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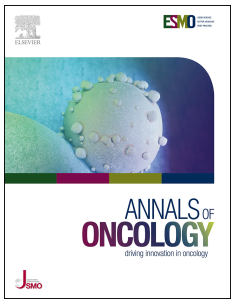

A segregated-team model to maintain cancer care during the COVID-19 outbreak at an academic center in Singapore

Natalie Ngoi, Joline Lim, Samuel Ow, Wei Ying Jen, Matilda Lee, Winnie Teo, Jingshan Ho, Raghav Sundar, Moon Ley Tung, Yee Mei Lee, Ednajoy Ngo, Siew Woon Lim, Jason Ong, Frances Lim, Glenn Bonney, Balamurugan Vellayappan, Francis Ho, Jeremy Tey, Noreen Chan, Sanjay de Mel, Michelle Poon, Shir Ying Lee, Liang Piu Koh, Te Chih Liu, Lip Kun Tan, Alvin Wong, Andrea Wong, Siew Eng Lim, Allen Yeoh, John EL. Wong, David Tan, Boon Cher Goh, Wee Joo Chng, Ross Soo, Cheng Ean Chee, Yen Lin Chee, Soo Chin Lee, Anand D. Jeyasekharan, for the National University Cancer Institute, Singapore (NCIS)

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

The National University Cancer Institute of Singapore (NCIS) Workflow Team

(Full author list in the appendix)

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Appendix 1 (Full author list)

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1. COVID-19 in Singapore

On 11 March 2020, the World Health Organization (WHO) declared the coronavirus disease 2019 (COVID-19) outbreak a pandemic[1]. Singapore was one of the first countries to receive imported cases of COVID-19 on 23 January 2020[2,3]. 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, prior to its rapid spread in South Korea, Europe and the United States (US). The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) responsible for COVID-19 is closely related to the SARS-CoV[4] 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[5] (DORSCON) (Supplementary Table 1). 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 Haemato-Oncology. The higher risk of COVID-19 complications in cancer patients[6] required a coordinated effort to ensure business continuity while maintaining patient and staff safety. With this pandemic threatening to overwhelm healthcare 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.

2. Learning from history: lessons from the 2003 SARS outbreak

Singapore's experience of the SARS epidemic lasted three months from March 2003[7]. During this period, 238 people were infected and 33 fatalities occurred in Singapore, five of whom were health care professionals[8]. Infection and quarantine of healthcare workers caused a widespread disruption of patient care. 44% (12 of 27) of 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:

a. Staff need to be protected from infection risk and burnout due to manpower shortage from quarantine, necessitating drastic workflow changes

b. Limited resources and facilities for oncological care and infection control, including blood products, isolation rooms and PPE will be depleted during outbreaks, necessitating careful allocation or re-designation
c. 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
d. 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.

3. 2020 NCIS team-segregation pandemic strategy

NCIS is located within the main campus of a 1000-bed public healthcare 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 1).

3.1 Clinical service

3.1.1 Segregated-team work flow

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 sub-teams were further geographically confined to specific ward, outpatient and office areas to minimize exposure and cross-contamination (Supplementary Figure 1). 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 performed dispensing of outpatient prescriptions and review of chemotherapy orders, while the other team compounded chemotherapy, managed investigational studies and stored inventory (Supplementary Figure 1). 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 8km 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.

3.1.2 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 delivery of maintenance chemotherapy to childhood leukemia patients residing outside of Singapore. For patients undergoing radiation therapy, hypo-fractionated 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 three 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 (HEPA)-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.

3.1.3 Management of suspect cases and personal protective equipment (PPE) conservation

In the outpatient setting, thermal scanner and questionnaire screening was performed 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 2). 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 performed using a surgical mask and meticulous hand-hygiene.

3.2 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 3), 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.

3.3 Safety, welfare and morale of staff

During the SARS epidemic, failure of control over nosocomial spread drastically increased levels of fear and anxiety amongst healthcare 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 healthcare workers was low, and staff with respiratory symptoms or fever were given at least five days of medical leave. Crucially, staff morale 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.

4. Effect of workflow changes on cancer center activity

Over a one-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. 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).

5. 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, providing clarity on triggers for change to workflow. Strong leadership and rapid communication ensured quick implementation of protocols and changes. However, the long-term feasibility of these workflows is unknown. The impact of COVID-19 on treatment and outcomes of patients with cancer, patients' perspectives, the psycho-emotional impact on healthcare workers, and economic repercussions are important areas of future research.

While the overall principles are similar to those reported by colleagues in the US[9] and United Kingdom[10], 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 six 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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Figure 1: Principles underlying the NCIS pandemic approach

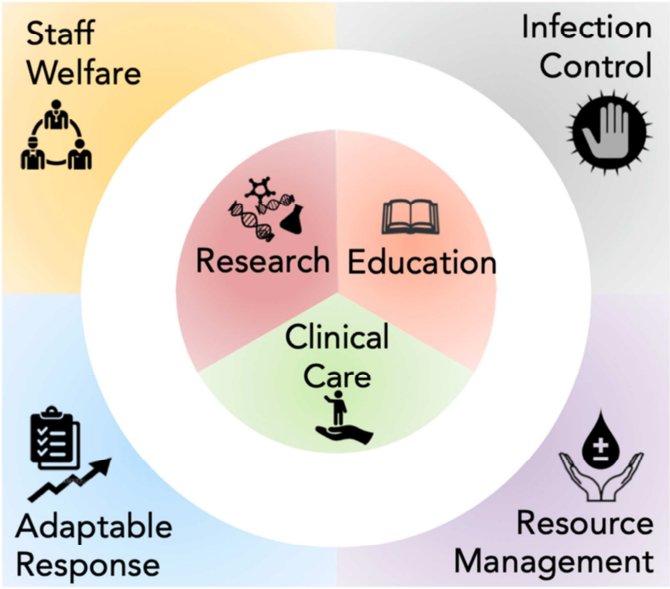

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Table 1: Outcome indicators monitored during workflow implementation and compared against historical monthly average in 2019 at the main NCIS campus

	Average month in 2019	Average from 10 Feb – 10 Mar at DORSCON orange
OUPATIENT CLINIC LOAD		
Outpatient clinic (total number of patients)	6385	5222
Number of first-visit (FV) consultations	572	518
Number of follow-up consultations	5813	4704
Chemotherapy/ treatment chair utilization	77%	76%
Number of non-urgent patient appointments deferred by physician	NA	1038
INPATIENT		
Admissions to NCIS (total number of patients)	444	320
COVID-19 -RELATED PROCEDURES AND ADMISSIONS		
Number of COVID-19 PCR swabs taken	NA	70
Number of admissions for suspected COVID-19 cases	NA	34
Number of confirmed COVID-19 cases amongst NCIS patients	NA	1
Number of confirmed COVID-19 cases amongst NCIS staff	NA	0
RESEARCH		
Number of patients recruited onto clinical trials (total)	145	202
Number of patients recruited on interventional studies	20	35
Number of patients recruited on non-interventional studies	125	167

DORSCON: Disease Outbreak Response System Condition; FV: first-visit; PCR: polymerase chain reaction

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Supplementary Material

Supplementary Table 1: Key workflow alterations according to DORSCON status

DORSCON status		GREEN *Immediate health impact to Singapore is expected to be low*	YELLOW *Public health impact to Singapore local population is low to moderate*	ORANGE *Public health impact to Singapore local population is moderate to high where evidence of local transmission has taken place, and there is a risk of community spread*	RED *Public health impact to Singapore local population is high where there is, or potential of, widespread and sustained community outbreaks*
Trigger to move to this level		• Reports of cases in a country with high travel connectivity to Singapore, but no evidence of sustained community transmission • Imported confirmed cases without local transmission	• Community spread reported overseas but not in Singapore • Imported cases with limited local spread, beyond quarantined contacts	• Community spread • Late detection of imported case, with 2 or more subsequent generations of transmission **OR** • Detection of 1 or more cases without travel history or links to known cases	• Widespread local transmission in Singapore • Unlinked cases (multiple) outside healthcare setting **OR** • Rate of increase in numbers of new cases.
Population of interest	Outpatient visits	Routine screening[a]	Routine screening[a]	• Enhanced screening[b] • Early isolation of patients with fever / respiratory symptoms with review by dedicated medical team • Re-scheduling of non-essential appointments • Option of Tele-medicine and Home-Delivery service	• Stringent reduction of non-essential clinical visits • Reduction in clinic sessions • Routine use of Tele-medicine and Home-Delivery services • Consider alternative ambulatory treatment protocols[f]
	In-patient	No change	No change	• Rapid identification of suspected COVID-19 cases for isolation under Pandemic Service, tele-consult provided to managing Internist team	• No inpatient chemotherapy • Potentially merge Hematology-Oncology service with medical disciplines
	Visitor	No change	No change	• Restrict to 1-2 visitors • Temperature screening	• No visitors in outpatient setting[g],

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					• Restrict to 1 visitor in inpatient setting
Research studies	Direct impact on patient care[c]	No change	No change	• New studies can commence[d] • Schedule of assessments as per protocol[d]	• Follow MOH guidance • Consult RO • Consider options to ensure subject and staff safety is not compromised
	Direct impact on patient care (high risk)[e]	No change	No change	• Consider suspension of research • Seek approval from RO • Minimize staff involved in these areas • Staff appropriately trained in infection control and PPE	
	No direct impact on patient care	No change	No change	• Assessment by PI and sponsor • Suspend or reduce new subject recruitment for ongoing studies • Hold new studies	
	Non-interventional studies	No change	No change	• No change[d]	

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Healthcare Professionals	Medical staff/ nursing staff etc	No change	No change	• Temperature taking twice-daily • Splitting and segregation of teams • Dedicated staff to assess the febrile patient • Non-essential leave disallowed • Meetings to be conducted remotely	• Further segregation of Inpatient-only and outpatient only split teams with alternating work-home rotations every week • Restricted movement of staff between hospital sectors • All leave disallowed

The Disease Outbreak Response System Condition (DORSCON) levels represent an ascending order of health risk estimated to be posed to Singapore by an infectious disease outbreak. The department manpower deployment plan is calibrated to each level of health risk. Adapted from https://www.gov.sg/article/what-do-the-different-dorscon-levels-mean. *Disease Outbreak Response System Condition, DORSCON; Ministry of Health, MOH; Personal protective equipment, PPE; principal investigator, PI; research office, RO*

a. Recent travel history to Middle East and potential exposure to the Middle East Respiratory Syndrome Coronavirus (MERS-CoV)
b. Screening measures at the outpatient clinics include increased temperature control checkpoints, and suspect case definition criteria updated routinely according to the Ministry of Health (www.moh.gov.sg/covid-19)
c. Research not in high-risk area, which is defined as EMD, ICU, pneumonia wards, isolation wards
d. Unless otherwise advised by MOH and NUHS
e. High risk area is defined as is defined as EMD, ICU, pneumonia wards, isolation wards
f. such as oral formulations, subcutaneous in place of infusional therapy to reduce risk of exposure
g. May allow one visitor to accompany patient under special circumstances (language barrier, mobility issues)
h. Stricter measures in addition to ORANGE workflow

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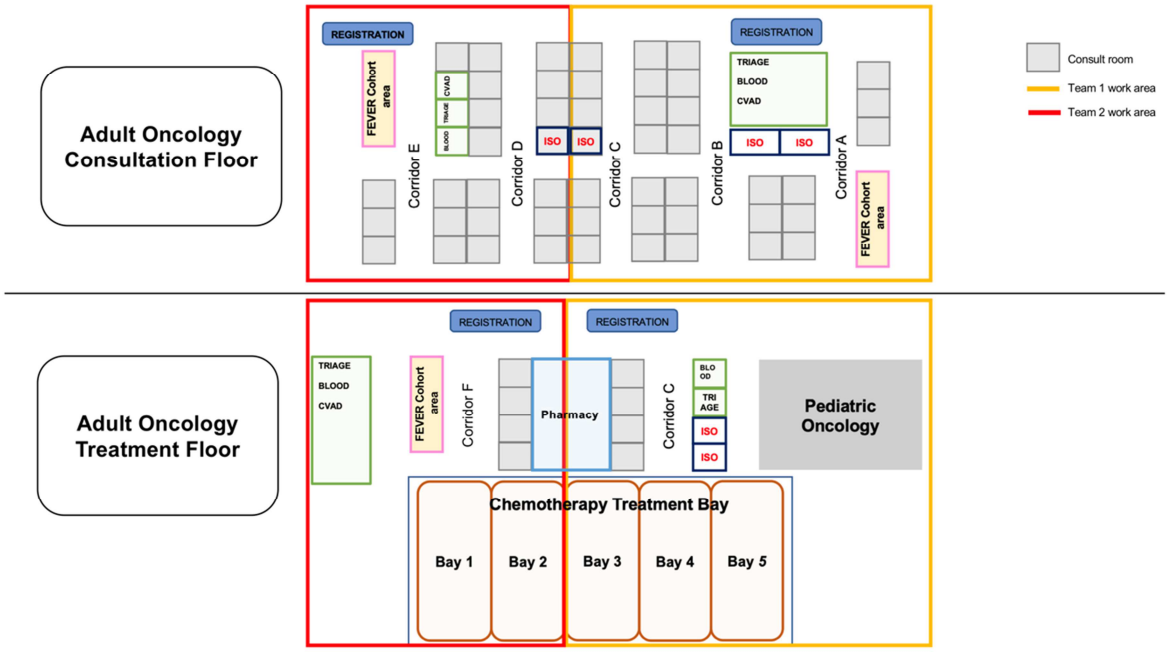
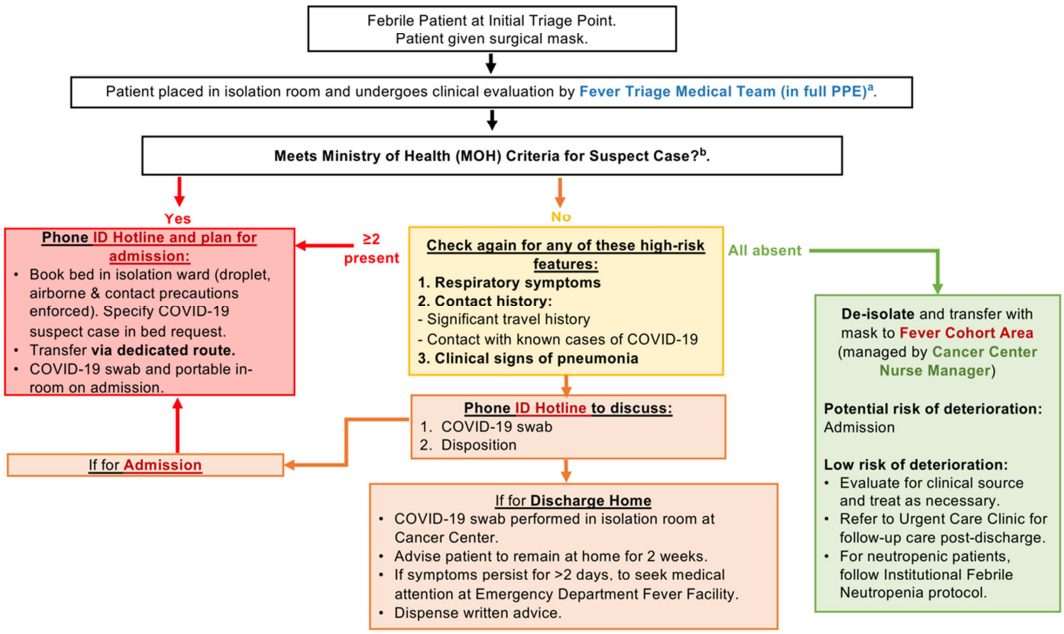
Supplementary Figure 1: Depiction of the re-organization of the cancer center and treatment areas in order to facilitate daily work in the segregated-team model



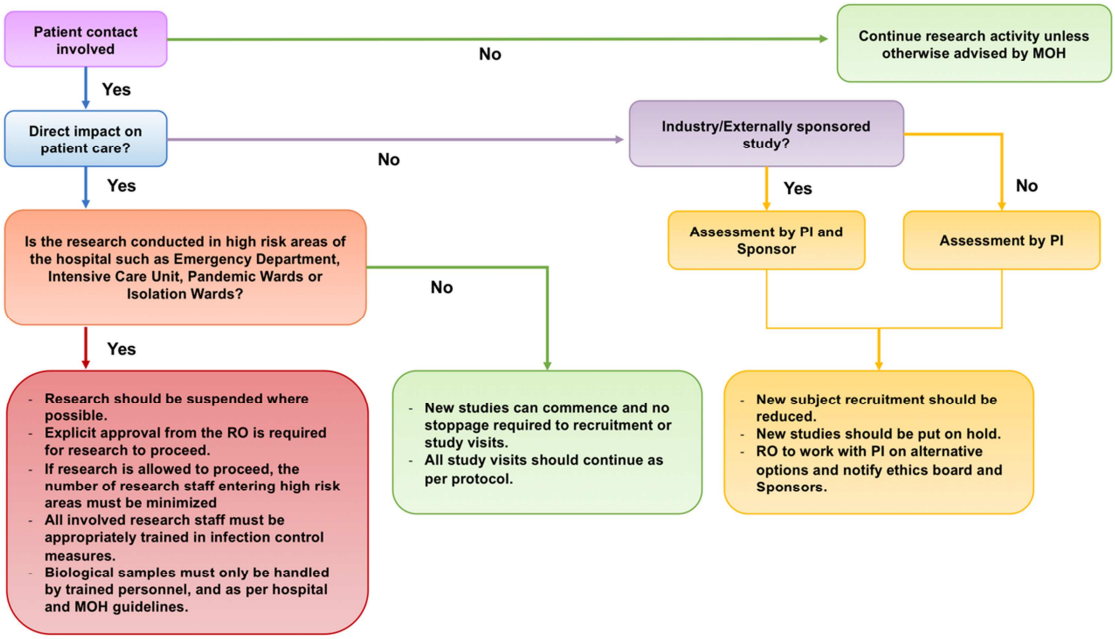
On all floors of the Cancer Center, separate geographical sections were demarcated with physical barriers for separate staff teams. *CVAD: Room for central venous access device care; TRIAGE: Room for nursing triage; BLOOD: Room for venipuncture; ISO: Isolation room.*

Supplementary Figure 2: The management of patients presenting with fever in outpatients



Patients with fever at triage are given a surgical mask and placed in an isolation room immediately and reviewed by the fever triage medical team in full personal protective equipment. If the MOH suspect case definition criteria is met (www.moh.gov.sg/covid-19), the case is escalated to the infectious diseases (ID) consultant on call and is admitted. If the patient does not meet clinical suspect case definition criteria, but still has other suspicious symptoms or contact history, further management is discussed with ID. [a]Full PPE is comprised of goggles, N95 mask, gloves and full gown. [b]Criteria are evolving and is updated as per ministry of health guidelines (www.moh.gov,sg/covid-19). *MOH: ministry of health; ID: infectious diseases*.

Supplementary Figure 3: Guide to research activities depending while health risk DORSCON level is at Orange



Research that is not conducted in high risk areas of the hospital, and which have direct impact on patient care are prioritized. Adapted from National University Health System Research Office guideline. *MOH: ministry of health; RO: research office; PI: principal investigator*.

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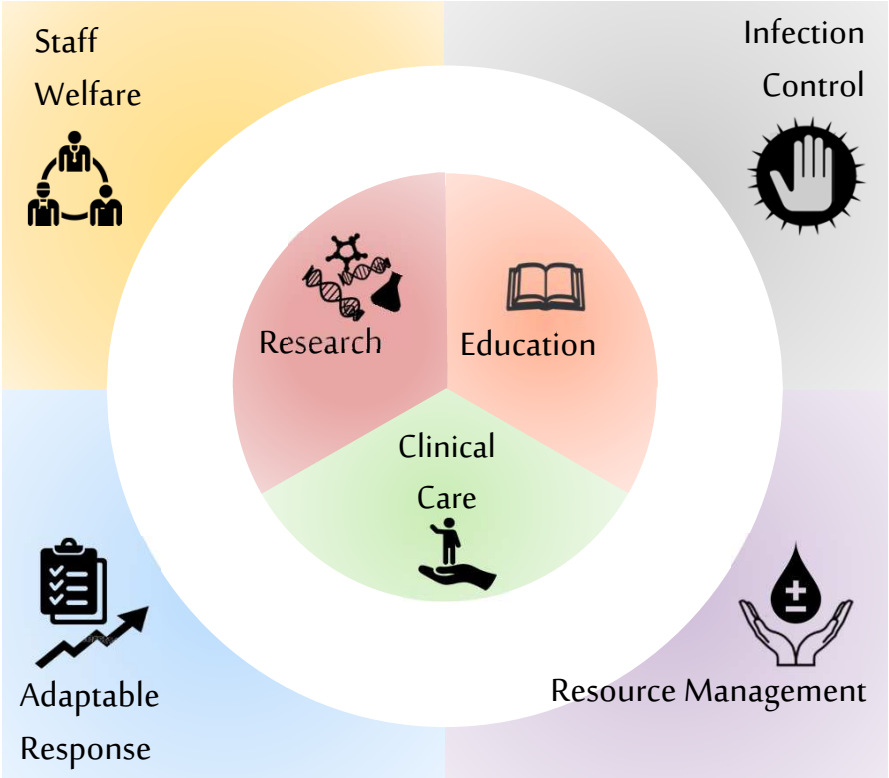

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