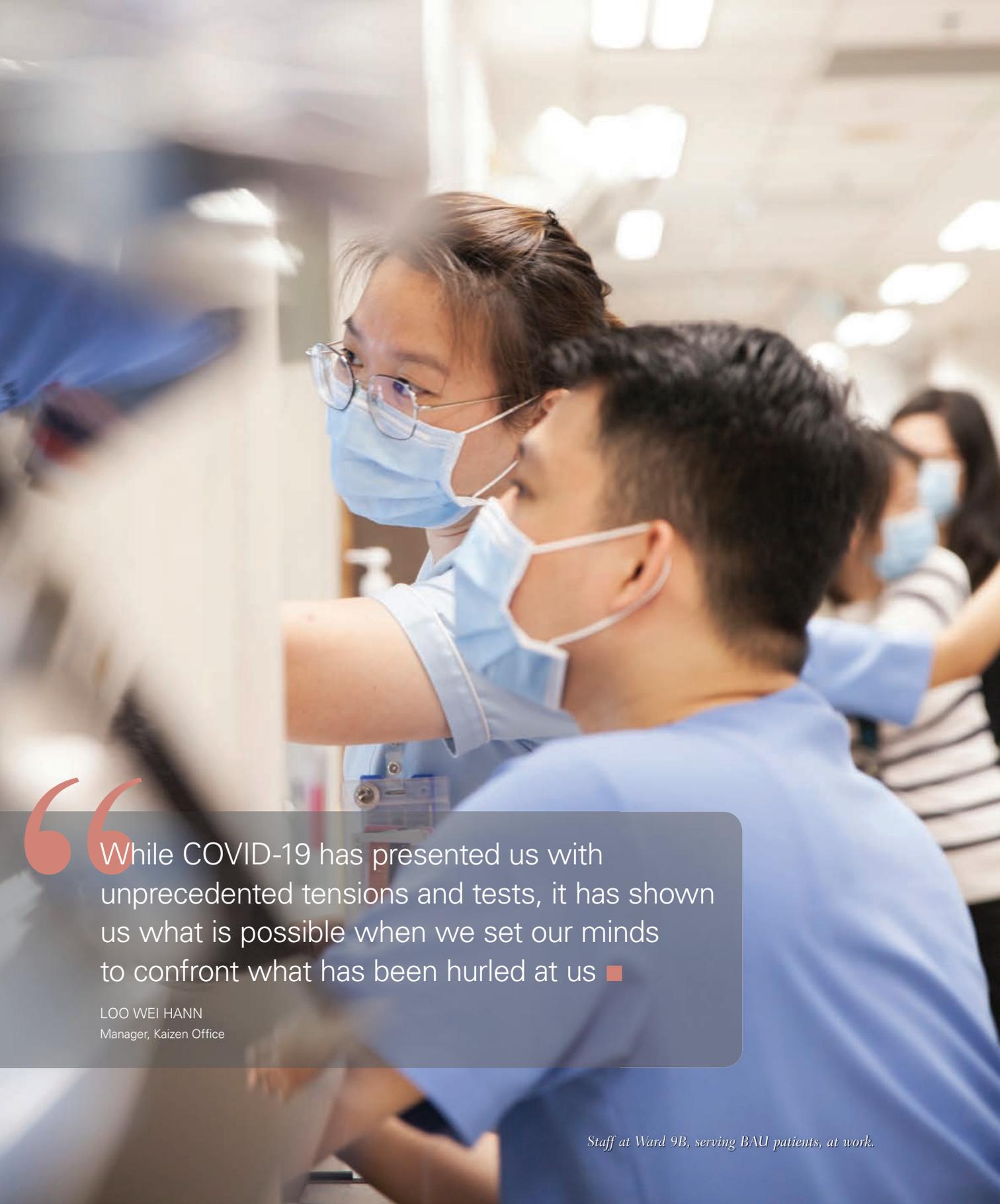
Just as the infrastructure has proven its ability to be scaled up during outbreak times, medical care in the new normal will have to be transformed. It has to begin with the transformation of one’s mindset, followed by his or her skills set.

“We have to adapt to the ‘new normal’. Given that COVID-19 is likely to be present in the next few years,

we have to change our mindset in the way we work, including our job roles and responsibilities. When needs arise, we just need to learn to work together – it’s no longer my job or your job,” says Hong Yun, Principal Occupational Therapist, Rehab, who was deployed to conduct swab tests as well as assist in patient transfers aside from his primary BAU role.



A lab technician at the NCID Infectious Disease Research Lab.



“While COVID-19 has presented us with unprecedented tensions and tests, it has shown us what is possible when we set our minds to confront what has been hurled at us ■

LOO WEI HANN  
Manager, Kaizen Office

*Staff at Ward 9B, serving BAU patients, at work.*

## ONE STEP AHEAD

While TTSH has done well thus far in facing off with COVID-19, it has no plans to rest on its laurels. The war against any outbreak requires planning and staying ahead of any scenario.

“Future-proofing the healthcare infrastructure is key,” says Er. Goh Mia Siang, Director FMO. SARS was the initial blueprint upon which he drew up engineering control measures to support operational needs in an outbreak. With COVID-19, the biggest challenge is being able to quickly expand facilities within TTSH to screen, treat and house patients. Now, he is thinking about the next outbreak.

“Strengthening the resilience of the healthcare infrastructure is first and foremost; followed by provision for a surge in infectious patient volume – as we have seen in COVID-19,” he adds. “When future-proofing the healthcare infrastructure, we need to build-in modularity and scalability, and ensure reliability, resiliency, maintainability, efficiency, and effectiveness over aesthetic.”

Healthcare is first in and last out of any outbreak, and always in between outbreaks. It is therefore crucial that TTSH maintains its approach of continual learning so as to respond,

recover and ready itself for the next outbreak.

All said, in order to stay one step ahead of “peacetime” and “outbreak” healthcare needs, it takes imagination, conviction and courage to remodel and repurpose care for the future.

“While COVID-19 has presented us with unprecedented tensions and tests, it has shown us what is possible when we set our minds to confront what has been hurled at us, and inspired us to express our creativity and ingenuity to come up with better care solutions,” says Loo Wei Hann, Manager, Kaizen Office. ■



*Staff carrying out strict safety and security measures at all entrances throughout TTSH-NCID.*

## HOSPITAL WITHOUT WALLS: CARE ANYTIME, ANYWHERE

Innovation at TTSH never stops. One of the key lessons COVID-19 has taught healthcare is that the task of reinventing the hospital – through redesigning of jobs and care and leveraging technology – has become even more urgent.

The outbreak has revealed that by using smart technologies, whether artificial intelligence (AI) and analytics, digital applications or telehealth, resources can be calibrated and distributed to better meet the diverse and evolving needs of its wide-ranging patient base. This becomes all the more

essential when faced with limitations such as restricted face-to-face time between patient and doctor or therapist, and the challenge of prioritising manpower during a pandemic.

As TTSH adapts to intelligent use of technology to support new models of care and workforce transformation, it hopes to move towards being a “Hospital without Walls”. This is why it has embarked on a journey to digitalise care. In the end, its aim is to shift from administering care at a fixed time and place to the “delivery of care anytime, anywhere”.



Digitalisation takes centrestage at TTSH.



Beyond hospital walls, TTSH staff reach out to meet community health needs even during COVID-19.

### DIGITALISING CARE

Digitalisation of care has taken centrestage in TTSH’s drive in redesigning its care model. The objective is to establish a care continuum for patients, to empower them to own and manage their care and to enable them to access care on-the-go seamlessly, whether during peacetime or outbreak. To do so, it is necessary to understand the level of healthcare the hospital has – its capacity, capabilities and manpower – *vis-à-vis* the needs of the estimated 1.4 million residents it is charged to care for in

Central Singapore. The match has to be constantly monitored so as to attain optimal effectiveness and efficiency.

The COVID-19 episode has demonstrated the value of digitalisation. Besides the use of digital technology to manage hospital operations, safe management and contact tracing, technology has made possible the continued care for BAU patients. For example, due to the redeployment of over 1,500 staff to the frontline during the peak of COVID-19 – including those in allied health – clinic visits by BAU patients were drastically reduced.

Yet, these patients were able to continue receiving support such as speech and occupational therapy via telehealth initiatives, where therapists guide patients to recover through innovative therapeutic devices and digital applications (read more in Chapter 12).

Separately, its newly-commissioned RTLS or Real-Time Location System facilitated tracking of patients and staff to improve operational efficiency, while its live streaming and analytics from key ground operations across the hospital, including real-time clinical surveillance



Telemedicine in action as doctors communicate with their patient online.

data, provided the hospital with timely and critical information to coordinate response effectively across its campus.

TTSH is intent on building “healthier and happier communities” with its partners. This is to bring care beyond the hospital to the community. This is part of the three shifts advocated by MOH to transform the national healthcare system to bring healthcare closer to home and support Singaporeans to age well in their community.<sup>9</sup> To do so, TTSH sees digitalisation as a key enabler.

### HOSPITAL WITHOUT WALLS<sup>10</sup>

To illustrate how digitalisation enables TTSH’s quest in bringing care beyond the hospital’s walls – and into the community – the Clinics Without Walls (CoW) concept serves as a prime example. Following the redesign of the TTSH Medical Centre (MEC) that began in 2009, which saw increased outpatient capacity, better care coordination through speciality groupings and cell-concept consultation, among many other new features, the hospital was bent on transforming its clinics to become CoWs by deploying digital technologies to stack transactions at its clinics to “patient journeys”.

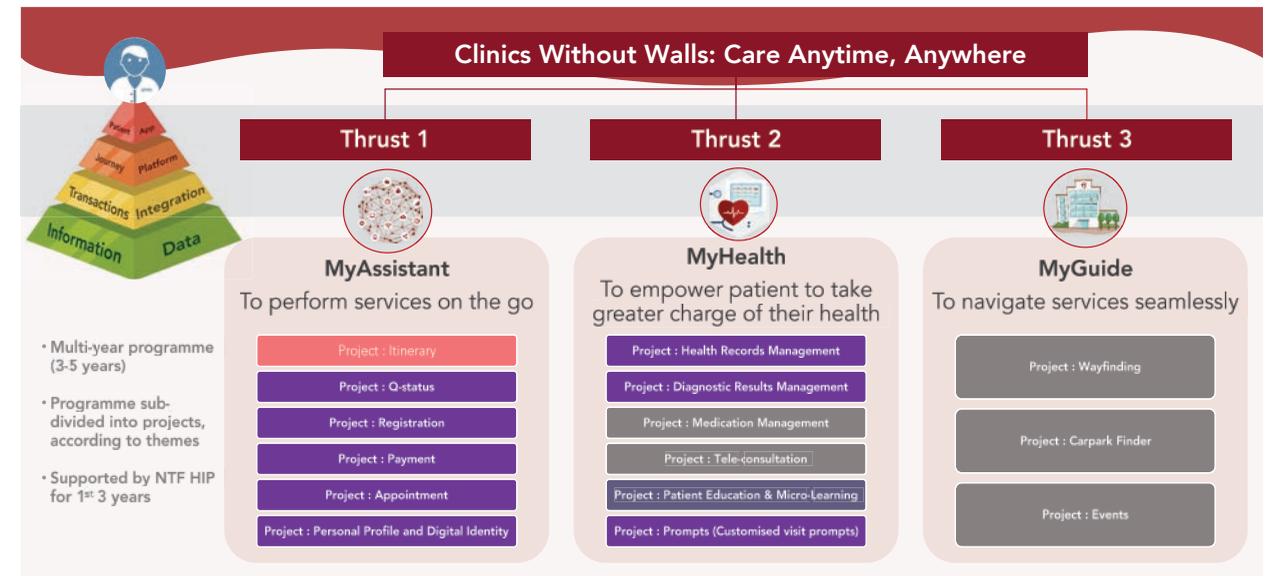
Through the deployment of digital tools (from e-kiosks to digital applications), care follows the patient,

and he or she may build a “care relationship” with TTSH care providers across settings. This is powered by the CoW Digital Stack (or digital strategy). The stack is designed to reflect a patient profile and aims to deliver care through three thrusts, *MyAssistant*, *MyHealth* and *MyGuide*. Each thrust is tailored to provide patients with personalised access to ambulatory care. The CoW concept has since been introduced to MEC Clinic B1A and Ang Mo Kio Specialist Centre.

In addition, TTSH is leveraging existing national digital applications such as HealthHub<sup>11</sup> to quickly deploy solutions as part of its CoW digital stack. Patients who visit other public health institutions can also have a more integrated experience with HealthHub. TTSH patients can expect to progressively

access a whole host of functions relating to their care relationship with the hospital, including e-registration, queue management, visit itinerary, personalised education, micro-learning, self-assessment tools, medication orders and appointment scheduling.

Combining innovation and digitalisation, Clinic B1A is today counter-less. It is part of TTSH’s recovery strategy from COVID-19 as it shifts to a “new normal”. It sets the stage for the hospital’s digitalisation of care. Patients who step into Clinic B1A are now greeted by just one or two PSAs (Patient Service Associates) ready to assist them with registration at the



Graphical presentation of key aspects of “Clinics Without Walls: Care Anytime, Anywhere.”

“ Instead of supporting registration, I can have more time to do my value added assignments, like medication supply verification ■

CHO KAI LIN  
Senior Patient Service Associate, Clinic B1A



self-service e-kiosks. The counter-less clinic improves safe management and creates a better sense of arrival.

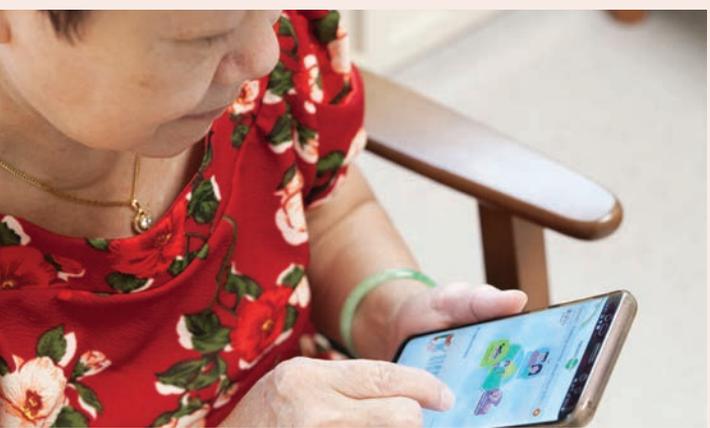
“We can now move around to register patients with the computer-on-wheels so that our patients on crutches or walking aids would not have to walk so much,” remarks Lily Ng, PSA Assistant Supervisor.

Adds Cho Kai Lin, Senior PSA, “Instead of supporting registration, I can have more time to do my value added assignments, like medication supply verification.”

Significantly, as patients learn to gradually take charge and manage their care, healthcare workers can begin undergoing job up-skilling to deliver what patients value in TTSH’s new care model.

“Staff are happy that patient journey is simplified and are excited in their role expansion to provide better care for patients,” smiles Senior Nurse Manager Bavani Deyvi.

*Digitalisation-enabled initiatives at Clinic B1A, empowering staff to carry out value added assignments and encouraging elderly patients to go digital.*



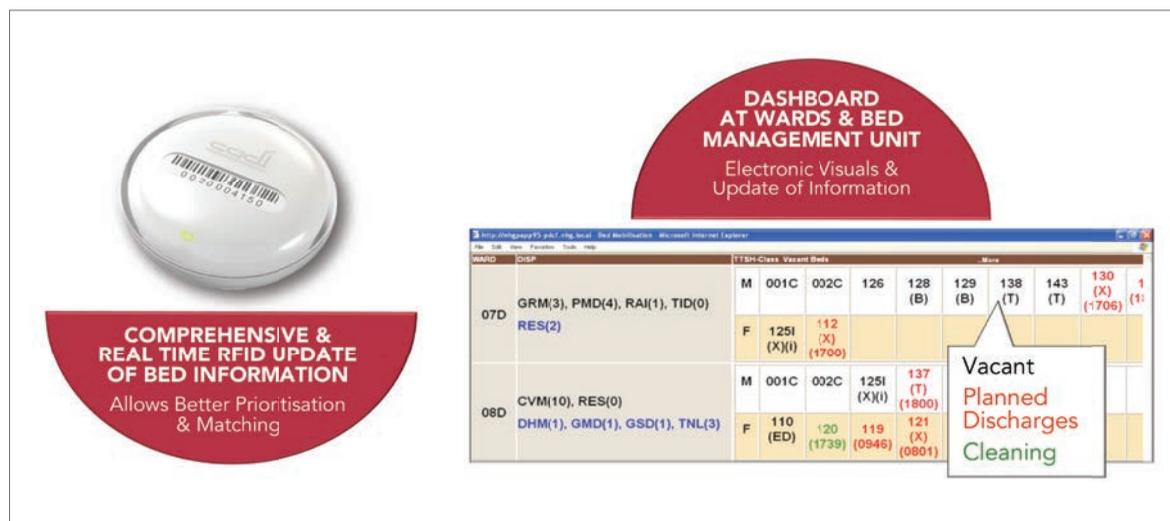
*At the TTSH Operations Command Centre, where information drives workflow and optimises resources.*

### DIGITAL INNOVATION

One landmark initiative that was commissioned just in time before COVID-19 struck was TTSH’s Operations Command Centre (OCC), which operates the new Command, Control and Communications (C3) System. The first-of-its-kind in the world, C3 won the Excellence Champion Medal at the 2020 National Healthcare Innovation and Productivity Awards by MOH. Co-developed by TTSH, Integrated Health Information Systems (IHiS) and ST Engineering, and supported by MOH, the system provides

real-time visibility, flow management and resource optimisation to enable the hospital management to coordinate workflow, and make timely and effective decisions. The outbreak presented the hospital an opportune time to test and accelerate the development of C3 capabilities for an outbreak scenario, amid an outbreak itself.

Singapore saw its first locally-transmitted case of COVID-19 on 4 February 2020, and the definition for suspect cases was changed. Within a day, there was a surge of nearly 500 people showing up at the Screening Centre



Infographic depicting an example of how digital innovation assists in managing beds.

at NCID. The risk of overcrowding was imminent.

With the swift adaptation of C3 to TTSH's outbreak response workflows, the hospital was able to communicate and coordinate operations, based on reliable and timely data from across multiple systems and the frontline. Hence, instead of being overwhelmed, NCID was able to quickly open another hundred beds for patients and safely manage the crowd.

Other key decisions such as manpower deployment and stock of critical supplies were made with the help of C3. Serving as the "integrated brain" behind TTSH-NCID, C3 also allows coordination between the two sides' BAU and outbreak responses so that both can work integrally. The 12 staff at OCC have a bird's-eye-view of everything that is going on in TTSH and NCID, from potential

crowds forming across the campus to the availability of patient beds, down to the number of gloves and masks used each day – the system is connected to RTLS. It has enabled TTSH-NCID to preempt and plug any gaps or shortages in advance.

Dr Jamie Mervyn Lim, COO, TTSH and Central Health, remarked to *The Straits Times* that up till 2008, TTSH had relied on a "pen, paper and phone" system of managing its operations, with each department doing its own thing.<sup>12</sup> It was far from an efficient system, since management and staff could not optimise their processes as there was no immediate information available on where the empty beds were, or which patient had been discharged.

Since that time, the hospital started to introduce innovative technologies such as the real time Radio Frequency

Identification (RFID) Tagging System to automate admission and discharge workflow, and to identify where patients were located. In 2011, TTSH developed and rolled out the Artificial Bed Management System (AIBMU) to provide rule-based decision support – 345 rules in total – on bed allocation based on priority and matching. All of this paves the way for better prioritisation, matching of resources and manpower use. From an army of staff manually managing beds before the introduction of AIBMU, today only three administrative staff per shift are required to manage the bed allocation needs of the hospital's 1,700 beds.<sup>13</sup> The IT-enabled productivity gain is manifestly significant.

The journey of bridging innovation and digitalisation continues in earnest. C3 is continually being adapted and upgraded, with the eventual aim of linking it with other partners in the healthcare network, such as community hospitals, ambulance service providers, polyclinics and other public hospitals.

## A MORE HUMAN TOUCH

TTSH is on a purpose-driven adventure to redefine care as a hospital without walls. It is noteworthy that the hospital of the future should neither be one that waits for patients to fall ill and come to its doors, nor one that discharges patients

and leaves them without support in the community. TTSH sees healthcare evolving from a facility-centric to person-centric model; from episodes of care to relationships in care; from a volume-based model to delivering what patients value. It aspires to continue its legacy of crossing milestones in innovation, all for the good of patient care. It sees the convergence of care innovation and digitalisation as a remarkable opportunity to transform care beyond boundaries, to deliver care anytime, anywhere.<sup>10</sup>

"Innovation and digitalisation presents the biggest opportunity for change," says CEO Dr Eugene Soh. "When we become more comfortable and smarter interacting digitally, we have great capacity to care. This way, healthcare becomes more human." ■



Human touch remains the cornerstone of TTSH's care model. A staff showing a patient how to use an app.

## AUGMENTING PROTECTION: SAFETY AND SPEED

**B**etter, Faster and Safer. These three adjectives are not just “good to have goals” in TTSH’s fight against COVID-19. They form a key pillar in the hospital’s comprehensive and innovative “protection” measures to ensure staff while carrying out their duties are adequately protected from the infection, and in turn, patients – COVID-19 as well as BAU – and visitors are protected. These include safe management; innovating PPE gears such as the face shield; ensuring safe practice at work; and redesigning work process.

*A staff registering a visitor's particulars at a designated entrance, as part of safe management measures.*

“The public were not aware of the tightened measures and the staff did not know what to expect – it was quite overwhelming on both sides ■

KRISTEN LYNN TAN  
Senior Executive, VES

### SAFETY AT THE DOOR

While the Screening Centre staff at NCID were most in need of immediate protection, elsewhere in the hospital campus, the coronavirus remained a real threat.

To ensure “safety starts at the door”, it took concerted efforts by staff from the various departments to do their part. In the early days of the pandemic, the

Visitor Experience Services (VES) team swiftly took charge of setting up the entrance screening points and putting up advisory posters – not just at the front entrance, but across the two buildings; the Office Administration (OA) planned and facilitated Business Continuity Plan (BCP), organising office arrangements and safe distancing practice in pantries; the Estate Office (EO) managed the common spaces, such as seating benches, taxi stands and shuttle bus queue, with safe management measures; and the Security staff helped out with the ongoing installation of signages and directing visitors to the nearest temperature screening stations. The list continues.

When the DORSCON level was raised to Orange on 7 February 2020, the hospital stepped up its safe management measures. Security reduced the number of entrances – so as to effectively implement temperature screening – while ensuring that there were sufficient entry and exit points for visitors.



Safe entry at the TTSH Main Building.

Soh Sing Heng, Senior Executive, Estate Office, who was involved in the movement restriction measures and security deployment, recalls the long queues at the entrance. A one-metre mandatory distance between each person in the queue meant that the line wound and stretched a long way.

Unfamiliar with this new procedure, visitors would get angry at having to go through the safety measures and scanning twice, if they happened to leave the hospital temporarily and needed to get back in. Auxiliary police were stationed to

ensure cooperation from the public, and to diffuse situations, where necessary.

Explains Sing Heng, “The work to establish safety at the entrances began much earlier, before security started to actively manage situations. EO was the key department tasked to come up with a campus lockdown plan. We had to lock many of the access area doors and urgently put up signages to redirect the public to the right entrances, where they would undergo temperature screening. This way, we protect the hospital from the risk of COVID-19 spread. It took



Triage stations at the Screening Centre at NCID.



“Some of us who were in midnight shifts had to quickly put up the ‘latest’ posters produced by the Communications team, only to realise by morning that the same posters had to be replaced ■

SHELLEY LAU SUI LANG  
Senior Patient Information Associate, Patient Service

*A Visitor Experience Services (VES) team member recording a visitor's particulars.*

many of us, including security officers, to lock the doors at TTSH and NCID. I remember we did so till after midnight, the day before DORSCON orange was implemented.”

Shelley Lau Sui Lang, Senior Patient Information Associate, remembers, “We had to explain to visitors that all these social distancing measures were to protect everyone. Most would understand and comply, but some would resist and argue with us. In tricky situations, we would call the security to handle the matters.”

It wasn't only the public who were affected by the changes. TTSH's retail tenants had to change their operations overnight. Safe distancing measures had to be put in place – at one point, only takeaway orders were available, affecting business instantly. Vendors coming to TTSH had to go through safe entry at the loading bay. This posed some initial issues as many had to go in and out to unload their goods.

TTSH began implementing its safety measures on Friday, 24 January 2020, the eve of Chinese New Year, and one day after the first COVID-19 case hit Singapore.

Kristen Lynn Tan, Senior Executive, VES, shared, “The public were not aware of the tightened measures and the staff did not know what to expect – it was quite overwhelming on both sides.” VES had to act quickly to create and put up

new signages, as well as publicise on social media to let people know about the new measures in place, such as temperature-taking and doing Travel Health Declaration before entry could be facilitated.

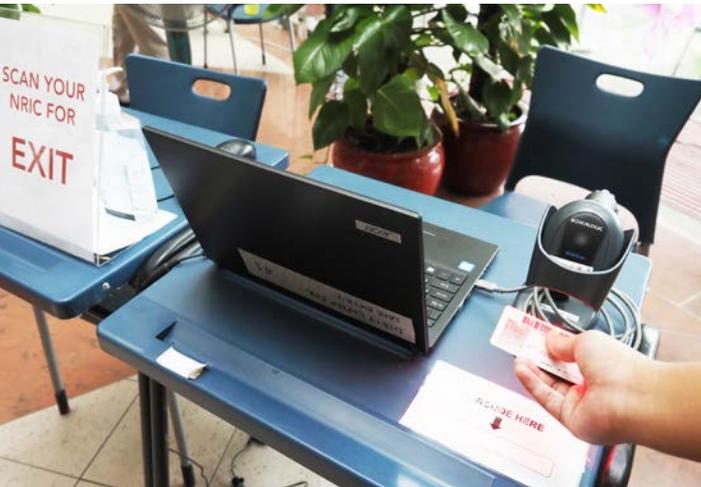
The printing of signs and posting “what-to-do” updates on TTSH's social media became a way of life for the VES and Communications team. With new directives and changes arriving from the Ministry of Health (MOH) daily – sometimes several times a day – the information materials had to be updated constantly. The Communications team printed hundreds of every version, and laminated each one, only to have those become obsolete in a matter of hours sometimes. The VES team, along with others who volunteered, stayed back till midnight on Friday, the eve of Chinese New Year, to put up all the signs.



*Thermal scanners like this device are deployed at virtually all the entrances across TTSH campus.*

“The work to establish safety at the entrances began much earlier. We had to lock many of the access area doors and urgently put up signages to redirect the public to the right entrances ■

SOH SING HENG  
Senior Executive, Estate Office



Visitors are required to register their entries via specific QR Codes or scanning their NRICs.

Shelley quips, “Some of us who were in midnight shifts had to quickly put up the ‘latest’ posters produced by the Communications team, only to realise by morning that the same posters had to be replaced!”

The team had to pivot with every change and find swift solutions: *Vendors coming in and out?* They put stickers on them so they didn’t need to scan them again; *clog at the entrance due to the amount of time taken to fill a declaration form by hand?* By the next working day, they had iPads at the entry point for faster form-filling. Each step of the way, the VES, Security, Estate Office, Office Administration and Communications team innovated to keep the process smooth and everyone safe.

In response to the COVID-19 cluster that emerged in TTSH from 28 April to 17 May 2021, as detailed in Chapter 4, the already stringent safety protocols in the hospital were further enhanced, such as the introduction of hospitalisation segregation zones. It was to better protect the staff and patients amid a potentially long COVID-19 battle.



Face shields are widely used by the 12,000-strong TTSH-NCID staff.

### SAFETY BY DESIGN: FACE SHIELD

Working behind the scenes in supporting TTSH-NCID’s response to COVID-19 is the 14-member Kaizen team.

Kaizen is a concept of continuous improvement involving all levels of an organisation, from CEO to frontline and backline workers.

The team worked closely with doctors and nurses at the onset of COVID-19. Chua Jia Xiang, Lead Service Designer, Kaizen Office, explains, “We hope to bring tested solutions to the ground as

quickly as we can so that users can deliver better care with efficiency. But first, we need to have a good understanding of the challenges faced by colleagues, and empower staff by building their capabilities to co-create creative solutions together.”

“Our primary role is to facilitate value creation and innovation,” adds Thian Kun Ming, Industrial Designer, Kaizen Office. Ideas to overcome problems come from any staff in the organisation; the Kaizen team helps to shape and innovate these ideas so that the solution is



*A designer working on the face shield design at CHILL.*

“ We hope to bring tested solutions to the ground as quickly as we can so that users can deliver better care with efficiency ■

CHUA JIA XIANG  
Lead Service Designer, Kaizen Office

delivered well. These solutions may take different forms, from product creation to process improvement. During COVID-19, these solutions were created to ensure every staff member and patient continue to be protected safely.

The situation at Ground Zero (Screening Centre) was dire. Not only were frontline staff working round the clock to test a growing pool of suspected COVID-19 patients, they had to battle a limited supply of PPE items. Acute shortages due to global supply-chain disruptions in the early course of the

pandemic presented the innovation team at CHI Living Lab (CHILL), a collaborative workspace with facilities to support prototyping, with an opportunity to swiftly design and develop an ideal face shield for staff – one that can provide robust protection with better fit and comfort.

There were a number of requirements that the face shields needed to meet: they needed to provide full protective coverage over the N95 masks that frontliners needed to wear; they needed to be a good fit for extended use; they needed to offer



*Testing out the face shield prototype.*

“Our primary role is to facilitate value creation and innovation ■

THIAN KUN MING  
Industrial Designer, Kaizen Office

clear visibility with no fogging up; they had to be easy to put on and take off; and they had to be disposable or easy to wipe down. Production-wise, they had to use easily-available materials; easy to scale and manufacture, and be priced competitively against other shields, or less. Factors aplenty had to be considered.

The facilities at CHILL were used to rapidly iterate test models of the face shield. Much research and trial-and-error testing went into it, with staff testing out the shields and giving feedback on things like the fit and the reflection from the shield. Eventually, after redesigning the face shield countless times and within two weeks, the team created two prototypes that met not just the safety and functional requirements but also were comfortable for prolonged wear. Two versions were produced: one for disposable use, another, reusable.

“As engineers, we are heavily involved in product development,” remarks Chung Kai Siang, Innovation Technologist, Kaizen Office.

The fact that the hospital was putting in such urgent effort to protect its staff reassured those in the frontline – that their safety is paramount.

In the true spirit of innovation that TTSH carries, the problem of protecting frontliners’ eyes soon transformed into an opportunity for the creation of registered face shield designs that would deliver protection and comfort for staff working long hours in the battlefield. Not only that, the hospital is also gearing up to produce these shields for export overseas.

### SAFETY@WORK: DAILY PRACTICE AND STEPPED UP CLEANING

To create a safe environment for staff to work, whether on the frontline or backline, a series of campaigns, dubbed “Life in the Time of COVID-19” was rolled out: #EatAlone, #EatApart, #EataClean, Monitor Your Health, Mask Up to Protect One Another, Zoom Meeting, etc. All of this was to encourage staff to maintain safe distance within the



Samples of posters being put out to educate the staff on Safety@Work.

“ I am not fearful. I do my job with confidence . . . I feel happy for the patients when I see them get better and go home ■

WANG FANG  
Housekeeping Services

hospital premises, even as the hospital expected patients and visitors to comply with its safe management measures.

Separately, the regime of cleaning across the hospital was significantly stepped up.



Housekeeping staff work untiringly long shifts to keep the environment clean and safe.

The 450-strong housekeeping staff had to ramp up its cleaning efforts across the campus, in particular high touch areas in clinical areas, common areas and staff areas. Areas with nook and crannies had to be done manually. To accommodate the step-up in cleaning schedules, roster patterns were changed to include more staff on night shifts and extended shifts (up to 12 hours). This was to facilitate standby for round-the-clock cleaning assistance. Working the longest shifts and taking plausibly the biggest risks in keeping the rest of the staff and patients safe, the hospital recognises the need to care for the housekeeping staff.

“I am not fearful. I do my job with confidence . . . I feel happy for the patients when I see them get better and go home,” says Wang Fang, Housekeeping Services, who worked 10-hour shifts at the CDC Ward 84.

Taking on 12-hour shifts of wiping chairs and tables which patients had used at the Screening Centre is Vega John Christopher Urian, Housekeeping Services, who says, “Our supervisors care



Inspired by the Kaizen team, porters can now pick up swab test specimens from shelves built outside the COVID-19 care ward, reducing their exposure to infection risks.

about our safety and make sure we wear our PPE correctly . . . it’s not easy but we work as a team.”

### FASTER: REDESIGNING PROCESS

During the first COVID-19 peak in March-May 2020, the situation at Ground Zero was in a flux. Strict safety protocols were in place around the hospital and at the Screening Centre, the waiting areas and treatment areas were segmented into High Risk and Low Risk areas to maintain safety and prevent

cross-contamination. The problem was that at that point, the High Risk cases were far fewer than the Low Risk, causing a bottleneck in the Low Risk area of the Screening Centre as new suspect cases piled up.

The Kaizen team was alerted and sent to find an immediate solution with the respective stakeholders. “We believe in the ‘go-and-see’ method: we observed every touch point at the Screening Centre from the registration to patient discharge at the exit,” says Loo Wei Hann, Manager, Kaizen Office. “We noticed

“There were many battles to fight, from infrastructure issues to clinical considerations and certain high-risk symptoms ■

EVE CHENG PEI YING  
Management Executive, Kaizen Office

that the Low Risk area was very crowded, and there was a need to clear the queue fast. Several solutions were proposed. One of these ideas was, instead of divided resources for the two areas, have the two areas share resources.”

This was the period in late March 2020 when overseas students were returning home and the migrant worker dormitory infection numbers were climbing. “There were many battles to fight, from infrastructure issues as the NCID building was new, to clinical considerations and certain high-risk symptoms,” explains Eve Cheng Pei Ying, Management Executive, Kaizen Office.

“We came in from a fresh eyes perspective,” she says. “We encouraged the clinical team to think beyond the boundaries.” After much consideration and discussion, the clinical team adapted the suggestions to adjust the process flow at the Screening Centre for flexibility to manage the patient loads.

Another workflow challenge faced during that busy period was the need to

speed up the turnaround time for swab test results. The Kaizen team observed how, once the swab was taken, there were many process steps before the swab specimen reached the Department of Laboratory Medicine (Lab). Once it was in the Lab, there was another series of steps to get each specimen tested. Kaizen, the Lab and Screening Centre then decided there was a need to change the way the swabs were packed for transport to the Lab.

“We studied how to reduce turnaround time,” says Jia Xiang, “then we redesigned the test tube rack to fit in more test tubes so that we could cut down a lot of the processes that were involved.”

Wilson Chin Wei Sheng, Innovation Technologist, Kaizen Office, continues, “We also improved on design of the rack and added handles so that the Lab technicians could easily lower the test tubes into the testing bath.”

Such crucial design improvements to a *product* can lead to improvements in the *process*. “We seek to make things better; it’s our passion,” says Kai Siang.



A redesigned test tube rack that fits more test tubes, reducing processing time.

### BETTER: INNOVATING DELIVERY

The pharmacists at the Screening Centre faced an influx not just of patients who needed medication for flu-like symptoms, but sometimes among the migrant workers, drugs for chronic diseases like high blood pressure. Pharmacy staff had to overcome language barriers in counselling these medications. To speed up the process of dispensing URTI medications, the pharmacy department created a URTI pack, containing the “standard” drugs given to those who showed flu symptoms. “We called it



Pharmacists organising medical supplies at the NCID Pharmacy.

“Crisis changes norms of behaviour. We were trying to encourage medication delivery but COVID-19 happened and it became the new normal ■

MOHAMED RAZEEN BIN SAMSUDEEN  
Assistant Manager, Kaizen Office

the ‘Happy Meal’,” quips Gavin Cheah Jia Sheng, Senior Pharmacist, NCID Pharmacy, alluding to how fast the drugs could be dispensed this way.

This helped to keep things flowing well at the pharmacy, since, even with language barriers, the patients coming through the Screening Centre received the same medications for the common issues.

While TTSH was leading the fight against COVID-19, it still had its BAU patients to care for. Some of these patients still had their scheduled appointments while others had theirs postponed due to reduced BAU capacity. Regardless of their appointment status, all these patients still required their medication. Safe-distancing measures would mean even longer queues and higher risk of cross-infection.

How then do you augment protection? Shorten queues or reduce crowds by innovating the delivery of medication.

In the beginning, as a mitigation measure, medication delivery was actively promoted at the entrance of the Pharmacy to encourage patients to adopt delivery and head home. Meanwhile, the clinics were also doing their part to promote and get patients on board medication delivery. However, the clinics had no visibility with regard to delivery slot availability and were depending on the Pharmacy to arrange the burgeoning

number of deliveries. This resulted in delayed deliveries, which caused some patients having to personally visit the Pharmacy to collect their medication instead. Mohamed Razeen Bin Samsudeen, Assistant Manager at the Kaizen Office was part of the team tasked with improving the process of medication delivery.

Sparked by an administrative staff’s brilliant idea of adopting TTSH’s existing central appointment system, the team managed to provide visibility to the clinics to arrange delivery slots for patients to receive their medication in a more timely manner.

The Pharmacy had been trying to encourage more patients to take up medication delivery for some time before COVID-19. “Crisis changes norms of behaviour. We were trying to encourage medication delivery but COVID-19 happened and it became the new normal,” notes Razeen.

## PROTECTION ASSURED

Augmenting protection is about ensuring every staff is safe, and taking care of patients and visitors, whether through introduction of measures and policies or through innovation. In the end, nevertheless, to truly assure protection, it needs everyone to play a part – self-discipline, staying vigilant and having consideration for one another. ■

## REDESIGNING CARE: LEARNING IN CRISIS

**L**earning never stops at TTSH. From top-level learning on how to coordinate and integrate the many different parts in its care delivery system to frontline learning on how to protect healthcare workers – BAU or outbreak – learning at TTSH has always been and will always be about redesigning care to deliver better patient experience and wellbeing, and staff’s safety and emotional being.

In TTSH learning culture, there are no *best* care solutions, only *better* care solutions. As a *kampung*, the people learn to innovate at all times so as to deliver better care.

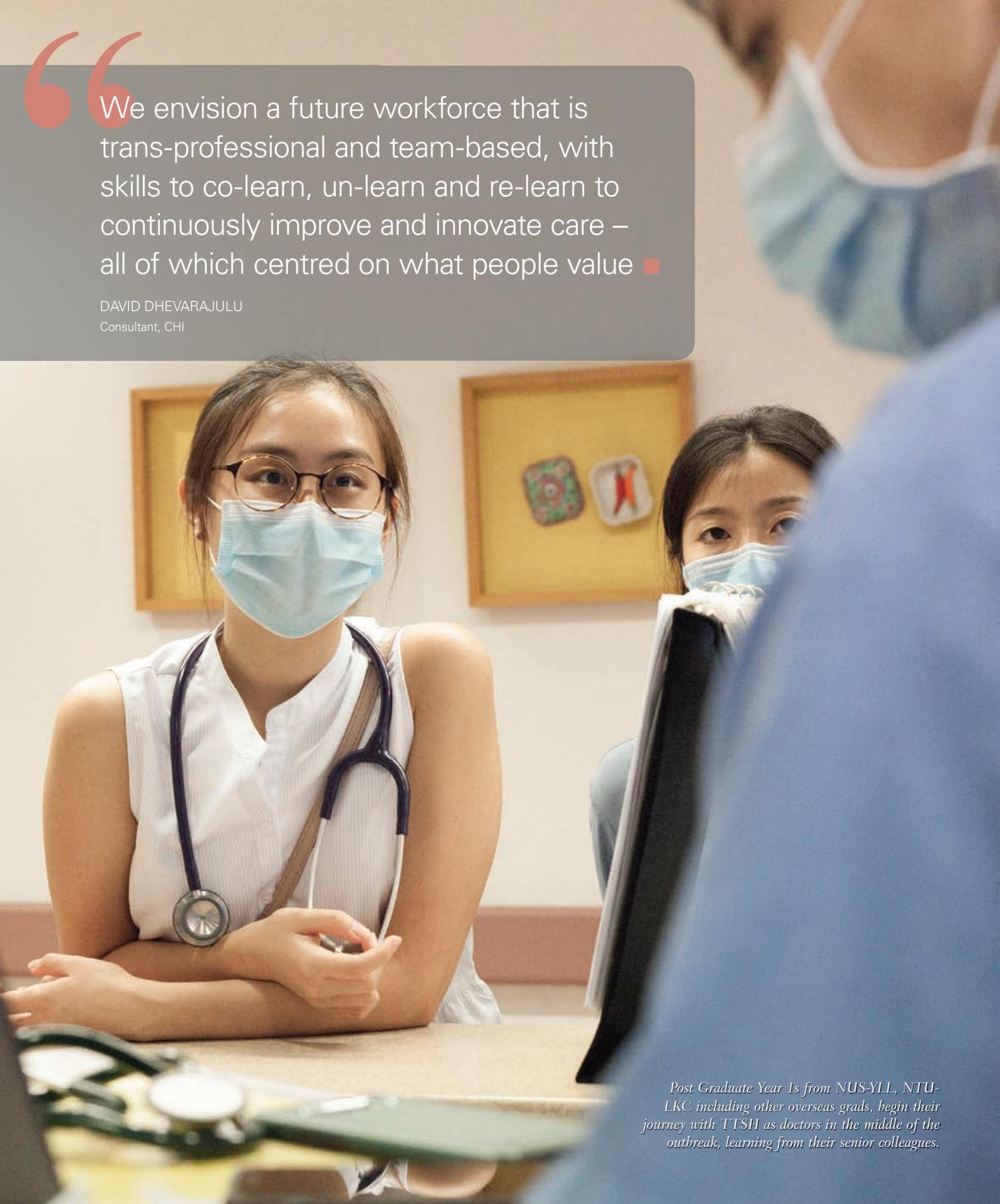
“To better care for patients, we need to keep learning, innovating and growing. We can’t afford to stay ‘comfortable’ with what we already know or how we do things ■

LAURA HO PEI WAH  
Deputy Director of Nursing

*Two ward staff discussing an operation matter at Ward 9B, a BAU ward.*

“We envision a future workforce that is trans-professional and team-based, with skills to co-learn, un-learn and re-learn to continuously improve and innovate care – all of which centred on what people value ■

DAVID DHEVARAJULU  
Consultant, CHI



*Post Graduate Year 1s from NUS-YLL, NTU-LKC including other overseas grads, begin their journey with TTSH as doctors in the middle of the outbreak, learning from their senior colleagues.*

“To better care for patients, we need to keep learning, innovating and growing. We can’t afford to stay ‘comfortable’ with what we already know or how we do things. The world evolves and so must we,” observes Laura Ho Pei Wah, Deputy Director of Nursing, a veteran nurse who looks after TTSH’s inpatient operations efficiency.

She continues, “Everybody is a problem solver, and each of us has two jobs to play: Doing our job well and doing our job better.”<sup>1</sup>

David Dhevarajulu, Consultant of Centre for Healthcare Innovation (CHI) agrees,<sup>2</sup> “We envision a future workforce that is trans-professional and team-based, with skills to co-learn, un-learn and re-learn to continuously improve and innovate care – all of which centred on what people value.”

## LEARNING IN CRISIS

There is no crisis to waste. It is important that every TTSH staff learns as he or she does, and not just learn after it is done.

The hospital was in the midst of developing an Outbreak Scenario for its C3 capabilities when COVID-19 struck. “3Cs” stand for Command, Control & Communications and are handled by the hospital’s newly opened Integrated Operations Command Centre (OCC). There was no better time to accelerate

the development of the hospital’s C3 capabilities for an outbreak scenario than during an outbreak itself.

As the “brain” of the hospital, C3 is a smart system of systems that can sense, think and respond to optimise patient flow and care delivery. It enables a mind-set shift in hospital operations from resource management to flow optimisation to autonomous orchestration. It was a classic case of “quantum leap in learning” in the face of a major pandemic. (For more details on 3Cs, please read “One Step Ahead: Reimagining Care” in Chapter 10).

Crisis spurs creativity. It’s a “natural” classroom – fast-forwarded to spur co-learning, unlearning, and relearning. It kindles a curious meeting of the hearts and minds to do things better. Galvanising the wits of man and the



*A senior nurse trainer showing the care ambassadors – many of them SIA crew members – how to turn a “patient’s” body.*



Learning from each other, as staff discuss and explore ideas to improve patient care in the ward.

crafts of his hands, the adventure of learning inspires both innovation and personal growth.

“While the COVID-19 crisis presents us with one of the most pressing challenges the hospital has to confront, it also gives us one of the best opportunities to learn how to redesign care better – both process and product,” says Chua Jia Xiang, Lead Service Designer, Kaizen Office.

“I felt that I was sometimes not in control of the situation due to the pace of work and failed to achieve certain standards I had set up out for myself.

This lack of mastery was demoralising. In turn, I learnt how to *manage self* through a mindset shift where control of a situation is not a single endeavour but a team sport. By adopting this new way of thinking, I was able to achieve a more sustainable outcome for the organisation,”<sup>3</sup> reflects Benjamin Wong Tien Yong, Management Executive.

Hong Yun, Principal Occupational Therapist, Rehab, recalls, “I had to learn new things – swab tests, patient transfer, ECG, triage, and as a ‘lab runner’ – transporting lab samples at the hand-over area in the Screening Centre to the Lab

“ I learnt how to *manage self* through a mindset shift where control of a situation is not a single endeavour but a team sport ■

BENJAMIN WONG TIEN YONG  
Management Executive

while adhering to standard procedures and strict infection control measures! Wherever the need arises, I was prepared to fill it. All said, aside from the new skills I’ve picked up, I’ve learnt to work together in a team. My colleagues have now become my friends. By learning to give, I’ve gained.”

### TURNING “ORDINARY” INTO “EXTRAORDINARY”

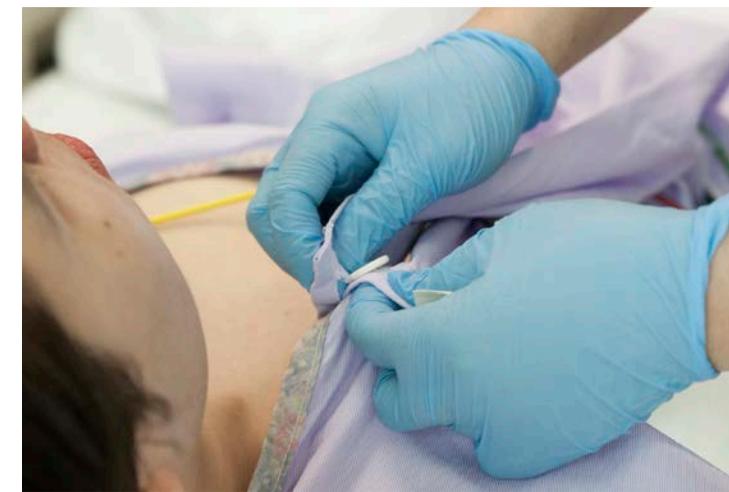
“Innovation must be our bridge between learning and doing, so we can transform healthcare for the future,” urges CEO Dr Eugene Soh, during a townhall meeting with TTSH staff in late 2018.<sup>4</sup>

Indeed, learning without innovation and growth serves no purpose. In the context of care delivery in TTSH, it means better patient care and better staff well-being. And each learning-innovation journey doesn’t have to be “loud” or “showy”. It can start small.

“It’s wonderful to see how by paying a little more attention to details, and with a little ingenuity and imagination, we

can turn an ordinary procedure into an extraordinary feat, just like how Deputy Director of Nursing Laura Ho and her team did in coming up with a one-piece gown instead of two-piece pyjamas – saving time and manpower!” observes Dr Hoi Shu Yin, Chief Nurse, TTSH & Central Health.

Many “small but significant” innovations have been introduced in nursing where 3,600 nurses serve. For example, nurses usually have to wait about 10 minutes for a porter to arrive to help wheel each patient. It is not



A one-piece patient pyjamas saves time and manpower.

so now. By fitting a motorised fifth wheel to new hospital beds, the nurses can wheel patients on their own. With only one nurse to manoeuvre, during an “outbreak” mode like COVID-19, it effectively minimises the number of personnel exposed to possible infectious diseases. More, the new beds come with a weighing scale. This means nurses no longer need to carry an immobile patient off the bed to be weighed. The hospital is in the process of retrofitting all its 1600 beds with the fifth wheel. Separately, the one-piece patient pyjamas, with buttons on the side, has cut down the number of nurses and time needed to put on new garments for ICU patients. Another seemingly small innovation has yielded a significant outcome. Previously, nurses had to walk an average of 8km each shift to access their workstations placed up to 200m away in the middle of a cluster of wards. Today, with workstations placed at the very ward where they deliver care, they can easily retrieve patient information (from the computer) and items such as kidney dishes, syringes and urine bottles. They now walk an average of 5.2km during each shift! This is translated into more patient-nurse interaction time.<sup>5</sup>

“All these solutions introduced over the past decade may not amount to much on their own, but they have saved the

nurses much agony during this period. The hospital is able to cope at this time (COVID-19) while facing a manpower crunch in its nursing department because of the sum of these innovative solutions. We’re grateful that the hospital has empowered our nurses to eliminate unnecessary work processes daily so that they can focus on patient care,” adds Laura.



It’s wonderful to see how by paying a little more attention to details, and with a little ingenuity and imagination, we can turn an ordinary procedure into an extraordinary feat ■

DR HOI SHU YIN  
Chief Nurse, TTSH & Central Health

*Dr Hoi Shu Yin sharing her thoughts with her colleagues.*



*New hospital beds are equipped with a weighing scale, and a fifth wheel to cut down manpower and operational time.*



Innovations such as these wall-mounted glove and wet wipe dispensers ease the hygiene regime of frontline staff.

## INNOVATION ACROSS THE BRIDGE

Across the TTSH Main Building, in the frontline at the Screening Centre and COVID-19 wards, the spirit of innovation thrives too. For example, as it was difficult to distinguish the identities of staff dressed in full PPE, colour tapes – with their names inscribed – were used to identify them. In addition, a holder for essential items was installed inside each COVID-19 care cubicle for nurses. This helped them to perform hand hygiene without having to doff their PPE,

lessening their exposure to the infection and saving time. Porters are also kept safe. An improved SOP spared them from having to enter COVID-19 care wards to collect specimens. They only need to utilise the clean specimen boxes placed on a shelf outside the ward. Previously, they had to fetch “dirty” boxes directly from the COVID-19 care unit.<sup>6</sup>

In the allied health arena, the physiotherapists are working hard to help their patients recover amid restrictions on face-to-face rehabilitative therapy sessions. Besides tele-consultation

services, they have developed “Heart-Track”, a novel gamified mobile app based on a cardiac rehabilitation (CR) model of care. Paired with a heart rate sensor – a technology-enabled device designed specifically for patients post PCI – the app helps them complete CR effectively at home without the need to travel to the hospital or any centre, while clinicians remotely monitor their progress through an online portal, thus saving them time and money!

On another front, occupational therapists have been collaborating with CHI Living Lab (CHILL) to create a 3D-printed universal holder for feeding. The idea came about from observing post-stroke and neuromuscular patients struggling with feeding due to limited hand motion and strength. Enabling them to be independent in self-care, the 3D-printed assistive device can be semi-customised according to patients’ specific needs. It is also more flexible, compared to buying fixed-feature adaptive utensils off the shelf. The prototype is currently at patient trial stage, undergoing testing and improvement before actual production.<sup>7</sup>

Lastly, to facilitate better communication between healthcare workers and migrant workers served at TTSH, Shaina Tan En Ling from the Kaizen Office, together with co-designer Jason Leow, created visualaid.sg, a resource site of illustrated translations



The 3D-printed universal holder (top) and “Heart-Track” mobile app (middle and bottom) are some of the innovations developed to enable better patient care.



*A pharmacy staff responding to queries from patients/visitors.*

“It’s all about creating a better experience for the users ■

EVE CHENG PEI YING  
Management Executive, Kaizen Office

that can be used as flashcards. In her interview with *better.sg*, and *todayonline*, Shaina says, “I realised we needed something that was physical to use with their patients instead, and where I thought I could value-add with my own skillset as a designer was to include some visual cues and visual aid to help people understand these (clinicians’) questions better along with the translations.”<sup>8</sup>

Innovation to deliver better care starts with empathy by understanding the needs of patients. Coupled with collaboration and creativity, it allows TTSH to adopt a system perspective that facilitates the creation of ideas that are truly innovative.

Mohamed Razeen Bin Samsudeen, Assistant Manager, Kaizen Office remarks, “Innovation is about making things better. One way is to create novel solutions for the problems faced. Another is to creatively use existing solutions for new uses or solve new problems. For example (as mentioned in Chapter 11),

TTSH already has an existing enterprise appointment system to schedule patient appointments at outpatient clinics. This is something that PSAs at the clinics use on a daily basis and hence are familiar with. At the height of COVID-19, our medication deliveries were delayed as the clinics were getting patients to take up medication delivery without knowing if there were available slots. We found a new use for the enterprise appointment system to help provide visibility to the clinics on available delivery slots. This allowed the PSAs to advise accordingly on when patients can anticipate their delivery and allowed patients with depleting drug supply to proceed straight to pharmacy instead of waiting for delivery.”

Eve Cheng Pei Ying, Management Executive, Kaizen Office, sums it all up, “It’s all about creating a better experience for the users.”

“When we (learn and) keep innovating in the way we do things, we renew ourselves as an organisation. This way, we perpetuate what I’d call ‘organisational youth’ ■

DR EUGENE FIDELIS SOH  
CEO, TTSH & Central Health



## RENEWAL: CO-LEARNING, UNLEARNING, RELEARNING

There is no life where there is no growth. And to grow means having the humility, determination and discipline to keep learning. Not just self-learning, but also co-learning, unlearning and relearning. Only then can an individual renew himself or herself within a larger community. For an organisation, the “fuel” of learning that sparks innovation at the workplace is akin to “blood of renewal”. It is a first-order “must-have”, or the organisation may cease to exist. For TTSH, it means cultivating an enduring culture of learning and spirit of innovation – a continuous renewal – to redesign care so as to bring about better patient experience.

“When we (learn and) keep innovating in the way we do things, we renew ourselves as an organisation. This way, we perpetuate what I’d call ‘organisational youth’,” concludes Dr Soh.

For a 177-year-old hospital, the word “youth” certainly teems with glee, life and possibilities. ■

*Rigorous drills being conducted at Level 7 in preparation for a surge in overflow of COVID-19 patients.*