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A segregated-team model to maintain cancer care during the COVID-19 outbreak at an academic center in Singapore

COVID-19 IN SINGAPORE

On 11 March 2020, the World Health Organization (WHO) declared the coronavirus disease 2019 (COVID-19) outbreak a pandemic. Singapore was one of the first countries to receive imported cases of COVID-19 on 23 January 2020. Subsequently, local chains of transmission have set in, leading to Singapore having one of the highest number of COVID-19 cases outside of China in February 2020, before its rapid spread in South Korea, Europe, and the USA. The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), responsible for COVID-19, is closely related to the SARS-CoV which caused the SARS epidemic in 2003. As a consequence of SARS, Singapore set up a series of national prevention and response measures including the creation of a Disease Outbreak Response System Condition (DORSCON) (supplementary Table S1, available at Annals of Oncology online). On 7 February 2020, Singapore’s DORSCON level was escalated from yellow to orange signifying community transmission, triggering heightened surveillance, border control, containment protocols, and widespread contact tracing.

The National University Cancer Institute, Singapore (NCIS) is a comprehensive academic cancer center in Singapore, managing about 7000 outpatients and 450 inpatients per month in adult and pediatric hemato-oncology. The higher risk of COVID-19 complications in cancer patients required a coordinated effort to ensure business continuity while maintaining patient and staff safety. With this pandemic threatening to overwhelm health care systems globally, we aim here to share our experience with a segregated-team workflow in response to COVID-19, whilst maintaining the core activities of a comprehensive cancer center.

LEARNING FROM HISTORY: LESSONS FROM THE 2003 SARS OUTBREAK

Singapore’s experience of the SARS epidemic lasted 3 months from March 2003. During this period, 238 people were infected and 33 fatalities occurred in Singapore, five of whom were health care professionals. Infection and quarantine of health care workers caused a widespread disruption of patient care. Some 44% (12/27) of the current senior NCIS faculty were practicing during the SARS epidemic, bringing ‘institutional memory’ to this outbreak. Below are specific lessons that were considered vital to the business continuity operations of a cancer center during an outbreak:

- Staff need to be protected from infection risk and burnout due to manpower shortage from quarantine, necessitating drastic workflow changes.
- Limited resources and facilities for oncological care and infection control, including blood products, isolation rooms, and personal protective equipment (PPE) will be depleted during outbreaks, necessitating careful allocation or redesignation.
- The difficulty in identifying viral infection in cancer patients poses unique challenges to screening and in-hospital transmission; requiring distinct surveillance protocols from non-cancer patients.
- Workflows and policies evolve rapidly during an outbreak, requiring an adaptable framework for clinical care and therapeutic trials that can be escalated or de-escalated quickly in coordination with the hospital/nation.

2020 NCIS TEAM-SEGREGATION PANDEMIC STRATEGY

NCIS is located within the main campus of a 1000-bed public health care tertiary hospital, the National University Hospital (NUH), and interacts closely with other clinical departments and services in NUH. The guiding principle of the NUH response to DORSCON orange was to ensure staff and patient safety through team segregation and careful resource allocation. The NCIS COVID-19 business continuity plan, outlined below, was developed from this framework (Figure 1 and supplementary Table S1, available at Annals of Oncology online).

Clinical service

Segregated-team workflow. Central to the principle of business continuity is the need to minimize the loss of workforce. All NCIS staff (clinical and non-clinical) were segregated into two teams to ensure that whole departments were not quarantined in the event of an infection. Physicians’ leave was cancelled to maximize manpower resources. Physician subteams were further geographically confined to specific ward, outpatient, and office areas to minimize exposure and cross-contamination (supplementary Figure S1, available at Annals of Oncology online). Each outpatient sector had its own registration counter, triage, venipuncture service, consultation rooms, isolation rooms, and lavatories, to facilitate contact
tracing. In the cancer pharmacy, one team carried out dispensing of outpatient prescriptions and review of chemotherapy orders, while the other team compounded chemotherapy, managed investigational studies, and stored inventory (supplementary Figure S1, available at Annals of Oncology online). Each team at the radiotherapy treatment center comprised radiation oncologists, radiation therapists, physicists, nurses, and administrative staff. A smaller team of physicians was dedicated to cover an NCIS satellite center located 8 km away and cross-hospital transfer of staff was prohibited.

Community cancer services (e.g. home chemotherapy and nursing) were discontinued to consolidate manpower. Face-to-face meetings were cancelled, and all department meetings, including multidisciplinary tumor boards, were conducted on a secure video-conferencing platform.

**Resource conservation and allocation.** Reduction of patient volume was necessary to allow sustainability of a segregated-team model. In outpatients, non-resident referrals were stopped and appointments for patients on cancer surveillance...
were deferred. Telemedicine consults, home delivery of medications, and online payment was encouraged. Volunteer groups coordinated the delivery of maintenance chemotherapy to childhood leukemia patients residing outside of Singapore. For patients undergoing radiation therapy, hypofractionated treatments were favored, while specialized procedures such as stereotactic body radiotherapy, radiosurgery, and brachytherapy were limited. In the inpatient setting, cancer surgeries were allowed to proceed as planned but all non-cancer surgeries were postponed by 3 months. Hospital negative-pressure isolation rooms were reassigned to the pandemic team for COVID-19 suspected and confirmed cases. Due to an anticipated shortage of these rooms hospital-wide and the nursing complexity of hematopoietic stem cell transplant (HSCT) patients, low-risk suspected COVID-19 HSCT patients were kept in the HSCT unit high-efficiency particulate air-filtered single rooms with an antechamber. Non-HSCT hematology patients who were low-risk suspected cases for COVID-19 were admitted to neutral pressure isolation rooms, rather than negative pressure rooms, thereby preventing them from being exposed to other nosocomial infection sources. A nationwide blood product shortage resulted from social distancing practices, cancellation of mobile blood drives, and stringent donor screening. For cancer patients, blood stocks were conserved for emergency surgeries, active bleeding, and semi-elective cancer surgeries. Red cell and platelet transfusion were limited per patient and lower hemoglobin thresholds were accepted for asymptomatic patients.

Management of suspect cases and PPE conservation. In the outpatient setting, thermal scanner and questionnaire screening was carried out on all patients and visitors at two checkpoints within the hospital/medical center. A febrile patient or one meeting the Ministry of Health criteria for a suspect case was escorted to a cancer center isolation room for subsequent management (supplementary Figure S2, available at Annals of Oncology online). Each case was discussed with the on-call coronavirus consultant. All cancer patients admitted with confirmed or high-risk suspected COVID-19 were managed in a designated ward by the pandemic team, staffed by internal medicine physicians, with telemedicine support from hematology-oncology. This reduced the utilization of N95 masks and gowns in the cancer wards. All routine patient care was carried out using a surgical mask and meticulous hand-hygiene.

Research and education
Research staff (trial coordinators, data/regulatory affairs managers) were also segregated into two teams and followed similar protocols as the clinical teams. Our unit enrolls approximately 300 therapeutic trial patients each year. In line with our Institutional Central Research Office guidelines (supplementary Figure S3, available at Annals of Oncology online), therapeutic cancer studies continued as per protocol, provided this was not conducted in high-risk areas (i.e. isolation wards and intensive care units). Due to travel restrictions affecting overseas study subjects, options were explored to use laboratory tests in the subject’s home country, telemedicine consults, and courier of study medicines. Institutional ethics review boards and sponsors were forewarned about possible increases in protocol deviations during this period. Teleconferencing was utilized to continue academic activities including clinical trial monitoring, departmental meetings, and education. For example, blood cell morphology education continued via teleconferencing with the use of a digital microscope, while flow-cytometry teaching used screen-capture software for live gating.

Safety, welfare, and morale of staff
During the SARS epidemic, failure of control over nosocomial spread drastically increased levels of fear and anxiety amongst health care workers. Since then, all health care institutions conducted compulsory PPE training, N95 mask fitting, and yearly hand hygiene exercises for staff, in preparation for future outbreaks. Clear communication was also recognized to be key to minimizing uncertainty among staff. From the outset of the COVID-19 outbreak, senior hospital management gave daily email updates on the status of cases nationwide, modifications to workflow, and suspect case definition. NCIS staff were issued personal thermometers for twice-daily temperature recording. The threshold for COVID-19 testing in health care workers was low, and staff with respiratory symptoms or fever were given at least 5 days of medical leave. Crucially, staff morale

| Table 1. Outcome indicators monitored during workflow implementation and compared against historical monthly average in 2019 at the main NCIS campus |
|-----------------|-----------------|-----------------|
|                  | Average month in 2019 | Average from 10 February to 10 March at DORSCON orange |
| Outpatient clinic load | 6385 | 5222 |
| Outpatient clinic (total number of patients) | 572 | 518 |
| Number of first-visit consultations | 5813 | 4704 |
| Number of follow-up consultations | 77% | 76% |
| Chemotherapy/treatment chair utilization | NA | 1038 |
| Number of non-urgent patient appointments deferred by physician | 444 | 320 |
| Admissions to NCIS (total number of patients) | 70 | 34 |
| COVID-19 cases | 1 | 0 |
| Number of confirmed COVID-19 cases amongst NCIS patients | NA | 0 |
| Number of confirmed COVID-19 cases amongst NCIS staff | 145 | 202 |
| Research | 20 | 35 |
| Number of patients recruited on to clinical trials (total) | 125 | 167 |
| Number of patients recruited on non-interventional studies | 20 | 35 |

COVID-19, coronavirus disease 2019; DORSCON, Disease Outbreak Response System Condition; NCIS, National University Cancer Institute of Singapore; PCR, polymerase chain reaction.
was expected to be affected by the workload of team segregation, cancellation of leave, and enforced social distancing. Strategies to boost morale were therefore considered vital, and included sharing of appreciation messages, provision of refreshments, as well as the setup of a group chat to share anecdotes, information, and banter.

**Effect of workflow changes on cancer center activity**

Over a 1-month period during team segregation (Table 1), the average monthly outpatient clinic load dropped by 20%, mostly due to deferment of non-urgent visits. The utilization rate of chemotherapy chairs, average waiting time for new consults and to start treatment were similar. The total number of admissions decreased by 30%. A total of 70 COVID-19 test kits were used; 74% (52/70) in the outpatient and 26% (18/70) in the inpatient setting. A total of 34 patients were admitted due to suspected SARS-CoV-2 during this period, with only one confirmed case that required mechanical ventilation in the intensive care unit. Clinical trial recruitment was unaffected (Table 1).

**DISCUSSION**

Several factors unique to Singapore’s situation facilitated the NCIS approach: its small size, a well-structured public health system, and exceptional contact tracing. Public hospitals in Singapore are integrated with the national DORSCON system, and exceptional contact tracing. Strong leadership and rapid communication ensured quick flow changes on cancer center activity. 

While the overall principles are similar to those reported by colleagues in the USA and UK, the concept of center-wide team segregation is central to our approach and was guided by our experience from the 2003 SARS epidemic. In the last 6 weeks we have had an opportunity to stress-test this model. We show that despite COVID-19 community transmission, the segregated team model allowed the continuation of cancer care and clinical trials, and may be replicable in other similar centers globally. While the exact workflow will be center-specific, we hope that the principles of the segregated team approach described here may provide a modifiable framework for local strategy planners in cancer centers at high risk for COVID-19 transmission.

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