

Singapore's experience in managing the COVID-19 pandemic: Key lessons from the ground

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ABSTRACT

Singapore managed the COVID-19 pandemic in the past three years and gleaned valuable lessons on patient management when the public healthcare system was inundated with COVID-19 patients. There were several initiatives, which included setting up of community treatment facilities to help hospitals manage in-patient loads that did not require acute monitoring, leveraging telemedicine, and developing heuristics to sort patients based on their clinical disposition to various care pathways and to effectively manage patients of different medical needs. These initiatives were implemented in the second year of the epidemic in 2021 and did not include the dormitory-based migrant workers and migrant workers in the construction, maritime and production sectors who were under the care of the Assurance, Care and Engagement Group (ACE) in the Ministry of Manpower that had its own set of treatment management measures. The different care pathways ensured that patients received appropriate levels of care and allowed healthcare facilities to focus on more acute cases. In 2022 alone, 23,159 patients were discharged from community treatment facilities against the background of 1.9 million COVID-19 patients. These initiatives would not be possible without the oversight of an advisory board comprising senior leadership from the healthcare clusters and the Ministry of Health to align clinical governance with medical policies, and prompt and immense support from medical specialist panels. The strong public-private partnership forged in the process was instrumental in the successful operation of community facilities and implementation of patient care protocols, coupled with harnessing information technology and leveraging on emerging data to refine care protocols.

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INTRODUCTION

In the early days of the pandemic when information on COVID-19 infection was lacking, all COVID-19 positive patients were admitted into acute hospitals for isolation and monitoring. With the exponential increase in the number of infections, COVID-19 Treatment Facilities (CTFs) were set up to help hospitals manage in-patient loads. When the Delta variant prevailed, the National Sorting Logic (NSL) that assigned patients into different care protocol was developed. It allowed patients with positive Polymerase Chain Reaction (PCR+) or Antigen Rapid Test (ART+) results to recover at home if they were minimally symptomatic and not predisposed to severe infection risks. When more experience was accrued in the management of COVID-19 illness, the patient care model underwent further review, in consultation with COVID-19 Treatment and Care Facilities Medical Board (CTCFMB) and the Specialist Panel. The Specialist Panel comprises medical specialists that include geriatricians, paediatricians, obstetricians & gynaecologists, oncologists, rheumatologists, and nephrologists, appointed to provide advice and guidance to the Medical Operations and Policy Centre (MOPC) in formulating and developing COVID-19 policies, specific to geriatric, paediatric, pregnant, immunocompromised and renal failure patients. In the protracted Omicron phase, CTCFMB guided the development of Protocol 2 Primary Care (P2PC) and the home recovery programme, allowing CTFs to focus on high-risk patients. (P2PC allowed patients with minor COVID-19 symptoms and at low risk of developing severe COVID-19 disease to recover at home under the care of primary care providers.) When paediatric patients were affected by the Omicron variants, CTCFMB and the Specialist Panel developed care protocols that allowed low-risk paediatric patients to be admitted to CTFs, thereby releasing hospital capacities for

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high-acuity patients. These initiatives were implemented in the second year of the epidemic, in 2021, and did not include the dormitory-based migrant workers and migrant workers in the construction, maritime and production sectors who were under the care of the Assurance, Care and Engagement Group (ACE) in the Ministry of Manpower that had its own set of treatment management measures.

More than 31,000 patients were admitted to CTFs from the start of the pandemic and the monthly peak admissions during the Delta and Omicron waves were 3600 (October 2021) and 6000 (March 2022) patients, respectively. CTCFMB tracked patients for U-turns and escalation to public healthcare institutions (PHIs) to monitor for appropriate patient management. “U-turns” describe patients being conveyed back to the institutions they were transferred from, as they were not ready for CTF care due to acuity of their condition, within 24 hours of arrival at the CTF. If the duration of stay at the CTF went beyond 24 hours, it would be termed as an “escalation”. CTCFMB also tracked patients’ oral anti-viral medication utilisation in the CTFs to improve the recovery process.

With the declaration of Disease Outbreak Response System Condition (DORSCON) Green in Singapore on 13 February 2023, it was timely to glean the lessons learnt from the evolving patient care models over the last three years.

The DORSCON alert level system is a colour-coded systematic outbreak response system, with red indicating an outbreak where disease is severe and

spreading widely and green indicating the other end of the spectrum where disease is mild or is severe but does not spread easily from person to person. In between, there is orange level, indicating disease is severe and spreads easily from person to person but disease has not spread widely in Singapore and is being contained; and yellow, where disease is severe and spreads easily from person to person but is occurring outside Singapore or is spreading in Singapore but is typically mild or being contained.

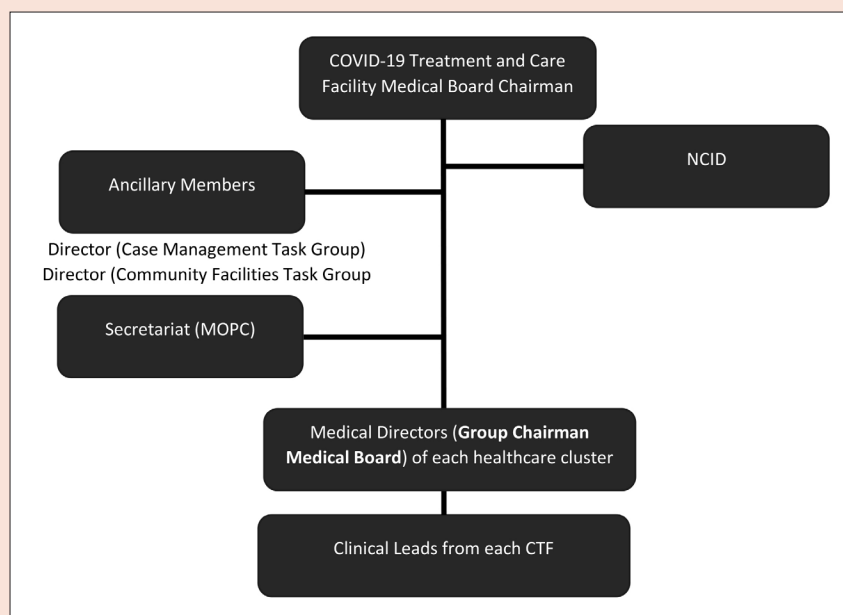
TAKEAWAYS FROM AFTER-ACTION REVIEW

CTCFMB structure

The CTCFMB comprises medical directors of the CTFs, Group Chairmen of Medical Board (GCMB) of the three healthcare clusters in Singapore, i.e. National Healthcare Group, National University Health System, Singapore Health Services (SingHealth), and the Ministry of Health (MOH) Deputy Directors of Medical Services. The CTCFMB was supported by various Task Groups under MOH’s Crisis Strategy and Operations Group, with the Executive Director and Clinical Director from National Centre for Infectious Diseases (NCID) providing advisory roles (Fig. 1). Its terms of reference are to provide strategic oversight, which includes execution of clinical policies promulgated by MOH and monitoring each CTF’s performance in terms of patient and staff safety.

This composition allowed cluster senior leadership to set clinical governance for the community treatment and care facilities, while MOH leadership provided oversight for medical policy alignment.¹

Fig. 1. Composition of the CTCF Medical (Community Facilities Task Group).



CTF: COVID-19 Treatment Facilities; MOPC: Medical Operations and Policy Centre; NCID: National Centre for Infectious Disease

Public-private partnerships

CTFs were operated during the pandemic to allow PHIs to conserve limited manpower and focus on supporting bed capacity expansion for COVID-19 patients with high acuity. These CTFs were located across Singapore, situated within existing healthcare facilities (e.g. Bright Vision Community Hospital, Tampines Nursing Home, Crawford Hospital, Ren Ci Hospital, and IHH/Parkway Hospitals) and non-healthcare facilities that were repurposed for CTFs (e.g. Connect @ Changi and F1 Pit Building). Public-private partnerships were established to operate these CTFs. Clinical services in some community facilities were operated using volunteers from PHIs' operational services, but most were supported by Singapore Armed Forces Medical Corps in the early stages and eventually taken over by private medical providers and some volunteer healthcare workers. This partnership between public and private providers was facilitated by CTCFMB's clinical governance, which aligned evidence-based clinical protocols and processes across all CTFs.

The CTCFMB provided clear guidelines on the level of medical care provided, including when to provide COVID-19 therapeutics across all relevant routes of administration, ensuring the provision of supplemental oxygen and maintaining continuity of care for chronic disease management among many of the elderly patients decanted to CTFs. Medical manpower staffing ratios were also clearly stipulated to ensure patients do not get compromised attention. The ratio of doctors to patients was at least 1:40, and the ratio of nurses and healthcare assistants to patients were at 1:6 to 1:8, respectively. Although CTFs were generally not required to offer the services of a dietitian, physiotherapist, occupational therapist or speech therapist, CTFs sited within existing healthcare facilities usually do provide some allied health services. Patients who require these services would be right-sited to the appropriate CTFs.

Bringing in private medical providers to provide medical services to patients who did not require acute care, governed by guidelines to ensure appropriate level of care by the CTCFMB, had effectively allowed patients to be decanted safely from the PHIs to the CTFs and released over 23,000 PHI beds in 2022 for patients with higher acuity.

Nonetheless, we recognise that our rich resource of primary care providers in the private sectors—which include specialists in private practice—could have been engaged earlier to help with the management of COVID-19 patients. More of this would be explored in the subsequent sections.

Harnessing information technology and evidence-based patient management

The National Sorting Logic

The National Sorting Logic (NSL)^{2,3} is a consolidated guideline that assesses patients' conditions, determines the initial disposition for each patient, and right-sites patients based on their relative risk profile for the appropriate level of medical care (Table 1). In general, symptomatic high-risk patients would be conveyed directly to the emergency departments, while clinically stable or asymptomatic high-risk patients would be conveyed to CTFs for recovery, and all other patients would recover at home. The NSL was continuously revised in response to the changing pandemic landscape and driven by government COVID-19 statistics. During DORSCON Orange and Yellow, patients performed self-triaging by answering questions listed in a prescribed FormSG (i.e. a government online form filling service maintained by Open Government Products). This sped up the administrative process and increased the throughput of general practitioners (GPs) in triaging and diagnosing patients. The use of FormSG also allowed patient data to flow seamlessly and error-free from one database to the next, maintaining data integrity crucial for monitoring of patient movement.

Data and evidence were continually assessed to guide policy actions for different types of patients with expert input from public health and infectious diseases experts advising the CTCFMB. Using up-to-date data from the NPHEU (National Public Health and Epidemiology Unit) and NCID teams, which showed reduction of ICU cases with decrease in case fatality rate from 30 to 28 per 10,000 patients, coupled with significantly lower levels of inflammatory markers, incidence of pneumonia and individuals who require oxygen supplementation, the CTCFMB guided the implementation of the P2PC, which right-sited patients to primary care, helping to further preserve healthcare resources.

The progressive relaxation in the policy governing disposition of various patient groups can be found in Table 2, which demonstrated the constant need to assess the evolution of information and balance it against the need to preserve healthcare resources for more acutely ill patients. Policy changes were generally supported with two to three months of data although consistent trends could be observed after one month of monitoring.

Table 1. Rationale for the National Sorting Logic, Key Functions and Key Learning Points from the CTF and Home Recovery Programme.

National Sorting Logic		
Rationale	National CTCFMB for uniform standards of clinical governance (patient, crisis management governance and staff safety)	
	Central research governance (data integrity and confidentiality) and regular morbidity and mortality reviews	
	Adapt and evolve based on the changing pandemic landscape	
	National Sorting Logic is premised on risk stratification; this determines the initial disposition of each case	
	Correctly sites patients based on their relative risks and symptoms (age, vaccination status and other health conditions)	
CTF		Home Recovery Programme
Key Functions	Monitor patients' recovery in a controlled environment	Default management for the general population
	Continuation of specific treatment (such as anti-virals) after decanting from hospitals	Can also be utilised by the vulnerable population through co-management with doctors-in-charge and specialist panels
Key Learning Points	- Involve private medical groups and uniformed services (e.g. SAF) early, as part of national response to run the facilities - Adapt and evolve based on the changing pandemic landscape - GPs are the custodians of the National Sorting Logic and have the following functions: - Refer emergency cases to PHIs - Refer symptomatic high-risk patients to CTF - Refer other patients (non-emergency, intermediate- to low-risk) for home recovery - Central medical board should be convened early in pandemics to provide clinical governance for all CTFs - Central operations unit is required to manage and ensure seamless patient flow among the facilities - Must have resources to continue specialised treatment such as anti-viral therapy	- Intermediate- to low-risk COVID-19 patients can be managed at home - Telemedicine service is required for 24hourly medical support to patients. - Central agency to monitor telemedicine providers' performance to ensure conformance to service standards and quality - Medication distributed via couriers ensures speedy delivery to patients - Issuance of electronic medical certificates reduces administrative effort

CTCFMB: COVID-19 Treatment and Care Facilities Medical Board; CTF: COVID-19 Treatment Facilities; SAF: Singapore Armed Forces; GPs: general practitioners

Telemedicine Allocation and Reconciliation System

Telemedicine, supported by the Telemedicine Allocation and Reconciliation System (TMARS), was important in supporting the NSL. TMARS comprised 37 telemedicine providers and has a maximum daily capacity of 5300 consultations. Usage of TMARS supported the transition of paediatric and obstetrics patients from hospital care to Protocol 1 or P2PC, allowing more patients to benefit from the home recovery programme. Continuous data collection provided feedback to finetune the telemedicine regimen—the number of telemedicine reviews required for P2PC patients was reduced, freeing up telemedicine capacity to provide timely care for more patients.

While the NSL was an effective and successful tool during the pandemic, it relied entirely on hospitals to triage COVID-19 patients in the emergency departments before the patients were "sorted" into subsequent care pathways. It was

acknowledged during the after-action review led by the Crisis Strategy and Operations Group (CSOG), that primary healthcare providers should be included as an additional resource to help triage COVID-19 patients. They should be integrated into subsequent iterations of the sorting logic in TMARS platform, which will continue to be enhanced to optimise ease of access and use for doctors.

Managing special populations

Paediatric patients

Initially, all children below 12 years old were conveyed to children's emergency departments at the National University Hospital (NUH) or KK Women's and Children's Hospital (KKH) for triaging and assessment of their suitability for home recovery. At the peak, this process resulted in significant delays with some patients waiting 72 hours or more for a consult, due to the emergency

Table 2. Evolution of the National Sorting Logic for Geriatric, Obstetric, Paediatric and Renal Patients.

Patient Group	Duration	Care Facilities (PHIs/CTFs)			Protocol 1			Protocol 2 (Primary Care)	
		Not Fully Vaccinated	Fully Vaccinated		Not Fully Vaccinated	Fully Vaccinated		Not Fully Vaccinated	Fully Vaccinated
Geriatric	Prior to 16 Feb 2022	Age ≥ 50	Age ≥ 80	Not Applicable	70 ≤ Age < 80	Age ≥ 80		Not Applicable	Not Applicable
	16 Feb 2022 to 12 Feb 2023	Age ≥ 80	Not Applicable	70 ≤ Age < 80	Age ≥ 80			Age < 70	70 ≤ Age < 80
	13 Feb 2023 to date	- CTF, if unsuitable for Home Recovery Programme - Default Home Recovery under GP/telemedicine care - Escalate to PHI when condition deteriorates							
Obstetric	Dec 2021 to 5 Feb 2022	GA < 26 weeks (CTF) GA ≥ 26 weeks (hospital)	GA ≥ 26 weeks (hospital)	Not Applicable	GA < 26 weeks			Not Applicable	
	6 Feb 2022 to 15 Feb 2022		Not Applicable		GA < 34 weeks				
	16 Feb 2022 to 24 Oct 2022	GA < 36 weeks (CTF) GA ≥ 36 weeks (hospital)			GA < 36 weeks				
	25 Oct 2022 to 12 Feb 2023	GA ≥ 36 weeks (hospital)		Not Applicable				GA < 36 weeks	
Paediatric	13 Feb 2023 to date	- CTF, if unsuitable for Home Recovery Programme - Default Home Recovery under GP/telemedicine care - Escalate to PHI when condition deteriorates							
	9 Oct 2021 to 5 Jan 2021	Age < 1 year 1 year ≤ Age* < 4 years		1 year ≤ Age				Not applicable	
	6 Jan 2022 to 21 Jan 2022	Age < 3 months		3 months ≤ Age < 12 years				12 years < Age	
	22 Jan 2022 to 15 Feb 2022	Age < 3 months		3 months ≤ Age < 5 years				5 years < Age	
	16 Feb 2022 to 24 Mar 2022	Age < 3 months		3 months ≤ Age < 3 years				3 years < Age	
	25 Mar 2022 to 24 Oct 2022	Age < 3 months		3 months ≤ Age [†] < 1 year				1 year < Age	
	25 Oct 2022 to 12 Feb 2023	Age < 3 months		Not applicable				3 months ≤ Age < 1 year	
	13 Feb 2023 to date	- CTF, if unsuitable for Home Recovery Programme - Default Home Recovery under GP/Telemedicine care. ** - Escalate to PHI when condition deteriorates							

Table 2. Evolution of the National Sorting Logic for Geriatric, Obstetric, Paediatric and Renal Patients. (Cont'd)

Patient Group	Duration	Care Facilities (PHIs/CTFs)		Protocol 1		Protocol 2 (Primary Care)	
		Not Fully Vaccinated	Fully Vaccinated	Not Fully Vaccinated	Fully Vaccinated	Not Fully Vaccinated	Fully Vaccinated
Renal	Oct 2021 to Jan 2022	Hospital, in-hospital dialysis		Not applicable		Not applicable	
	Jan 2022 to 20 Feb 2022	CTF, National Dialysis Centre dialysis		Not applicable		Not applicable	
	21 Feb 2022 to 12 Feb 2023	CTF, if unsuitable for Home Recovery Programme		- Can utilise each day's last session at each Regional Dialysis Centres for dialysis - Default Home Recovery under GP/telemedicine care - Escalate to PHI when condition deteriorates		Not applicable	
	13 Feb 2023 to date	- CTF, if unsuitable for Home Recovery Programme - Can utilise any dialysis centre and any session for dialysis - Default Home Recovery under GP/telemedicine care - Escalate to PHI when condition deteriorates					

CTF: COVID-19 Treatment Facilities; GA: gestational age; GP: general practitioner; PHI: public healthcare institution

*If assessed to be unsuitable for home recovery.

**COVID-19 positive neonates with fever ($\geq 38^{\circ}\text{C}$) should continue to be referred to the children's emergency department for clinical assessment and considered for admission to conduct inpatient investigations/management. Children with comorbidities and infants less than 3 months old, should be co-managed with their paediatricians.

*With effect from 15 May 2022, family units with COVID-19 positive children from 3 months old may be decanted to Connect@Changi

Note: Paediatric and renal patients were managed regardless of vaccination status.

Note: Case fatality rates were collected for at least one month before implementing policy changes, and most policy changes were supported with 2–3 months of case fatality data.

Table 3. Comorbidities, Age and Vaccination Status, Exam/Symptoms (CAVES) criteria developed by MOH.

Domains (CAVES)	Indications for Paediatric Home Recovery Programme
Comorbidities	Example: No chronic conditions that might be decompensated due to COVID-19 infection, e.g. asthma exacerbation of chronic lung disease, inborn errors of metabolism etc. (NB: This list is by no means exhaustive and not all chronic conditions will be impaired by a concurrent acute COVID-19 infection.)
Age and Vaccination Status	Aged 1 year and above
Exam/ Symptoms	• None of the following: • Any significant pain or discomfort • Significant chest pain • Shortness of breath • Hyperpyrexia • Prolonged fever or clinically significant respiratory symptoms for more than 5 days • Poor feeding/reduced appetite/poor urine output less than 4 times daily • Persistent vomiting/abdominal pain with impaired intake • Lethargy/reduced consciousness • Clinical suspicions/concerns of Kawasaki or Multisystem Inflammatory Syndrome in Children (MIS-C) • Any parental concerns

departments' limited capacities. With clinical data that children generally develop mild symptoms from COVID-19 infection and did not require hospitalisation, the Home Recovery Programme Paediatric Team (HPT), comprising community paediatricians across Singapore, was formed to divert patients away from the children's emergency departments. The HPT triaged children remotely via teleconsultations using the CAVES criteria, referring to comorbidities, age and vaccination status, exam/symptoms (Table 3), facilitating prompt assessment and escalation of only critical cases to NUH or KKH. Only 626 out of 30,733 paediatric screened by HPT patients required escalation. Subsequently, the CTCFMB recommended admitting paediatric patients aged 3 months and older into a CTF, accompanied by caregivers. The CTF was equipped with paediatric medical supplies and paediatric consumables, such as paediatric-sized blood pressure cuffs, pulse oximeters, IV plugs, diapers, bathing tubs and milk powder, to cater to this population.

The lower bound age for home recovery protocol was eventually reduced³ from above 12 years old to 3 months and older with the assessment of paediatric patients aged 3 months and older taken over by GPs. This freed the HPT to care for younger children aged below 3 months and at-risk children (i.e. patients who risk developing severe COVID-19 diseases due to comorbidities and signs of concern).

Geriatric patients

Patient management commenced with admitting patients aged "above 49 years who were not fully vaccinated" and "above 79 years and fully vaccinated", to PHIs or CTFs.⁴ However, emerging evidence showed that most seniors, especially the

fully vaccinated ones, recovered uneventfully. This prompted the NSL to be amended to expand the age groups of patients managed under the home recovery programme, allowing patients "above 79 years who were fully vaccinated" to be managed at home with telemedicine⁵⁻⁷ supervision. Patients "above 79 years who were not fully vaccinated" still required admission to hospitals for close monitoring.

Obstetric patients

Initially, all COVID-19 obstetric patients were admitted to PHIs for close monitoring. In the Omicron-predominant period between January to March 2022, there were no obstetric patient mortalities and the oxygen utilisation rate remained low at 0.02% (1 out of 4166 cases), while the hospitalisation rates of obstetric patients during the Delta-predominant and Omicron-predominant waves were 10.5% and 2.4%, respectively. In general, the data showed very few incidences of severe illness among obstetric patients below 36 weeks of gestation. From October 2022, regardless of vaccination status, patients below 36 weeks of gestation were allowed to recover at home³ with close self-monitoring while patients above 36 weeks of gestation were cared for at CTFs or hospitals. With more information supporting safe self-monitoring of obstetric, the policy was revised to allow them to recover at home⁹ regardless of vaccination status and gestational age.

Renal patients

In the early days of COVID-19, all renal patients with COVID-19 infection were admitted to PHIs for close monitoring and dialysis support. Subsequently, renal patients could be managed in CTFs (Table 3), with conveyance to two designated National Dialysis Centres for dialysis.^{10,11} However,

this arrangement disrupted the centres' normal operations, as non-COVID-19 renal patients could not schedule their own dialysis sessions. Greater understanding of COVID-19 disease progression led to further relaxation, and COVID-19 renal patients could recover at home under telemedicine supervision and were allocated the last dialysis session¹¹ of each day at their respective Regional Dialysis Centres. This innovative scheduling allowed renal patients to continue their dialysis treatment without admission to PHIs and removed infection prevention and control burden on the dialysis centres.

Assessment on the management of special populations

When managing the special populations, some key operational challenges included ensuring that high-risk individuals were appropriately identified and flagged for the right level of care, as well as changing the mindset of the public to embrace home recovery as the default option for the seemingly vulnerable populations.

As discussed above, the initial disposition for managing paediatric and pregnant patients was to convey them to the CTFs and PHIs. It was only in October 2022 that policies were relaxed to allow paediatric patients 3 months to 1 year old and pregnant women of gestational age less than 36 weeks to recover at home under the P2PC protocol. This is despite earlier data showing low severity rates for paediatric and pregnant patients. Similarly, the transition to community-based recovery and eventually home-based recovery for patients on renal dialysis only started in January 2022. The earlier phase when hospital-based recovery was default had placed strain on the public healthcare system.

In both cases, the initial phases of management err greatly on the side of caution resulting in inconveniences in workflows and stretching of resources. On balance, the highly conservative approach might have still been reasonable in view of evolving variants of the COVID-19 virus, and close monitoring on its impact on the various special populations was prudent. Instead, agility needs to be built into the system to switch management tactics for special populations, or even the general population, when new data and evidence becomes available to guide medical care management.

CONCLUSION

The success in managing the surge of patients during the pandemic could be attributed to the nimbleness and ability to make rapid adjustments

based on prevailing clinical evidence, of the evolving disease, clinical presentation and outcome of patients. The CTCFMB composition was also a critical factor in providing effective and efficient leadership for the swift changes made in patient care model over the course of the pandemic. The excellent partnership between private and public healthcare should continue to be a feature in future pandemic preparedness efforts, with emphasis that early collaboration and effective communication links should be encouraged among all healthcare stakeholders for rapid information sharing and dissemination.

Declaration

The authors declare that there are no affiliations or financial involvement with any commercial organisation with a direct financial interest in the subject or materials discussed.

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