

Title. Responding to the COVID-19 outbreak in Singapore: Staff Protection and Staff Temperature and Sickness Surveillance Systems

Authors. Htet Lin Htun MPH,¹ Dwee Wee Lim MPH,^{1,2} Win Mar Kyaw MPH,¹ Wan-Ning Janis Loh MCom,¹ Lay Tin Lee MSc (OM),² Brenda Ang MPH,³ and Angela Chow PhD.¹

Affiliations.

1. Department of Clinical Epidemiology, Office of Clinical Epidemiology, Analytics, and Knowledge (OCEAN), Tan Tock Seng Hospital, Singapore, 308433 Singapore.
2. Occupational Health Services, Tan Tock Seng Hospital, Singapore, 308433 Singapore.
3. Department of Infectious Diseases, Tan Tock Seng Hospital, Singapore, 308433 Singapore.

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Corresponding author. Angela Chow, Department of Clinical Epidemiology, Office of Clinical Epidemiology, Analytics, and Knowledge (OCEAN), Tan Tock Seng Hospital, 11 Jalan Tan Tock Seng Singapore, 308433 Singapore. Tel: +65-63577477; Fax: +65-63577465; E-mail: angela_chow@ttsh.com.sg

Main point. A robust staff protection and health surveillance system that is routinely implemented can be quickly enhanced and customized for specific emerging infectious diseases, and rapidly deployed during outbreaks, to protect staff from nosocomial infections.

ABSTRACT

Background. Coronavirus disease 2019 (COVID-19) is an emerging infectious disease caused by novel coronavirus (SARS-CoV-2), and first reported in Wuhan, China, in December 2019. Since the severe acute respiratory syndrome (SARS) outbreak in 2003, Tan Tock Seng Hospital (TTSH) in Singapore has routinely fit-tested staff for high filtration N95 respirators, and established web-based staff surveillance systems. The routine systems were enhanced in response to Singapore's first imported COVID-19 case on January 23,2020.

Methods. We conducted a cross-sectional study, from January 23,2020 to February 23,2020, among healthcare workers to evaluate the effectiveness of the staff protection and surveillance strategy in TTSH, a 1600-bed multidisciplinary acute-care hospital co-located with the 330-bed National Centre for Infectious Diseases (NCID). As of February 23,2020, TTSH/NCID has managed 76% of confirmed COVID-19 cases in Singapore. The hospital adopted a multi-pronged approach to protect and monitor staff with potential COVID-19 exposures:(1) Risk-based personal protective equipment, (2) Staff fever and sickness surveillance, and (3) Enhanced medical surveillance of unwell staff.

Results. A total of 10,583 staff were placed on hospital-wide fever and sickness surveillance, with 1,524 frontline staff working in COVID-19 areas under close surveillance. Among frontline staff, a median of eight staff illness episodes was seen per day, and almost 10% (n=29) resulted in hospitalization. None of the staff was found to be infected with COVID-19.

Conclusions. A robust staff protection and health surveillance system that is routinely implemented during non-outbreak periods and enhanced during the COVID-19 outbreak is effective in protecting frontline staff from the infection.

BACKGROUND

Coronavirus disease 2019 (COVID-19) is a highly-transmissible emerging infectious disease (EID) caused by a novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). COVID-19 was first reported in Wuhan City, Hubei Province, China in December 2019, when a cluster of pneumonia with an apparent link to an open seafood and livestock market was identified [1]. A Chinese study reported that 3,019 healthcare workers (HCWs) were infected by February 12, 2020, contributing to 3.8% of total COVID-19 cases [2], and at least 22 have died [3].

In Singapore, the first imported case of COVID-19 was detected on January 23, 2020, in a 66-year-old male traveller from Wuhan admitted to a public hospital [4]. On January 30, 2020, the World Health Organization (WHO) declared the outbreak a Public Health Emergency of International Concern (PHEIC) [5]. As of February 23, 2020, a month since the first case, a total of 89 COVID-19 cases have been confirmed in Singapore [6].

In 2003, Singapore experienced an outbreak of severe acute respiratory syndrome (SARS), an EID that was also caused by a novel coronavirus. The outbreak began on March 1, 2003 when a returning traveller was admitted with atypical pneumonia to a six-bed cubicle in a 38-bed ward at Tan Tock Seng Hospital (TTSH), a 1400-bed acute care hospital. The index patient (at that time undiagnosed and unrecognised to have a novel infection) started off a chain of cases resulting in nosocomial transmission, infecting a total of 105 individuals, of whom 60 (57%) were HCWs from five general wards and a coronary care unit, with attack rates of up to 32.5% for ward-based staff [7].

Amongst the key measures found to be of importance to curtail the SARS outbreak in Singapore were the enforced use of personal protective equipment (PPE) and the practice of temperature monitoring of all hospital staff for the early identification of staff with SARS [8,

9]. After the SARS nosocomial outbreak, TTSH has routinely fit-tested staff for high filtration N95 respirators to be used in high-risk areas, and established web-based surveillance systems for monitoring clusters of sick staff [10], always preparing for the next outbreak.

On November 11, 2019, the various surveillance systems were integrated into a one-stop platform, “Staff Health Surveillance System (S3)”, for staff to make pre-travel declarations, report sickness absenteeism and details, record temperature measurements, and document fit-tested N95 respirators. The staff protection and surveillance systems were rapidly scaled up and enhanced, in response to the rapidly evolving COVID-19 outbreak in Singapore. We describe the staff protection and staff health surveillance strategies and review the effectiveness of these strategies at TTSH and its co-located National Centre for Infectious Diseases (NCID) in protecting staff from nosocomial infection of COVID-19, one month into the COVID-19 response.

METHODS

Design, Setting and Participants

In 2020, TTSH has grown to a 1600-bed multidisciplinary acute-care hospital, with a staff strength of >10,000. It also supports the co-located 330-bed NCID, which is the designated centre for outbreaks of emerging infectious diseases including COVID-19. On January 23, 2020, the second case of COVID-19 in Singapore, a 53 year-old female Chinese tourist from Wuhan was seen in TTSH’s Emergency Department (ED) and admitted to a negative-pressure isolation room in NCID. As of February 23, 2020, TTSH/NCID has screened, admitted, and managed 68 confirmed COVID-19 patients, the majority (76%) of COVID-19 cases in Singapore.

The hospital adopted a multi-pronged approach to protect and monitor HCWs with potential exposures to COVID-19 patients. The three key strategies include (1) Risk-based PPE based on risk of exposure from respective patient care activities, (2) Staff fever and sickness surveillance for early identification of unwell staff, and (3) Enhanced medical surveillance of unwell staff. We conducted a cross-sectional study, between January 23, 2020 and February 23, 2020, to understand the effectiveness of the staff protection and health surveillance strategies in protecting staff from nosocomial infection of COVID-19, in the first month of response to the COVID-19 outbreak.

(1) Staff protection

On January 2, 2020, in response to reports of atypical pneumonia circulating in Wuhan, China, Ministry of Health Singapore, released a circular to all hospitals in Singapore to look out for cases with fever and respiratory symptoms within 14 days of return from Wuhan. Patients who fit such criteria were to be admitted to negative pressure isolation rooms and staff were to take standard, droplet and airborne precautions.

For patients admitted to isolation rooms in NCID as suspect cases, as well as when their results were confirmed, staff wore N95 masks, eye protection, long sleeved gowns and gloves for routine care (Table 1). Similar PPE was worn in the “fever” zone of TTSH ED and the screening centre at NCID. Powered air purifying respirators (PAPRs) were used for patients who required intubation, and for aerosol-generating procedures in the intensive care unit (ICU).

For other areas in the hospital, the Department of Infection Prevention and Control (DIPC) established a policy on PPE based on the risk assessment taking into consideration the activities engaged by HCWs with the confirmed/suspected COVID-19 patients. When more cases not linked to travel from China emerged, and the Ministry of Health alert level was

raised to Disease Outbreak Response System Condition (DORSCON) Orange on February 7, 2020 [11], HCWs working in other areas were advised to wear surgical masks during the course of their clinical duties and the policy applies to all staff including non-TTSH employed staff working on the hospital premises including security officers and housekeeping staff. Nurses from the DIPC inspect clinics and wards daily to monitor and ensure HCWs' compliance with the use of PPE.

(2) Staff fever and sickness surveillance

A dedicated staff surveillance team at the Department of Clinical Epidemiology (DCE) closely monitored the temperature and sickness reporting of all HCWs working in TTSH and NCID, in particular those deployed to high risk areas (areas with exposure to confirmed or suspected COVID-19 patients). Staff were responsible for reporting their temperatures twice daily and sickness via the purpose-built S3 system. The S3 system was accessible via the hospital's intranet. In response to the COVID-19 outbreak, to enable convenient access anywhere anytime, internet-based forms utilizing the Singapore government's FormSG platform (temperature reporting: <https://form.gov.sg/#!/5e37870c73a1e90011942e50>; sickness reporting: <https://form.gov.sg/#!/5e384ade05296a00125a772e>) were created. Data submitted via the internet-based electronic forms were authenticated against individual staff's identities and profiles, and saved into the S3 system's database. This enabled campus-wide monitoring of staff temperature and sickness, as well as the stratification of staff by work areas based on the exposure risk to COVID-19. Travel declaration was also available on the S3 system and staff who had returned from travel to China within 14 days were also placed under close surveillance, as well as staff working in high-risk areas.

(3) Medical review and close surveillance

Staff with potential COVID-19 exposure was defined as a HCW working or having worked in the past 14 days in COVID-19 clinical or laboratory areas, or having returned from China in the preceding 14 days, or being close community contact of a confirmed COVID-19 case outside of work. Standard operating procedures were in place for such staff who developed fever or symptoms of acute respiratory infection (ARI), to be seen at TTSH ED fever zone. Subsequently, the workflow was revised for staff to be seen at NCID's Screening Centre (NCID SC), where a fast track for staff was created. Workflow for their evaluation at TTSH ED/NCID SC was as follows: (i) clinically low suspicion of COVID-19: staff were swabbed for COVID-19 and discharged with 5 days of hospitalization leave; and (ii) clinically suggestive of COVID-19 infection such as pneumonia: staff were admitted for further investigations including nasopharyngeal swabs for a minimum of two times at least 24 hours apart.

There was close staff surveillance of potentially COVID-19 exposed staff. This included: (i) staff who medically attended at TTSH ED/NCID SC (both those managed as outpatients, and those admitted for further investigations and then discharged); (ii) self-reported sickness with ARI symptoms via S3; and (iii) self-reported high temperature ($\geq 38^{\circ}\text{C}$). These staff were closely followed up via daily phone surveillance until symptom resolution and full recovery. At the end of the hospitalization leave, staff were medically reviewed at TTSH's Occupational Health Clinic (OHC), before returning to work. Daily phone surveillance of HCWs were performed by the team at DCE to assess for the progress of symptoms, inform results of SARS-CoV-2 tests [12] done at the outpatient setting, and provide information on follow-up visits to OHC.

Ethics approval

The study was approved with waiver of informed consent by the Domain Specific Review Board of National Healthcare Group Singapore (DSRB - 2020/00306).

RESULTS

Between January 23, 2020 and February 23, 2020, the TTSH/NCID campus-wide surveillance included 10,583 staff both TTSH-employed and outsourced staff (physicians: n = 1645, nurses: n = 4273, allied health professionals: n = 1875, administrative and ancillary staff: n = 2790), with an increasing number of staff amongst them being deployed for COVID-19 response as the number of confirmed COVID-19 cases increase. Figure 1 illustrates the number of staff closely monitored between January 29 (the first date when the data was available) and February 23, 2020. On February 23, 2020, there were a total of 1,524 (physicians: n = 363, nurses: n = 661, allied health professionals: n = 119, administrative and ancillary staff: n = 381) and 17 staff monitored because of working in COVID-19 clinical or laboratory high-risk areas and return from travel to China in the preceding 14 days respectively. All 1,524 staff were fit-tested for N95 respirators.

From January 23 to February 23, 2020, there were a total of 287 illness episodes involving 266 staff working in high-risk areas due to fever and other ARI symptoms (Figure 2). The median number of staff illness episodes seen at TTSH ED/NCID SC was eight per day (minimum was one on January 23, 2020 and February 1, 2020; maximum was 21 on February 11, 2020). In the first two weeks of the outbreak, majority of the staff were only clinically examined without SARS-CoV-2 test performed. Since February 7, 2020, a total of 167 illness episodes (58% out of 287 illness episodes) had a nasopharyngeal swab sent for SARS-CoV-2 PCR test at TTSH ED/NCID SC. Nearly 10% (n = 29) of the illness episodes

resulted in admission and 26 of them had at least two swabs taken at least 24 hours apart for SARS-CoV-2 PCR test. In all of the cases, SARS-CoV-2 was not detected.

DISCUSSION

Our findings have highlighted the importance of robust staff protection and staff health surveillance policies and systems during the current COVID-19 outbreak. Protecting HCWs during public health crises is an important strategy to prevent disease transmission, as nosocomial outbreaks are common for emerging infectious diseases [13]. Surveillance on the health of HCWs has the benefit of early identification of nosocomial transmissions [8]. Staff sickness reporting systems implemented during outbreaks have been found to be effective in the control of outbreaks [14]. However, very few healthcare facilities have implemented routine staff sickness surveillance systems that can be rapidly scaled-up during outbreaks. Our experience showed that the routine fit-testing of N95 respirators and staff sickness surveillance systems during non-outbreak periods have enabled the rapid scaling-up and enhancements of existing platforms to respond effectively to the outbreak. The one-stop intranet platform for documentation of fit-tested N95 respirators, reporting of sickness episodes, and recording of temperature measurements, could be rapidly enhanced to enable the convenient access by more than 10,000 staff via an internet-based platform on their mobile devices. Furthermore, the close clinical surveillance of frontline staff working in COVID-19 areas, involving medical reviews first at the hospital's emergency department then screening centre, the active daily phone surveillance on the medical condition of the staff until recovery, and the final review at the occupational health clinic prior to return to work, provided a safe environment for staff, patients, and visitors to the hospital.

Staff surveillance systems are designed to identify sick staff early and ensure that they receive appropriate treatment promptly, as HCWs are susceptible to infectious disease not

only from work, but also in the community [15]. Since SARS, the sickness reporting system in TTSH has undergone several improvements. During non-EID outbreak periods, staff sickness surveillance involves syndromic surveillance and the identification of infectious clusters among HCWs [16]. Not only has the system enabled the rapid detection of clusters to prevent nosocomial transmission, the continuous staff sickness reporting during non-outbreak periods has fostered a culture of responsibility and safety that form the foundation for enhanced staff health surveillance during the COVID-19 outbreak. Over the years, reporting of sickness has been ingrained in staff and become a part of the hospital culture and practice. As such, during outbreaks, staff are familiar with the surveillance system and aware of the importance of timely sickness reporting. Riding on the existing culture, temperature reporting and fever surveillance as an enhanced measure could be easily implemented with high compliance (>80%) hospital-wide (data not shown). Furthermore, regular communications and close working relationships among the DCE, DIPC, and OHC teams whenever a staff infectious cluster was detected by DCE, with enhanced infection control measures implemented by DIPC and sick staff managed at the OHC, has enabled a well-oiled and coordinated response to the COVID-19 outbreak.

To supplement the sickness and temperature reporting by staff, the staff sickness surveillance system was augmented with surveillance of medical attendances at the emergency department and screening centre. Furthermore, all admissions for suspect COVID-19 to the hospital were reviewed to actively identify any staff amongst them. This was to ensure a comprehensive coverage of all staff illness episodes. Our enhanced staff surveillance system also included the daily close monitoring and phone surveillance of sick staff until full recovery and medically reviewed at OHC before return to work. HCWs are known to continue working in spite of being sick [17]. However, as COVID-19 could present with very mild illness [18], all sick staff would have to be furloughed until full recovery.

We acknowledge that findings from our study could be limited due to the self-reporting of fever and other symptoms. However, any under-reporting was likely to be minimal, as staff compliance with twice daily temperature measurement and reporting, and sickness reporting were closely monitored by respective heads of department and chiefs of services.

A robust surveillance system has to be complemented with a strong staff protection policy. While surveillance serves to manage sick staff in a timely manner, staff protection policy is important for primary prevention of infectious diseases. A blanket enhanced PPE for all healthcare workers is not practical and a waste of resources in view of the world-wide reduction in PPE supplies and the discomfort caused by the PPE. High filtration masks add to the effort of breathing leading to dyspnoea, and may cause local skin reactions [19]. A risk-based approach ensures that HCWs exposed to COVID-19 are adequately protected without compromising the health of other HCWs with low risk of exposure to SARS-CoV-2.

One month into the outbreak, the hospital has been successful in protecting frontline staff from COVID-19 infection, and the nosocomial transmission of COVID-19 due to an infected staff.

Conclusion

A robust staff protection and health surveillance system that is routinely implemented can be quickly enhanced and customized for specific emerging infectious diseases, and rapidly deployed during outbreaks. Continuous staff sickness reporting during non-outbreak periods would foster a culture of responsibility and safety that form the foundation for enhanced staff health surveillance during outbreaks, to protect staff, patients, and visitors in the healthcare facility. Future research could explore the applications of similar staff health surveillance systems in various healthcare settings in developed and developing countries.

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Authors contribution:

Study conception and design: B.Ang and A.Chow

Acquisition of data: H.L.Htun, D.W.Lim, and W-N.J.Loh

Analysis of data and figures: H.L.Htun and D.W.Lim

Interpretation of data: H.L.Htun, D.W.Lim, L.T.Lee, B.Ang and A.Chow

Drafting of manuscript: H.L.Htun, D.W.Lim and W.M.Kyaw

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All authors read and approved the final manuscript.

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References

1. Zhu N, Zhang D, Wang W, et al. A Novel Coronavirus from Patients with Pneumonia in China, 2019. *N Engl J Med* **2020**; 382(8): 727-33.
2. Wang Y, Wang Y, Chen Y, Qin Q. Unique epidemiological and clinical features of the emerging 2019 novel coronavirus pneumonia (COVID-19) implicate special control measures. *J Med Virol*.
3. Adams JG, Walls RM. Supporting the Health Care Workforce During the COVID-19 Global Epidemic. *JAMA* **2020**.
4. Ministry of Health Singapore. Confirmed imported case of novel coronavirus infection in Singapore; Multi-ministry taskforce ramps up precautionary measures. Available at: <https://www.moh.gov.sg/news-highlights/details/confirmed-imported-case-of-novel-coronavirus-infection-in-singapore-multi-ministry-taskforce-ramps-up-precautionary-measures>. Accessed 01 March 2020.
5. World Health Organization. Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). Available at: [https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov)). Accessed 01 March 2020.
6. Ministry of Health Singapore. Two more cases discharged; No new confirmed case of COVID-19 infection. Available at: <https://www.moh.gov.sg/news-highlights/details/two-more-cases-discharged-no-new-confirmed-case-of-covid-19-infection>. Accessed 01 March 2020.

7. Chen MI, Leo Y-S, Ang BS, Heng B-H, Choo P. The outbreak of SARS at Tan Tock Seng Hospital-Relating epidemiology to control. *Ann Acad Med Singap* **2006**; 35(5): 317.
8. Tan C-C. SARS in Singapore-key lessons from an epidemic. *Ann Acad Med Singap* **2006**; 35(5): 345.
9. Gopalakrishna G, Choo P, Leo YS, et al. SARS transmission and hospital containment. *Emerg Infect Dis* **2004**; 10(3): 395.
10. Ang B, Poh BF, Win MK, Chow A. Surgical masks for protection of health care personnel against pandemic novel swine-origin influenza A (H1N1)-2009: results from an observational study. *Clin Infect Dis* **2010**; 50(7): 1011-4.
11. Ministry of Health Singapore. Risk assessment raised to DORSCON Orange. Available at: <https://www.moh.gov.sg/news-highlights/details/risk-assessment-raised-to-dorscon-orange>. Accessed 01 March 2020.
12. Sun Y, Koh V, Marimuthu K, et al. Epidemiological and Clinical Predictors of COVID-19. *Clin Infect Dis* **2020**.
13. Suwantarat N, Apisarnthanarak A. Risks to healthcare workers with emerging diseases: lessons from MERS-CoV, Ebola, SARS, and avian flu. *Curr Opin Infect Dis* **2015**; 28(4): 349-61.
14. Seto W-H, Cowling BJ, Lam H-S, Ching PT, To M-L, Pittet D. Clinical and nonclinical health care workers faced a similar risk of acquiring 2009 pandemic H1N1 infection. *Clin Infect Dis* **2011**; 53(3): 280.
15. Drumright LN, Holmes AH. Monitoring Major Illness in Health Care Workers and Hospital Staff. *Clin Infect Dis* **2011**; 53(3): 284-6.
16. Sadarangani S, Chen MI, Chow AL, Earnest A, Win MK, Ang BS. Use of healthcare worker sickness absenteeism surveillance as a potential early warning system for

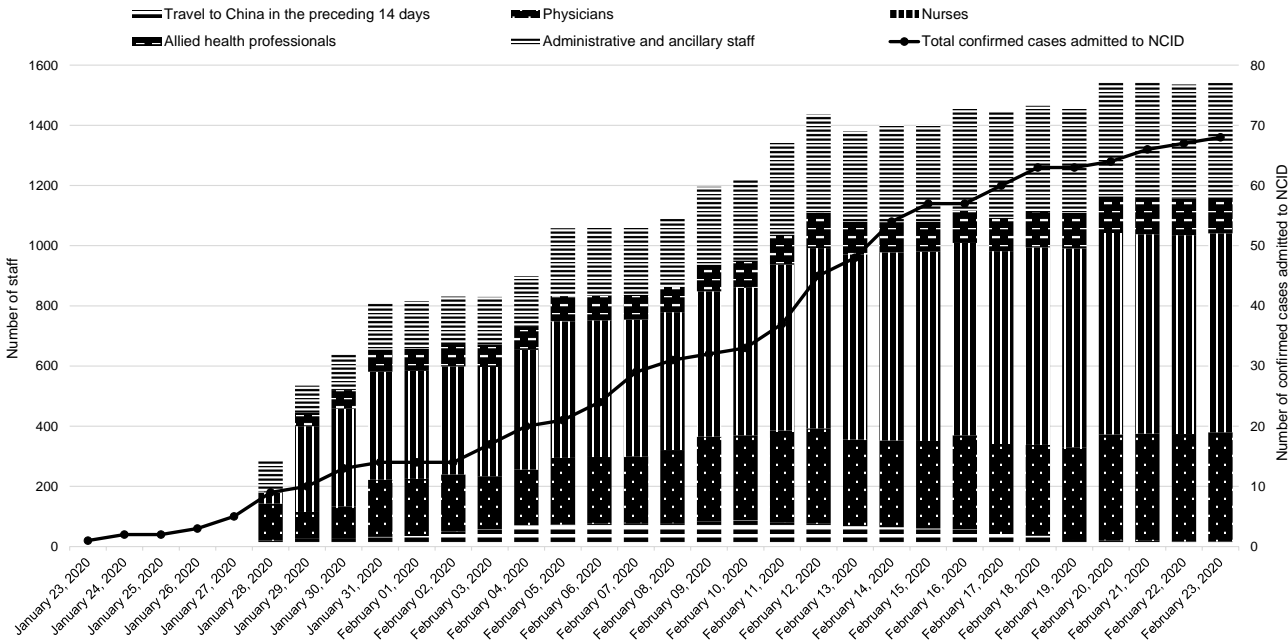
- influenza epidemics in acute care hospitals. *Ann Acad Med Singap* **2010**; 39(4): 341-2.
17. Aghaizu A, Elam G, Ncube F, et al. Preventing the next'SARS'-European healthcare workers' attitudes towards monitoring their health for the surveillance of newly emerging infections: qualitative study. *BMC Public Health* **2011**; 11(1): 541.
 18. Heymann DL, Shindo N. COVID-19: what is next for public health? *Lancet* **2020**; 395(10224): 543-5.
 19. Szeinuk J, Beckett WS, Clark N, Hailoo WL. Medical evaluation for respirator use. *Am J Ind Med* **2000**; 37(1): 142-57.

Figure legends

Figure 1. Number of closely monitored staff including physicians, nurses, allied health professionals, and administrative and ancillary staff working in high-risk areas, and staff travelled to China in the preceding 14 days, with total number of confirmed COVID-19 cases admitted to NCID during the study period (the first available data was on January 29, 2020)

Figure 2. Illness episodes of staff attended in Emergency Department or Screening Centre

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Admitted and discharged (≥ 2 negative SARS-CoV-2 tests)
 Medically reviewed as outpatients (one negative SARS-CoV-2 test)

Admitted and discharged (one negative SARS-CoV-2 test)
 Medically reviewed as outpatients (not tested)

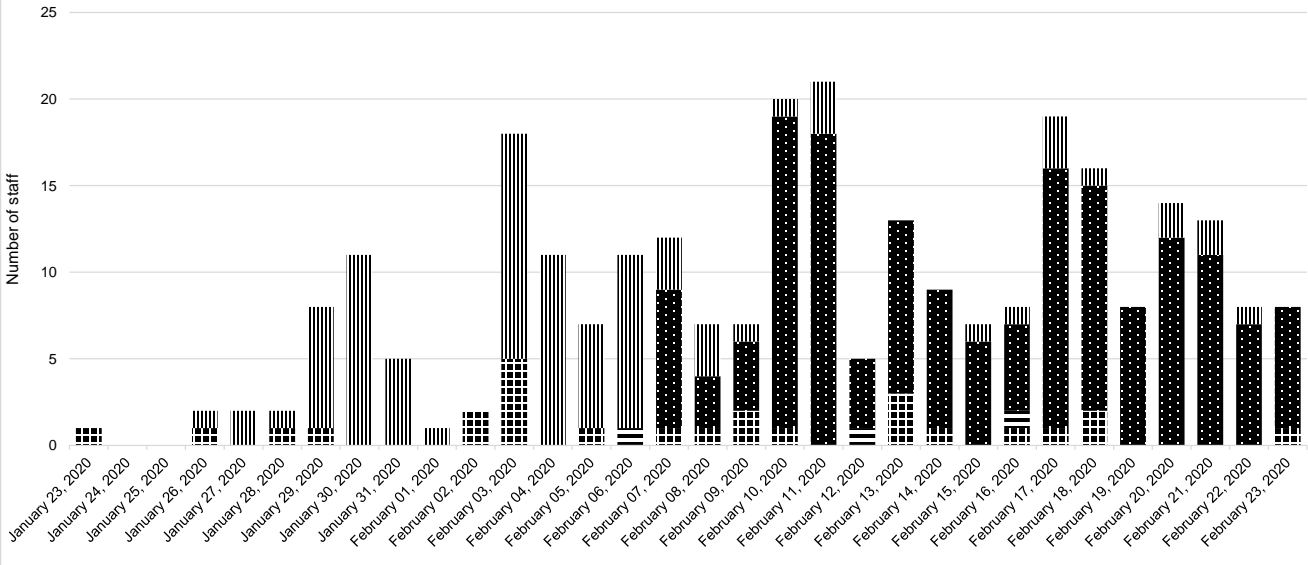


Table 1. Risk-based personal protective equipment (PPE) for healthcare staff

	Surgical mask	N95 respirator	Eye protection	Gown	Gloves
<i>High-risk areas (COVID-19 isolation rooms, TTSH ED Fever Zone, NCID SC, ID Clinic)</i>					
(i) Doctors and Nurses	..	✓	✓	✓	✓
(ii) Allied health professionals ^a	..	✓	✓	✓	✓
(iii) Ancillary staff ^b	..	✓	✓	✓	✓
(iv) Administrative staff	..	✓	✓	✓	✓
<i>Low-risk areas (Non-COVID-19 inpatient rooms, TTSH ED Non-Fever Zone, Non-ID Clinics, Other clinical areas)</i>					
(i) Doctors and Nurses	✓
(ii) Allied health professionals ^a	✓
(iii) Ancillary staff ^b	✓
(iv) Administrative staff	✓

Abbreviations: COVID-19, Coronavirus disease 2019; ED, Emergency Department; ID, infectious disease; NCID, National Centre for Infectious Diseases; SC, Screening Centre; TTSH, Tan Tock Seng Hospital.

^a Allied health professionals include pharmacists, occupational therapists, physiotherapists, phlebotomists, radiographers, and respiratory therapists.

^b Ancillary staff include health attendants, housekeepers, porters and security officers.