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Healthcare workers as a sentinel surveillance population in the early phase of the COVID-19 pandemic

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ABSTRACT

Introduction: Healthcare workers (HCWs) are a critical resource in the effort to control the COVID-19 pandemic. They are also a sentinel surveillance population whose clinical status reflects the effectiveness of the hospital's infection prevention measures in the pandemic.

Methods: This was a retrospective cohort study conducted in Singapore General Hospital (SGH), a 1,822-bed tertiary hospital. Participants were all HCWs working in SGH during the study period. HCW protection measures included clinical workflows and personal protective equipment developed and adapted to minimise the risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission. HCW monitoring comprised staff contact logs in high-risk locations, twice-daily temperature monitoring, assessment of HCWs with acute respiratory illnesses (ARIs) in the staff clinic and, in the event of an exposure, extensive contact tracing, detailed risk assessment and risk-based interventions. HCW surveillance utilised monitoring data and ARI presentations and outcomes.

Results: In the ten-week period between 6 January 2020 and 16 March 2020, 333 (17.1%) of 1,946 HCWs at risk of occupational COVID-19 presented with ARI. 32 (9.6%) screened negative for SARS-CoV-2 from throat swabs. Five other HCWs developed COVID-19 attributed to non-clinical exposures. From the nine COVID-19 exposure episodes investigated, 189 HCW contacts were identified, of whom 68 (36.2%) were placed on quarantine and remained well.

Conclusion: Early in an emerging infectious disease outbreak, close monitoring of frontline HCWs is essential in ascertaining the effectiveness of infection prevention measures. HCWs are at risk of community disease acquisition and should be monitored and managed to prevent onward transmission.

Keywords: COVID-19, healthcare worker surveillance, outbreak

INTRODUCTION

Healthcare-associated transmission accounted for 57 (41%) of 138 COVID-19 cases in a hospital in Wuhan, China, the city where the causative agent, severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), emerged in December 2019.[1] The majority (70%, 40/57) of these were in healthcare workers (HCWs). During the severe acute respiratory syndrome (SARS) outbreak in 2002–2003, 1,707 (21%) of 8,098 patients globally were HCWs.[2] While aggressive measures aimed at protecting HCWs have been advocated,[3] the rapid surge in cases with limited availability of personal protective equipment (PPE) has meant that resource utilisation often has to be rationalised.

The World Health Organization (WHO) recommended surgical mask, eye protection (goggles or face shield), gown and gloves for HCWs providing direct care to COVID-19 patients, based on the generally accepted understanding that transmission was through close contact and droplets[4] and not by the airborne route.[5] N95 respirators instead of medical masks are recommended for aerosol-generating procedures. However, the United States Centers for Disease Control and Prevention recommends using N95 respirators instead of surgical masks together with the other PPE that has been recommended by the WHO.[6] Healthcare institutions have had to develop PPE guidelines that are appropriate for their clinical settings, taking into consideration their PPE stockpiles. Another important consideration in developing these guidelines is HCW confidence and acceptance, especially in Singapore, where several HCWs experienced personal losses during the SARS crisis.

Control of COVID-19 is heavily reliant on HCWs in patient-fronting roles. With a rapid rise in cases, demand for HCWs increases steeply.[7] While it is acknowledged that HCWs are a most valuable resource that cannot be "*urgently manufactured*" and work at maximum capacity for extended period of times,[8] they have not been provided adequate protection in some regions of the world, with up to 20% of HCWs in parts of Europe becoming infected in

the course of their work.[9] When health systems are overwhelmed and PPE is limited, they become a susceptible population who may, in turn, become vectors in healthcare-associated transmission. As HCWs in direct clinical care interface with both the patient and health system, they are a sentinel surveillance population whose clinical status reflects the health of the system, being a measure of its preparedness and response.

HCW surveillance is an integral component of our hospital's infection prevention efforts, and our pandemic preparedness programme included enhanced HCW surveillance. However, in an emerging infectious disease outbreak in which information on transmission mechanism, clinical disease spectrum, susceptible population and optimum prevention measures is constantly evolving, protocols to guide PPE use and exposure management to prevent healthcare-associated transmission have to be based on broad principles. We aimed to determine the effectiveness of our infection prevention measures through a HCW surveillance system that was developed and utilised in the early stages (6 January 2020–16 March 2020) of the COVID-19 pandemic.

METHODS

Singapore General Hospital (SGH) is a 1,822-bed tertiary hospital with specialty services, including solid organ and stem cell transplant units. The Department of Emergency Medicine (DEM) has a fever area with three single rooms and two cohort rooms. In early January 2020, these were converted to five single rooms designated for suspected COVID-19 patients. By early February 2020, the Ambulatory Surgery Centre adjacent to the DEM (ASC-DEM) was converted to a 28-bed fever screening area with cohort rooms that accommodated up to eight beds separated by 1.8-m-high panels, both to maintain safe distancing and to prevent transmission of respiratory droplets. Patients in the ASC-DEM were required to wear surgical masks.

In SGH, there are 42 single-occupancy patient rooms in two isolation wards with appropriate ventilation systems to manage patients who require airborne infection isolation (AII) as a precaution. One of the two wards with 34 beds was designated for patients suspected and/or confirmed to have COVID-19 since early January 2020. As concern over COVID-19 rose among doctors in tandem with rising numbers in the country, the admission criteria for COVID-19 broadened, and more were admitted as suspected COVID-19 patients. Hence, by 12 January 2020, additional beds were allocated for lower-risk suspect cases in a ward with single rooms but normal pressure ventilation. In early February 2020, respiratory surveillance wards (RSWs) were opened, to which all patients with acute respiratory symptoms were admitted, regardless of epidemiological risk.[10] In RSWs, beds in cohort rooms were spaced at least 2 m apart for safe distancing, and patients were required to wear surgical masks. PPE for HCWs in these RSWs initially incorporated surgical masks, but this was changed to N95 respirators later on, in addition to the use of gown, gloves and eye protection.

In all these wards, patients were tested for SARS-CoV-2 within 24 hours of admission and were moved to AII rooms in the COVID-19-designated isolation ward once they were confirmed to be SARS-CoV-2-positive. In-house real-time reverse transcriptase polymerase chain reaction tests for SARS-CoV-2 became available on 22 January 2020. On 23 January 2020, we had our first laboratory-confirmed patient with COVID-19.

In the ten-week study period from 6 January 2020 to 16 March 2020, all patients with confirmed COVID-19 were placed in AII rooms even though they could have transited through rooms with normal pressure ventilation prior to laboratory confirmation. In all these patient locations, PPE guidance had to be developed to protect HCWs from airborne SARS-CoV-2 transmission, as shown in Table I. In addition, clinical and staffing workflows from triage to laboratory confirmation were designed to minimise the risk of transmission from patients with COVID-19 to HCWs.

The level of PPE required by HCWs was determined by the patient's risk of COVID-19 (pre-test probability) and the risk of transmission to the HCW through direct or indirect contact. Patient risk stratification was based on clinical and epidemiological criteria, which continue to evolve over time and have been described elsewhere.[11] Patients with respiratory symptoms and epidemiological risks were deemed to have the highest risk of COVID-19 and were managed in the designated isolation ward, with HCWs donning PPE to protect them from airborne and contact transmission. Patients with respiratory symptoms but without epidemiological risks were managed in RSWs, where HCWs donned PPE that protected them from droplet and contact transmission.

Early in the outbreak, the patient risk cohort consisted of travellers from Wuhan with respiratory symptoms, but this quickly expanded to persons with other epidemiologic risk associations, including travel to South Korea and Europe. These epidemiological risks became less defined as global and community spread continued. Hence, PPE recommendations for frontline HCWs had to be regularly updated to align with the epidemiological risk.

Although it was hypothesised that SARS-CoV-2 was mostly transmitted at short distances via large droplets, there was some evidence of long-distance aerosol transmission via fine particles,[12] and there was considerable anxiety among healthcare personnel towards donning PPE that did not protect against airborne transmission. Hence, in our healthcare institution, all patients suspected or confirmed to have COVID-19 were initially admitted to single rooms with AII precaution. PPE was developed to protect HCWs against airborne transmission.

About 10,000 HCWs are employed, either directly or indirectly, by SGH. The staff clinic at the hospital usually provides pre-employment screening, vaccination and primary healthcare services. Since the beginning of the outbreak, it was mandatory for all staff with respiratory symptoms to attend the staff clinic during office hours and the DEM after office

hours. The clinic was reorganised to receive patients with any infective symptoms in one section and all other patients in another section to reduce mixing of patients. HCWs with acute illnesses are screened for SARS-CoV-2 based on criteria similar to those for patients from the community. However, staff working in high-risk areas of the hospital, such as the isolation wards or DEM, are prioritised for SARS-CoV-2 testing.

In the event of an inadvertent exposure in any part of the hospital, contact tracing is done immediately by the Department of Infection Prevention and Epidemiology team to identify at-risk contacts, assess the degree of exposure, risk stratify and determine the level of monitoring required. Staff who are exposed are interviewed individually to ascertain the extent of contact. Collaborative history is also sought from teammates to verify the accuracy of the information gathered.

The hospital instituted three different HCW monitoring systems depending on the individual risk level. All HCWs in the hospital had to record their temperature twice daily in a nationally centralised electronic system[13] regardless of their designation or clinical work location. Telephone monitoring, in which HCWs are called daily to ascertain their health status, is the next level of monitoring. This was initially carried out for all staff in the isolation ward with direct patient contact. Subsequently, this was transitioned to monitoring HCWs who may have had inadvertent exposure from a breach in recommended PPE or improper donning or doffing of PPEs for a 14-day period following exposure. While the routine telephone calls to HCWs in isolation wards and the DEM initially seemed to allay anxiety, once processes were established and HCWs were confident of protective measures, this monitoring seemed intrusive and was transitioned to apply to only HCWs with potential exposures resulting from infection prevention breaches.

HCWs considered to have moderate risk exposure are required by the institution to self-quarantine at home or in a hospital-designated isolation facility for a 14-day period, where

minimal risk is defined as a face-to-face conversation at a distance of less than 2 m for longer than five minutes but less than 30 minutes, without wearing surgical masks (Table II). In circumstances where there has been a greater degree of exposure, HCWs are recommended to the Ministry of Health (MOH) for the issuance of a quarantine order. Initially, HCWs returning to work following self-quarantine (issued by institution) or quarantine (issued by MOH) were required to undergo a throat swab on Day 15 post exposure to document clearance before their return to work. However, this was discontinued as per the MOH Singapore advisory in March 2020.[14]

The practice of staff contact logs for staff working in the fever area in the DEM and COVID-19-designated isolation wards was commenced on 6 January 2020 when our first COVID-19 suspect case was admitted (Appendix). For clinical areas, in addition to the duration of exposure, information is captured on the type of PPE worn and proximity to patients. Staff who worked in the laboratory processing specimens for SARS-CoV-2 testing were included in the surveillance. Data was collated and entered into Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) spreadsheets.

Staff presenting to the staff clinic and DEM were matched against staff contact log and risk stratified. Symptomatic staff from high-risk COVID-19 locations were admitted for further management. All SARS-CoV-2 swabs of staff (inpatient and outpatient) were tracked so that contact tracing and exposure management could be initiated promptly in case of a positive result. Staff on enhanced monitoring or quarantine post exposure were monitored daily through direct communication or via the Human Resource (HR) Department, which managed staff who were under quarantine. The Department of Infection Prevention and Epidemiology coordinated with the isolation ward clinical team, staff clinic, DEM, nursing team, HR and MOH to develop and maintain this HCW surveillance system. This formed the basis for an electronic surveillance system that was developed and implemented.[15]

The study was approved by our hospital's Institutional Review Board (CIRB ref no. 2020/2436) with a waiver of informed consent, as this was a descriptive study based on data collected as part of surveillance and outbreak management.

RESULTS

In the ten-week period between 6 January 2020 and 16 March 2020, all patients who were confirmed to have COVID-19 infection were managed in single AII precaution rooms in the isolation ward. Of 543 suspect COVID-19 cases admitted to SGH during this time, 17 (3.1%) were confirmed positive (out of 226 confirmed COVID-19 cases nationwide). Of 1,946 HCWs who had direct or indirect contact with patients with COVID-19 during this period, 333 (17.1%) presented to either the staff clinic or DEM with acute respiratory illness, and 32 (9.6%) of them underwent throat swabs for SARS-CoV-2, which were all negative. 18 were admitted and screened, while 14 were screened as outpatients. As laboratory testing capacity was limited and there was no established community transmission in the early stages of the pandemic, symptomatic HCWs were risk stratified and swabbed only when they were considered to be at risk for COVID-19, therefore accounting for the low proportion tested.

During the same ten-week period, five HCWs who had no risk exposure to SARS-CoV-2 in clinical or laboratory areas in SGH, and hence were not in the staff contact log, were confirmed to have COVID-19. They included two medical social workers, a psychologist, a nurse and a researcher. Three were from community exposures (medical social worker, nurse and researcher), one was imported (the psychologist returned from a conference in the United States) and one was a probable transmission in the non-clinical office area of the hospital (second medical social worker).

Of nine cases of exposure to COVID-19 patients in the hospital that were investigated during this period, three index cases were patients from the community who were admitted to

non-isolation wards, one index case was a mildly symptomatic son accompanying a patient who was subsequently diagnosed with COVID-19, and five other index cases were the aforementioned HCWs at SGH. 189 HCW contacts of these nine cases were identified. One of them was symptomatic at the time of contact tracing and was screened, testing positive for COVID-19. 68 (36.2%) of the remaining exposed HCWs were placed on quarantine. Between 23 January 2020 and 13 March 2020, ten HCWs placed on self-quarantine or quarantine had throat swabs on Day 15 post exposure and all tested negative for SARS-CoV-2. None of these HCWs developed COVID-19 at the end of the 14-day quarantine period.

Utilisation of PPE and direct patient contact was greatest in the isolation ward and DEM (Table III). Nurses had the most episodes of direct patient contact compared to other HCWs, but 86% of the time, their contact time was less than 20 minutes. In comparison, doctors had sixfold fewer episodes of direct patient contact (578 vs 3,407), and 91% of the time, contact time was less than 20 minutes. Nurses and doctors had direct patient contact more than 80% of the time (Table IV). 92% of the environmental cleaning staff spent 20 minutes or less in the patient room and had direct contact with patients less than half the time. As expected, direct patient contact was greatest in the isolation wards, followed by the DEM.

DISCUSSION

In China, as of 24 February 2020, 3,387 of 77,262 patients with COVID-19 were HCWs; as of 3 April 2020, 23 of them had died.[16] Only two of these HCWs had been treating COVID-19 patients, suggesting inadvertent exposure early in the outbreak, either within or outside the healthcare system.

The risk of transmission from a patient with an atypical disease manifestation to an unsuspecting HCW was recognised early in the outbreak. In SGH, effort was taken at several levels to minimise the risk of inadvertent exposure to an undiagnosed COVID-19 patient.[17]

When such exposures occur despite these preventative measures, thorough risk assessments are done and interventions made to prevent secondary transmission. Strategies such as patient triage, bed allocation, PPE assignment, and in the event of an exposure, detailed contact tracing, individual risk assessment, risk assignment and contact management, have been used to prevent nosocomial transmission of COVID-19.[18]

In a single-centre Chinese study in which 110 (1.1%) of 9,684 HCWs developed COVID-19 between 1 January 2020 and 9 February 2020, 12 (10.9%) were from contact with colleagues and 14 (12.7%) were attributed to community acquisition.[19] While it is important to select a staff cohort who has direct contact with COVID-19 patients for surveillance, resources have to be allocated for detection of staff and patient clusters in other hospital locations as well. Early in the outbreak, transmission in the healthcare setting is more likely due to breaches or inadequacy of the PPE used, but once community transmission is established, a healthcare cluster is likely to be due to lapses in early detection of cases among HCWs via community spread. In our cohort, all five HCW infections were non-frontline staff who were identified through enhanced staff management and monitoring through strict enforcement of symptom reporting, presentation to the designated staff clinic, and extensive contact tracing and case-finding measures.

As community transmission increases, there is increasing risk of HCWs acquiring COVID-19 in the community and subsequently transmitting it to other HCWs and patients in the hospital work environment. This is particularly significant in COVID-19 because patients may be transmitting the virus while asymptomatic.[20] This also represents a challenge for the development of a surveillance system targeting COVID-19.

The detailed staff contact log aided in assessing each exposure and in risk stratifying HCWs who were exposed. It also provided information on the type of exposures that each HCW had and the hospital locations of the exposures. The staff contact log not only provided

data on infection prevention measures but also information on resource utilisation and requirements for longer-term planning.

In a pandemic caused by a novel pathogen such as SARS-CoV-2, HCWs face tremendous stress due to the limited information on the pathogen, its transmissibility, disease severity, treatment options and outcome measures. This is compounded by disruption to their routine work, extended workloads, unfamiliar changing workflows and concerns about insufficient PPE. In addition to PPE assignment and having clearly defined workflows that are rehearsed and optimised to minimise exposure risk, HCWs' mental well-being should also be assessed, supported and managed. Surveillance of HCWs should include monitoring reactions and performance as well as provision of psychosocial support.[21] The mental health of HCWs impacts their behaviour, adherence to infection prevention measures and response to unexpected situations during clinical care. Although psychological support has been provided to HCWs through peer support services, systematic and follow-up assessments on anxiety have not been carried out among frontline HCWs in our institution.

In the early days of an emerging infectious disease outbreak when there is little data to inform practice and anxiety is highest among HCWs, close monitoring is an important surveillance strategy to both evaluate the effectiveness of infection prevention measures and reassure HCWs. In a study in another Singapore acute care hospital in April 2020, HCWs in the operative theatre and intensive care unit were reported to have high confidence in COVID-19 protection at work, indicative of the effectiveness of these early measures[22]. Healthcare personnel are integral to the control of an outbreak and constitute a scarce resource that cannot be rapidly augmented. Health systems have to recognise their critical role and allocate adequate resources for their protection.

Initial HCW protection and monitoring surveillance processes were set up based on disease characteristics of SARS. However, COVID-19 showed a lower incidence of fever,

larger proportion of asymptomatic infections and predominant community transmission compared to SARS, which had more limited community spread and explosive superspreading events in healthcare settings.[23] Hence, subsequent HCW monitoring strategies included one-off screening of asymptomatic staff cohorts with high community exposure risk as part of a national programme for personnel residing in dormitory settings. Expanded testing capabilities have allowed MOH to include healthcare workers in the list of persons whom laboratories can test for SARS-CoV-2 as part of their baseline testing workload.[24] Hence, unlike early in the pandemic when testing was restricted, HCWs who are symptomatic with acute respiratory infections or asymptomatic with risk exposure are currently promptly screened to exclude COVID-19. These strategies have greatly enhanced infection prevention efforts in this pandemic.

There are several limitations to the surveillance system described. In our exposure management, we did not incorporate laboratory testing to identify asymptomatic infection. This could have missed some infections in our HCW cohort. However, despite close monitoring and testing of high-risk symptomatic HCWs who had contact with COVID-19 patients, we did not identify any SARS-CoV-2 transmission from patient to HCW during the ten-week study period. Furthermore, the staff contact log is time- and resource-intensive to sustain in the longer term. Data in the staff log is dependent on individual memory recall and data entry may not be consistent or accurate.

In conclusion, HCWs are a sentinel surveillance population in an emerging infectious disease outbreak. Their clinical status is a measure of the preparedness and response of the health system they work in. Early on in an emerging infectious disease outbreak, close monitoring of frontline HCWs is essential in ascertaining the effectiveness of infection prevention measures that were implemented. Surveillance and testing strategies for both

frontline and non-frontline HCWs are essential for identification of community-acquired infections.

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Table I. Personal protective equipment (PPE) guidelines developed at the beginning of the pandemic for management of viral pneumonia cases (confirmed and suspected) of unknown cause.

No.	Contact points	PPE required for staff*
1	**Triaging/registration of patient**	
1.1	Staff at area receiving patient	Surgical mask
2	**Escorting of patient to designated isolation room**	
2.1	Staff escorting patient to designated isolation room or area upon knowledge of patient's declaration of relevant symptoms and travel history	N95 mask + gown + gloves
3	**Transportation of patient to SGH DEM or other areas for assessment (prior to decision to admit patient)**	
3.1	All staff involved in patient transfer, including but not limited to:	
	(i) Security staff controlling traffic/lift	N95 mask + gown + gloves
	(ii) Staff accompanying/transferring patient	Face shield + N95 mask + gown + gloves
	(iii) Ambulance driver	N95 mask
4	**Transportation of patient to SGH Ward 68 for admission**	
4.1	Security staff controlling traffic/lift	N95 mask + gown + gloves
4.2	Staff accompanying/transferring patient	Face shield + N95 mask + gown + gloves
5	**Performing patient examination/providing patient care**	
5.1	Staff attending to suspect or confirmed case (for non-aerosol-generating procedures)	Face shield + N95 mask + gown + gloves
5.2	Staff attending to suspect or confirmed case (for aerosol-generating procedures)	Face shield + N95 mask (PAPR only for trained staff) + gown + gloves
5.3	Staff attending to suspect or confirmed case for throat swab procedures	Face shield + N95 mask + gown + gloves
6	**Transportation of specimen to laboratory**	
6.1	Porter	PPE not required

7	**Laboratory processing**	
7.1	Laboratory staff processing specimen	Biosafety cabinet + N95 mask + gown + gloves
8	**Environmental services**	
8.1	Environmental services staff cleaning the room used by suspect or confirmed case, including by not limited to:	(Activate spill management protocol if there is any spillage)
	(i) Treatment/ward room	Face shield + N95 mask + gown + gloves
	(ii) Lift used for transfer	Face shield + N95 mask + gown + gloves
	(iii) Ambulance used for transfer	Face shield + N95 mask + gown + gloves
9	**Transportation to mortuary**	
9.1	Mortuary staff transferring deceased patient (suspect or confirmed case) to mortuary cart (with entry to patient's room)	N95 mask + gown + gloves

*All areas are to ensure that the necessary PPE are readily available to staff when required. *Practise standard precautions in all situations, e.g. staff to wear face shield and gowns when splash or exposure to body fluids is anticipated. DEM: Department of Emergency Medicine; PAPR: powered air-purifying respirator; SGH: Singapore General Hospital*

Table II. Staff exposure risk assessment guide.

No.	PPE		Exposure risk	For 14 days following exposure to suspected/confirmed case	
	Exposed staff	Suspected/confirmed COVID-19 patient		Twice-daily temperature and symptom monitoring	Home isolation
1	None	None	Face-to-face conversation > 5 min	Yes	Yes
2	None	Surgical mask, properly worn	Face-to-face conversation > 5 min	Yes	No
3	Surgical mask, properly worn	None	Face-to-face conversation > 5 min	Yes	No – risk assessment to be individualised (e.g. consider home isolation if high risk for eye mucous membrane exposure, e.g. patient coughs into staff member's face)
4	Surgical mask, properly worn	Surgical mask, properly worn	Face-to-face conversation > 5 min	Yes	No
5	Not wearing, at minimum, a mask-fitted N95 mask + eye protection	NA	Aerosol-generating procedures (e.g. using rotatory instruments in dental operatory)	Yes	Yes
6	At minimum, a mask-fitted N95 + eye protection	NA	Aerosol-generating procedures (e.g. using rotatory instruments in dental operatory)	Yes	No

Home isolation refers to self-quarantine issued by the hospital. NA: not applicable; PPE: personal protective equipment

Table III. HCW contact log with COVID-19 patients by hospital location.

Variable	No. (%) of episodes of contact								
	ARI ward	DEM	General ward	Isolation ward	Operating theatre	Outpatient clinic	Radiology	Security	Total
Mask									
N95	122 (58)	372 (81)	3 (100)	4,432 (94)	15 (100)	9 (100)	3 (100)	3 (100)	4,959 (91)
PAPR	29 (14)	45 (10)	0 (0)	264 (6)	0 (0)	0 (0)	0 (0)	0 (0)	338 (6)
Surgical mask	59 (28)	40 (9)	0 (0)	34 (1)	0 (0)	0 (0)	0 (0)	0 (0)	133 (2)
PPE									
Gown	65 (28)	247 (31)	3 (33)	4,348 (34)	15 (39)	9 (33)	3 (38)	3 (33)	4,693 (34)
Gloves	69 (30)	248 (31)	3 (33)	4,348 (34)	15 (39)	9 (33)	3 (38)	3 (33)	4,698 (34)
Face shield	58 (25)	164 (20)	2 (22)	3,984 (31)	8 (21)	8 (30)	1 (13)	3 (33)	4,228 (30)
Goggles	41 (18)	146 (18)	1 (11)	67 (1)	0 (0)	1 (4)	1 (13)	0 (0)	257 (2)
Contact time (min)									
< 5	46 (32)	167 (49)	0 (0)	997 (23)	4 (27)	1 (11)	3 (100)	0 (0)	1,218 (25)
5–10	34 (24)	100 (29)	1 (33)	1,336 (31)	8 (53)	0 (0)	0 (0)	0 (0)	1,479 (30)
10–15	23 (16)	49 (14)	1 (33)	943 (22)	0 (0)	4 (44)	0 (0)	0 (0)	1,020 (21)
15–20	21 (15)	14 (4)	0 (0)	452 (10)	2 (13)	2 (22)	0 (0)	2 (100)	493 (10)
20–25	6 (4)	5 (1)	0 (0)	172 (4)	0 (0)	0 (0)	0 (0)	0 (0)	183 (4)
25–30	6 (4)	6 (2)	0 (0)	146 (3)	0 (0)	2 (22)	0 (0)	0 (0)	160 (3)
> 30	6 (4)	3 (1)	1 (33)	301 (7)	1 (7)	0 (0)	0 (0)	0 (0)	312 (6)
Distance from patient									
Touched patient	57 (58)	162 (60)	0 (0)	2,758 (81)	6 (43)	2 (25)	2 (67)	0 (0)	2,987 (79)
1 m away	18 (18)	79 (29)	3 (100)	345 (10)	5 (36)	6 (75)	0 (0)	0 (0)	456 (12)
2 m away	7 (7)	15 (6)	0 (0)	83 (2)	0 (0)	0 (0)	1 (33)	2 (100)	108 (3)
No contact but in the same room	16 (16)	14 (5)	0 (0)	211 (6)	3 (21)	0 (0)	0 (0)	0 (0)	244 (6)

Percentages were calculated using the count in each category within a stratum (e.g. respiratory mask type) divided by the total count in that stratum, expressed as a percentage, in each staff location. ARI: acute respiratory infection, DEM: Department of Emergency Medicine; HCW: healthcare worker; PAPR: powered air-purifying respirator; PPE: personal protective equipment

Table IV. HCW contact log with COVID-19 patients by staff designation.

Variable	No. (%) of episodes of contact								
	Allied health	Ambulance	Doctor	Housekeeping	Nurse	Others	Porter	Security	Total
Mask									
N95	310 (86)	23 (96)	607 (92)	242 (96)	3,594 (92)	5 (100)	13 (93)	165 (76)	4,959 (91)
PAPR	43 (12)	0 (0)	35 (5)	5 (2)	231 (6)	0 (0)	0 (0)	24 (11)	338 (6)
Surgical mask	8 (2)	1 (4)	16 (2)	6 (2)	72 (2)	0 (0)	1 (7)	29 (13)	133 (2)
PPE									
Gown	294 (34)	22 (17)	578 (17)	235 (18)	3,407 (17)	5 (17)	13 (19)	139 (16)	4,693 (17)
Gloves	296 (35)	22 (17)	575 (17)	236 (18)	3,422 (17)	5 (17)	13 (19)	129 (15)	4,698 (17)
Face shield	211 (25)	12 (9)	513 (15)	211 (16)	3,139 (15)	5 (17)	10 (15)	127 (14)	4,228 (15)
Goggles	56 (7)	11 (8)	43 (1)	3 (0)	109 (1)	1 (3)	3 (4)	31 (3)	257 (1)
Contact time (min)									
< 5	72 (24)	1 (5)	153 (25)	77 (32)	870 (25)	0 (0)	1 (11)	44 (31)	1,218 (25)
5–10	70 (23)	2 (1)	221 (37)	57 (23)	1,093 (31)	0 (0)	1 (11)	35 (25)	1,479 (3)
10–15	75 (25)	6 (29)	131 (22)	53 (22)	721 (2)	0 (0)	4 (44)	30 (21)	1,020 (21)
15–20	43 (14)	7 (33)	44 (7)	36 (15)	344 (1)	0 (0)	2 (22)	17 (12)	493 (1)
20–25	12 (4)	0 (0)	15 (2)	10 (4)	143 (4)	0 (0)	0 (0)	3 (2)	183 (4)
25–30	8 (3)	2 (1)	18 (3)	3 (1)	118 (3)	1 (25)	1 (11)	9 (6)	160 (3)
> 30	26 (8)	3 (14)	22 (4)	8 (3)	247 (7)	3 (75)	0 (0)	3 (2)	312 (6)
Distance from patient									
Touched patient	174 (73)	2 (11)	338 (87)	75 (49)	2,337 (81)	0 (0)	3 (5)	58 (56)	2,987 (79)
1 m away	36 (15)	11 (58)	28 (7)	35 (23)	311 (11)	5 (1)	0 (0)	30 (29)	456 (12)
2 m away	9 (4)	3 (16)	13 (3)	22 (14)	53 (2)	0 (0)	1 (17)	7 (7)	108 (3)
No contact but in the same room	21 (9)	3 (16)	10 (3)	21 (14)	179 (6)	0 (0)	2 (33)	8 (8)	244 (6)

Percentages were calculated using the count in each category within a stratum (e.g. respiratory mask type) divided by the total count in that stratum, expressed as a percentage, for each staff designation. ARI: acute respiratory infection, DEM: Department of Emergency Medicine; HCW: healthcare worker; PAPR: powered air-purifying respirator; PPE: personal protective equipment

APPENDIX

SGH Campus: Staff Contact Log Sheet
(To be filled by all HCWs in contact with patient daily)

Patient's Sticker	**Department:**
	Ward:
	Room:
	Bed

S/N	Place of contact	Date of contact	Time of contact	Designation	Full Name	Dept	Mobile	NRIC								Mask?			PPE				Contact Time							Distance from patient				
																N95	PAPR	Surgical Mask	Gown	Gloves	Face Shield	Goggles	< 5 minutes	5-10 minutes	10-15 minutes	15-20 minutes	20-25 minutes	25-30 minutes	>30 minutes	Touched patient	1 m away	2 m away	3 m away	No contact but in the same room
1	*W68*	*25/01/20*	*13:30*	*SSN*	*Tan xxxx xxxx*			*S*	*1*	*1*	*1*	*1*	*1*	*1*	*E*	√			√	√		√			√						√			