COVID-19 Monitoring and Response for Military Bases in Singapore—Perspectives and Lessons From January to June 2020

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ABSTRACT
Introduction: Military forces around the world face an increased risk of the spread of communicable diseases, due to the close living quarters and congregated nature of the military camps. The Singapore Armed Forces (SAF) implemented a multi-pronged surveillance and containment strategy to reduce the risk of a coronavirus disease 2019 (COVID-19) outbreak within the local military camps. This paper details the epidemiological investigations of the COVID-19 cases in the SAF and highlights the strategies and public health measures undertaken, aligned with the national COVID-19 control strategy, to reduce the risk of COVID-19 transmission in the military camps.

Materials and Methods: Medical data of our military personnel who were infected with COVID-19 during the first 180 days of the pandemic were extracted from the military electronic health records. Contact tracing and activity mapping results were obtained from unit-level epidemiological data. A review of the organization’s response plans, instructions, and orders was conducted to collate the measures implemented across the same time period.

Results: Prompt contact tracing and activity mapping was done for each of the 24 SAF military personnel diagnosed with COVID-19 between February 2020 and June 2020, with possible links among the cases identified and investigated.

Conclusion: A combination of strategies in the formulation of public health measures based on key principles of early warning and surveillance, prompt diagnosis, and early containment were successful in preventing the formation of COVID-19 clusters within the SAF. This will provide a framework for the management of future pandemics within the military setting, driven by strong governance and leadership, to meet the military’s need to maintain operational readiness in a safe manner.

INTRODUCTION
On December 31, 2019, China reported a cluster of cases of atypical pneumonia in Wuhan, Hubei,1,2 subsequently identified as coronavirus disease 2019 (COVID-19). Singapore shifted its public health level to Disease Outbreak Response System Condition (DORSCON) Yellow on January 213 and confirmed its first imported case of COVID-19 on January 23.4 As the number of local unlinked cases began to rise, Singapore shifted the Whole-of-Government response to DORSCON Orange on February 7,5 adopting the “Alert” (early detection to minimize importation of COVID-19) and “Containment” (measures to limit the domestic spread of disease) disease response phases.6 A national multipronged surveillance and containment strategy was implemented.7 Case definitions, which were updated as the pandemic unfolded, were applied at all medical consults with mandatory testing implemented for individuals who fulfilled the case definition. Doctors were given the discretion to perform diagnostic testing based on their clinical or epidemiological suspicion for patients who did not meet the prevailing case definition. In addition, enhanced surveillance with testing were implemented among different population groups who were of a higher risk of COVID-19 infection, including community care patients with pneumonia or influenza-like illnesses, patients in intensive care units, or deaths with possible infectious etiologies. Testing and surveillance were also implemented for other high-risk individuals such as those arriving at air, land, and sea borders.5 COVID-19-positive cases identified were isolated at dedicated facilities, and active contact tracing and quarantining of close contacts were carried out for all COVID-19 cases. Other public health measures such as travel declarations, temperature screening, social distancing, and regular health monitoring were introduced.5,8 Mask wearing was also mandated by law.9 Additionally, a “circuit-breaker” from 8 April to 1 June10 – during this period all non-essential services were suspended, and companies had to provide for work-from-home arrangements. A travel ban on all tourists and short-term visitors entering Singapore was also introduced.

While non-essential services could be suspended and work from home could continue, the military had to maintain its
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FIGURE 1. Epidemiological curve of military personnel diagnosed with coronavirus disease 2019 (COVID-19; n = 24). Epidemiology curve showing the incidence and cumulative incidence of COVID-19 cases within the military from February 2020 to June 2020.

operational readiness. COVID-19 is highly transmissible, and military forces around the world face an increased risk of the spread of communicable diseases, as soldiers are often housed together in close quarters, share communal facilities, and engage in en masse training and related activities. In the Singapore context, our military personnel mostly live in the general community, except for trainees who are housed on military installations and return to their homes in the general community during weekends. Meals are provided and consumed on base for those housed in military installations, increasing the interactions between personnel across functional units. This paper details the epidemiological investigations of the COVID-19 cases in the Singapore Armed Forces (SAF) during the first 180 days of the COVID-19 pandemic and highlight the SAF’s public health response framework of early warning and surveillance, prompt diagnosis, and containment, which helped prevent the formation of COVID-19 clusters within the military and ensured that the military can function normally and safely during the pandemic.

METHODS

Medical data of our military personnel who were infected with COVID-19 during the first 180 days of the pandemic were extracted from the military electronic health records. Contact tracing and activity mapping results for each of the COVID-19 cases were obtained from the various unit-level epidemiological data, and a review was done for possible linkages. Cases that were possibly linked were further analyzed by the team. A review of the organization’s response plans, instructions, and orders was conducted to collate the measures implemented across the same time period.

RESULTS

As of end of June 2020, there were approximately 43,000 COVID-19 cases in Singapore. During the same period from end of January to end of June 2020, a total of 24 SAF military personnel were diagnosed with COVID-19 (Fig. 1) of which 9 cases were based overseas and were excluded from the scope of this paper. All 15 local cases were initially hospitalized in dedicated isolation wards of tertiary hospitals upon diagnosis of COVID-19. As the military population is generally young with no significant premorbid conditions, all the cases had mild infection of COVID-19 with no further complications and had since been discharged without any known morbidity (Table S1).

Most of the COVID-19 cases in the SAF (Table S1) were discharged upon two consecutive negative PCR tests for COVID-19 on nasopharyngeal samples taken 24 hours apart. Case 2 was PCR positive for COVID-19 at the end of 61 days of hospitalization but was assessed to be non-infectious and was discharged after the test-based discharge criterion was revised by Ministry of Health (MOH) to a time-based discharge criterion on May 28, 2020.

Detailed epidemiological investigations and contact mapping were performed for all the COVID-19 cases in the military. There were no known COVID-19 outbreak clusters within the SAF. Details of two groups of cases, for which there were suspected epidemiological linkages, are elaborated on in this section (Figs. 2 and 3).

Case 3 and case 4 took part in the same training course involving approximately 30 personnel within a classroom setting during the period from March 23 to March 25. Measures such as daily temperature screening with symptom and travel declarations were in place during the training course. The policy on mask wearing had not yet been implemented, and
FIGURE 2. Timeline of events for case 3 and case 4. Case 3 and case 4 attended a common training course from March 23 to March 25. Both were asymptomatic. On March 28, case 3 developed symptoms and was diagnosed with coronavirus disease 2019 (COVID-19) on April 1. Case 4 developed symptoms on March 29 and was diagnosed with COVID-19 on April 4. There was no evidence of transmission between the cases and did not constitute a cluster.

FIGURE 3. Timeline of events for case 5 and case 6. Case 5 and Case 6 were involved in a common training activity from March 23 to March 31. Case 5 developed symptoms on the last day of the training activity in camp (March 31) and was diagnosed with coronavirus disease 2019 (COVID-19) on April 4. Case 6 was identified as a close contact of case 5 and developed symptoms on April 5. He was diagnosed with COVID-19 on April 6. No further cases were diagnosed and the two cases did not constitute a cluster.

Both case 3 and case 4 had no prior travel history outside of Singapore and were noted to be well during the training course. Both case 3 and case 4 did not report any direct interaction with each other during the course. Case 3 developed respiratory symptoms on March 28, 3 days after the course while she was at home. She visited a community primary care clinic, was attended to by the doctor, and was given medical leave to rest at home. Subsequently, she developed anosmia on March 30 and self-presented to the emergency department on March 30. She was diagnosed with COVID-19 on April 1 and hospitalized on the same day. Case 4 developed respiratory symptoms at home on March 29. He visited a community healthcare doctor on the same day (March 29) and was given medical leave to rest at home. He presented to the Emergency Department on April 3 due to persistent symptoms and was tested for COVID-19. He was confirmed as a positive case for COVID-19 on April 4 and was hospitalized on the same day. Both case 3 and case 4 did not enter the military camp after the onset of symptoms.

Contact tracing and activity mapping were immediately undertaken for both cases. All identified close contacts were informed and served quarantine orders for a total...
duration of 14 days. Although case 3 and case 4 were found to be linked to the same training course, there was no evidence of transmission between both cases as the period of the training course did not fall within the window of infectivity for COVID-19. No further cases were linked to the training course, and the Contact Tracing Center at MOH did not consider the cases to constitute a cluster.

Case 5 and case 6 were involved in common training activities occurring in a military camp from March 23 to March 31 comprising approximately 40 personnel. Measures such as daily temperature screening with symptom and travel declaration were in place during the training course. The policy on mask wearing was not implemented yet and military personnel involved in the course were not wearing masks.

Both case 5 and case 6 had no prior travel history outside of Singapore in the past 14 days and were noted to be well during the training course. Case 5 developed respiratory symptoms on the last day of training, while in the military camp, on March 31. He reported his symptoms to a military doctor at the camp’s medical center and was given 5 days of medical leave to rest at home. Subsequently, he developed anosmia on April 3. He presented to a community primary care clinic on April 3 and was tested for COVID-19 on that same day. He was confirmed as a positive case for COVID-19 on April 4 and was hospitalized on the same day.

Contact tracing and activity mapping were promptly undertaken for case 5. Due to the enclosed nature of a training room and considerations regarding the common ventilation system within the compound, a more sensitive contact tracing definition was adopted. All personnel who were in the same premise in the same time period as case 5 were classified as close contacts. Twenty-six personnel, including case 6, were served quarantine orders for a total duration of 14 days on April 5. Case 6 subsequently developed symptoms during his quarantine period on the night of April 5 and presented to the hospital Emergency Department on the same day. He was tested for COVID-19 on April 5 and was confirmed positive for COVID-19 on the next day and hospitalized. There were no further cases linked to case 5 and case 6, and the Ministry of Health’s Contact Tracing Center did not consider the cases to constitute a cluster.

**DISCUSSION**

Data showing the potential spread of COVID-19 in congested settings highlight the potential risk of widespread COVID-19 transmission within a military setting. While the success of the SAF’s measures in maintaining a low incidence of COVID-19 cases within the military camps reflects the strength of our multi-pronged surveillance and containment strategy to reduce the risk of a COVID-19 outbreak, the success of our efforts was also highly dependent on the robustness of the public health measures taken at the national level. We will elaborate on how the public health measures taken by the SAF interplay with the broader national COVID-19 pandemic strategy and when combined were highly successful in controlling the spread of COVID-19 in our military camps.

Singapore was well-known for having one of the most robust surveillance systems with strong capabilities in epidemiological investigations and aggressive contact tracing measures during the COVID-19 pandemic. The SAF benefited from this strong public health environment and benchmarked our response plans with the national level plans, where COVID-19-positive cases were quickly identified, isolated, and close contacts ringfenced to minimize risk of transmission into and within the military camps. The SAF’s pandemic response plans, policies, and measures were strongly aligned with Singapore’s multi-pronged surveillance and containment strategy, and the SAF adapted quickly to changes in the national policies and guidelines. The SAF’s public health and pandemic response policies and measures can be categorized into four broad phases: early warning and surveillance, early diagnosis, early containment, and maintaining operational readiness and force protection.

**Early Warning and Surveillance**

Early warning and surveillance in the SAF were achieved primarily through digital surveillance and passive surveillance. Digital surveillance consists of regular monitoring of the global situation and emerging threats through reputable sources in the global news network. Passive surveillance relies heavily on military camp medical centers and ground units to raise alerts when there were suspected or diagnosed cases of COVID-19 within the SAF. Early on in the COVID-19 pandemic, the digital surveillance system flagged up early warning signs of the emerging COVID-19 pandemic. The SAF then promptly began to prepare and exercise its pandemic preparedness contingency plans, developed and refined from the previous 2003 Severe Acute Respiratory Syndrome (SARS) and 2009 Influenza A (H1N1) outbreaks.

**Early Diagnosis**

Healthcare provision in the SAF was achieved through a network of medical centers located within each military camp, which were also the frontlines of the COVID-19 pandemic response. Definitions on SAF COVID-19 suspect case criteria for the medical centers were continuously updated and adjusted in line with the national guidelines promulgated by
MOH. The clear communication of operational and clinical guidelines and updated suspect case criteria allowed the medical centers to swiftly risk-stratify symptomatic military personnel and identify those who may be of a higher risk of COVID-19 infection. All military personnel were required to declare their travel history, as well as conduct twice-daily symptom declaration and temperature-taking. This provided both a subjective and objective reassurance of health. The SAF had also built up and developed COVID-19 testing capabilities in partnership with DSO National Laboratories, which allowed the camps’ medical centers to perform nasopharyngeal swabs testing with a quick turnaround time for diagnostic confirmation of COVID-19 infection via PCR testing.

**Early Containment**

Suspect cases who were awaiting test results were provided with a mandatory 5-day medical leave, to mitigate the risk of COVID-19 spread within the military camps. Commanders were trained in contact mapping, which involves identifying the close contacts of the suspect cases from up to 2 days before symptom onset of the suspect case. A ring-fencing strategy, aimed to reduce the risk of potentially infected personnel transmitting the disease to the rest of the camp, was adopted for the management of the close contacts of the suspect cases. Temporary movement restrictions, as part of the ring-fencing strategy, was put in place for the identified close contacts to ring-fence them from the rest of the personnel in the military camp. Ring-fenced military personnel would be provided dedicated facilities and accommodation areas, separate toilets, and have their meals in dedicated dining areas. Pre-emptive measures such as daily temperature taking, health and symptom monitoring, as well as decontamination of living and shared training spaces were in place for these ring-fenced personnel.

Commanders were also involved in contact tracing for SAF COVID-19 cases. The contact tracing process would be initiated by MOH to identify close contacts of a newly confirmed case, who would then be served quarantine orders. Commanders were able to draw from their institutional knowledge of the military setting, to help facilitate and augment the national contact tracing efforts of cases involving military personnel.

**Maintaining Operational Readiness and Force Protection**

Safe distancing measures of at least 1 meter between military personnel within camps were instituted. Cohorting measures were introduced whereby units split into multiple sub-groups, known as “functional groups.” As interaction between functional groups was restricted, this would reduce the susceptible population within the force that would be affected, should a particular personnel become infected with COVID-19. Within the military camp, reporting hours and meal times were staggered to avoid congregation of different units within common areas in the military camps. Where possible, military personnel were also required to work from home, so as to minimize the volume of commuters on public transport, the amount of social contact from workplace, and risk of transmission from both large and mid-sized gatherings.

Military personnel were required to maintain high levels of personal hygiene, including regular handwashing and wiping down of common surfaces in communal facilities such as cookhouses, stairwells, and elevators. Military personnel were required to wear face masks, in line with the national policy on mask wearing, to reduce the risk of transmission from asymptomatic and pre-symptomatic cases.

Interactions in these communal settings and mixing between various functional groups of military personnel were minimized so as to reduce the risk of widespread COVID-19 transmission.

Non-essential training activities were also suspended at a time of significant community transmission in April. Of note, at the height of the pandemic, the Basic Military Training start phase was adjusted for one batch of newly enlisted military personnel (four intakes per year), for safety concerns over an increased risk of importation of COVID-19 cases from the community into the military setting, so as minimize the risk of COVID-19 transmission and outbreaks among our military training institutes.

In order to maintain the operational readiness of the military, essential training and key operations have to continue on despite the pandemic, while putting in place safe-distancing and cohorting measures highlighted earlier to reduce potential transmission into and within the military camps. In addition, military personnel involved in these essential operations were required to undergo a period of pre-isolation (from the wider Singaporean community) in the military camps before commencement of duties, so as to minimize possible importation and transmission of COVID-19. PCR testing and active surveillance with the COVID-19 testing were also conducted for these military personnel to ensure that they were not infected before assuming their operational duties. The selection criteria for PCR testing for these personnel were also reviewed and made more permissive, to reflect the low-risk threshold and facilitate case detection. Servicemen with acute respiratory infection symptoms were also instructed to seek medical attention immediately, so as to facilitate early removal from the cohort and mitigate the risk of potential spread of disease within military camps.

The SAF’s strategies detailed above required strong governance to put forth a concerted effort in the communication, implementation, and enforcement of the public health measures. Segal et al. and Steele et al. described the importance of governance as key factors in early detection and control of infectious diseases outbreak. The organizational structure and strong military leadership within the SAF allowed for timely and accurate dissemination of medical directives and protocols within each unit, and changing policies were quickly communicated and complied with. This was
further achieved with the help of military commanders in position of authority, which facilitated the communication of the intent of the SAF’s leadership and the public health policies.

LIMITATIONS
There are two main limitations to the findings in this paper. First, with evidence of asymptomatic and pre-symptomatic transmission of COVID-19, as well as the presence of a serial interval,19,23,24 asymptomatic or pre-symptomatic transmission may have occurred among the contacts of these groups of cases that were not detected from symptom screening. Fortunately, all SAF cases were identified early and contained with no further cases identified among the close contacts, making asymptomatic secondary transmission within these cases unlikely. Second, the policies implemented were in the context of a highly resourced and rules-based organization comprising of military personnel that could be easily mobilized for response operations. This allowed for effective implementation and adherence to strict movement restrictions, including additional periods of isolation away from the community of 14 days within the military camps. The success of the public health measures in this population may not be reproducible in other settings.

CONCLUSION
The COVID-19 pandemic had brought about unprecedented challenges for many countries and unique challenges for military forces as they do their best to balance the need to maintain operational readiness while ensuring force health protection. The successes achieved by the SAF in maintaining the low incidence of COVID-19 cases at the start of the pandemic was through strict control measures derived from key principles of early warning and surveillance, prompt diagnosis, early containment, and maintenance of operational readiness. These are valuable lessons learnt to help with the formulation of future pandemic responses for the SAF, which would be valuable for future generations and other militaries or similar organizations.

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SUPPLEMENTARY MATERIAL
Supplementary material is available at Military Medicine online.

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CONFLICT OF INTEREST STATEMENT
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