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Original Article

Prospective health surveillance for COVID-19 among health care workers at a university medical center in Taiwan, January to June 2020

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Background: Healthcare personnel (HCP) at the front line of care are exposed to occupational hazards that place them at risk for infection, which then endanger patient safety and compromise the capability of the healthcare workforce. As of March 8, 2021 more than 420,170 HCP in US had been infected with SARS CoV-2 with 1388 deaths. In two Taiwan hospitals COVID-19 outbreaks involved HCP and resulted in shutdown of service. This report describes our prospective health surveillance of the HCP and COVID-19 containment measures in a teaching hospital in Taiwan during Jan. 1 through June 30, 2020.

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Methods: We prospectively monitored incidents, defined as an HCP with the predefined symptoms, reported by HCP through the web-based system. HCP were managed based on an algorithm that included SARS CoV-2 RNA PCR testing. Infection prevention and control policy/practice were reviewed.

Results: This hospital took care of 17 confirmed COVID-19 cases during the study period and the first Case was admitted on January 23, 2020. Among the 14,210 HCP, there were 367 incident events. Of 283 HCP tested for SARS CoV-2, 179 had predefined symptoms. These included 10 HCP who met the national case definition for COVID-19 infection and 169 based on Extended COVID-19 Community Screening program. The other 104 asymptomatic HCP were tested based on hospital policy. All of them had tested negative.

Conclusion: We attribute our success in preventing COVID-19 infections among HCP to rapid, proactive, decisive, integrated national and institutional response in the early stages of the epidemic

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Introduction

Taiwan has experienced epidemic/pandemic due to the novel coronaviruses SARS and novel influenza H1N1 and H7N9.^{1–4} Healthcare personnel (HCP) are at the front line of care and are exposed to occupational hazards that place them at risk for infection.^{1,2,5,6} Among 8096 SARS cases reported to World Health Organization (WHO) in 2003, 21.0% were in HCP.⁵ As of March 8, 2021 The US CDC reported that more than 420,170 HCP had been infected with COVID-19 with 1388 deaths.⁶ This report probably underestimated the number of cases since there was no systematic surveillance and reporting of infection in HCP.

Contagious infectious diseases are not only occupational hazards for HCPs, but also endanger patient safety and compromise the capability of the healthcare workforce. A WHO report in 2020 emphasized the rights of HCP in addition to their roles and responsibilities.⁷ The WHO and the International Labor Organization released a comprehensive manual in 2018 that provides guidance to protect HCP and respond to public health emergencies.⁸ National and international recommendations for risk assessment and management of hospital HCP working with patients infected with SARS-CoV-2 are detailed and publicly available. However, there is limited guidance on how to establish national and institutional policies to protect HCP in the context of COVID-19 pandemic.⁹ In this report we described our experience on implementing specific infection prevention and control (IPC) policy and practice (P&P) at a large teaching hospital in Taiwan during the first 6 months of the epidemic.

Materials and methods

Study design

This study was conducted at the National Taiwan University Hospital (NTUH). NTUH is a teaching hospital located in Taipei, Taiwan with a total of 2632 beds that provides both primary and tertiary care. We described control measures,

reviewed and analyzed health surveillance incidence reports from 14,210 HCP and the results of COVID-19 testing from January 1, 2020 through June 30, 2020. The study protocol was approved by the Research Ethics Committee of the hospital and complies with the category of exempt review.

Infection prevention and control policies and practices

The Incident Command Center for COVID-19 pandemic has established since January 23 at NTUH. Superintendent chaired daily briefing since Lunar New Year holiday and multidisciplinary or cross sector policies were made efficiently. The IPC P&P had escalated based on the information and requests from the government^{10,11} and hospital surveillance data and is outlined in Table 1. This includes control at the source, control along the path, control at the person level, and engineering and environmental controls.

Prospective, hospital-wide health monitoring and surveillance

The Center for Infection Control (CIC) and the Occupational Safety and Health Office (OSHO) at the NTUH are responsible for IPC P&P for occupational safety and health. The health status of the HCP is monitored through a web-based hospital-wide health surveillance and reporting system. HCP surveyed include full-time personnel and outsourcing personnel. The coordinator of each department reports to OSHO all HCP who develop predefined symptoms during the reporting interval. These symptoms are structured to detect potential emerging infectious diseases or epidemiologically important endemic contagious diseases. They include fever ($>38\text{ }^{\circ}\text{C}$), cough of unknown cause ≥ 5 days, diarrhea for 12 h, and skin rash > 2 days. The predefined symptoms were modified and included taste or olfactory disorder in the context of COVID-19 pandemic.¹² The head nurses are responsible to daily monitor HCP with close contact to a COVID-19 confirmed Case and report the findings to the CIC.

Table 1 The infection prevention and control policy and practice implemented or strengthened at National Taiwan University Hospital to protect safety and health of healthcare personnel (HCP) and patients in the context of COVID-19 pandemic.

Category	Policies and Practices ^a
Control at the source	Early Case finding and aggressive contact tracing SARS Cov-2 RNA PCR targeted testing Isolation for the sick and quarantine for those at risk COVID-19 specific isolation precaution implemented preemptively and deescalated based on risk and testing results HCP health surveillance and reporting
Control along the path	Double triage at emergence service entry ²⁰ Universal masking, hand hygiene, temperature check and visitor restriction at hospital entry Information technology-assisted risk assessment of COVID-19 exposure for patients with scheduled admission and selected outpatient services Telehealth for patients at risk Dedicated path for at-risk patients indicated for emergence/urgent healthcare Universal masking of all personnel in hospitals
Control at the person	Hand hygiene is emphasized and alcohol hand rubs are widely provided at hospital entry and hospital wide. Rational selection and appropriate use of PPE Buddy system and/or tele-monitoring for IPC compliance of HCP who enter the room of COVID-19 confirmed cases Hospital web-based education and technique training and buddy system for PPE; monthly training for residents in the dedicated COVID-19 units 30-min policy for HCP in negative pressure room ^a Policy for clean zones such as dining area and meeting room, etc. Environment surveillance of SARS CoV-2 contamination
Others	Stockpile and rationing of PPE N95 respirator reuse policy ^b Symptomatic patients with risk of COVID-19 (notified cases) are empirically isolated individualized in negative pressure rooms or in single-bed rooms. Asymptomatic patients with risk of COVID-19 are quarantined in single-bed rooms. Aforementioned patients are allocated in dedicated units or rooms. Portable HEPA filtration at high-risk area such as COVID-19 clinics, dedicated single room for COVID-19 notifiable cases in the absence of negative pressure room

Abbreviation: HCP, healthcare personnel; PPE, personal protection equipment.

^a This 30-min policy reminds HCP not to stay in negative pressure rooms for more than 30 min. In order to implement this policy HCP need to integrate bedside activities and proper design the workflow and involve appropriate HCP numbers. For example, two HCP work together as a team for chest care. This policy was developed based on SARS experience¹ in order to prevent risk of infection due to inadequate protection. This may occur after intensive bedside care which results in sweating and loosening of previously well-fitted N95 respirators.

^b Due to shortage of N95 respirator, we cover N95 with a surgical mask and remove surgical mask when leaving patient room and N95 is discarded after one shift (8 h).

Infection control personnel contact the head nurse or chief of the unit to clarify additional information concerning adequacy/appropriateness of personal protection equipment (PPE) and compliance of hand hygiene, the health of other colleagues in the same unit and provide interim suggestions such as environment cleaning accordingly.

The risk-based management algorithm for HCP with predefined symptoms is shown in Fig. 1. HCP are placed on a compulsory sick leave and stay at home, health self-management, and be tested by SARS CoV-2 RNA PCR at the emergency room (ER) or COVID-19 clinic, or be admitted for isolation or quarantine. Table 2 provides the policies regarding SARS CoV-2 RNA PCR targeted testing and HCP returning to the workplace.

Case finding and contact tracing

The government started border quarantine rapidly after detecting the possible COVID-19 cluster news at Wuhan.¹³ COVID-19 is announced as category V notified diseases on January 15 and any patient who fulfilled Case definition should be reported to Taiwan Centers for Infection Control (CDC) within 24 h.¹⁴ CDC case definitions were modified based on global and local situations very frequently in the early phase of COVID-19 pandemic.¹⁵ Patients who fulfill COVID-19 notified case definition are managed as confirmed case which include traffic control during transfer, hospitalization at special units, HCP PPE, environment cleaning protocol, and de-isolation based on predefined criteria.¹⁶ Infection control personnel and public health

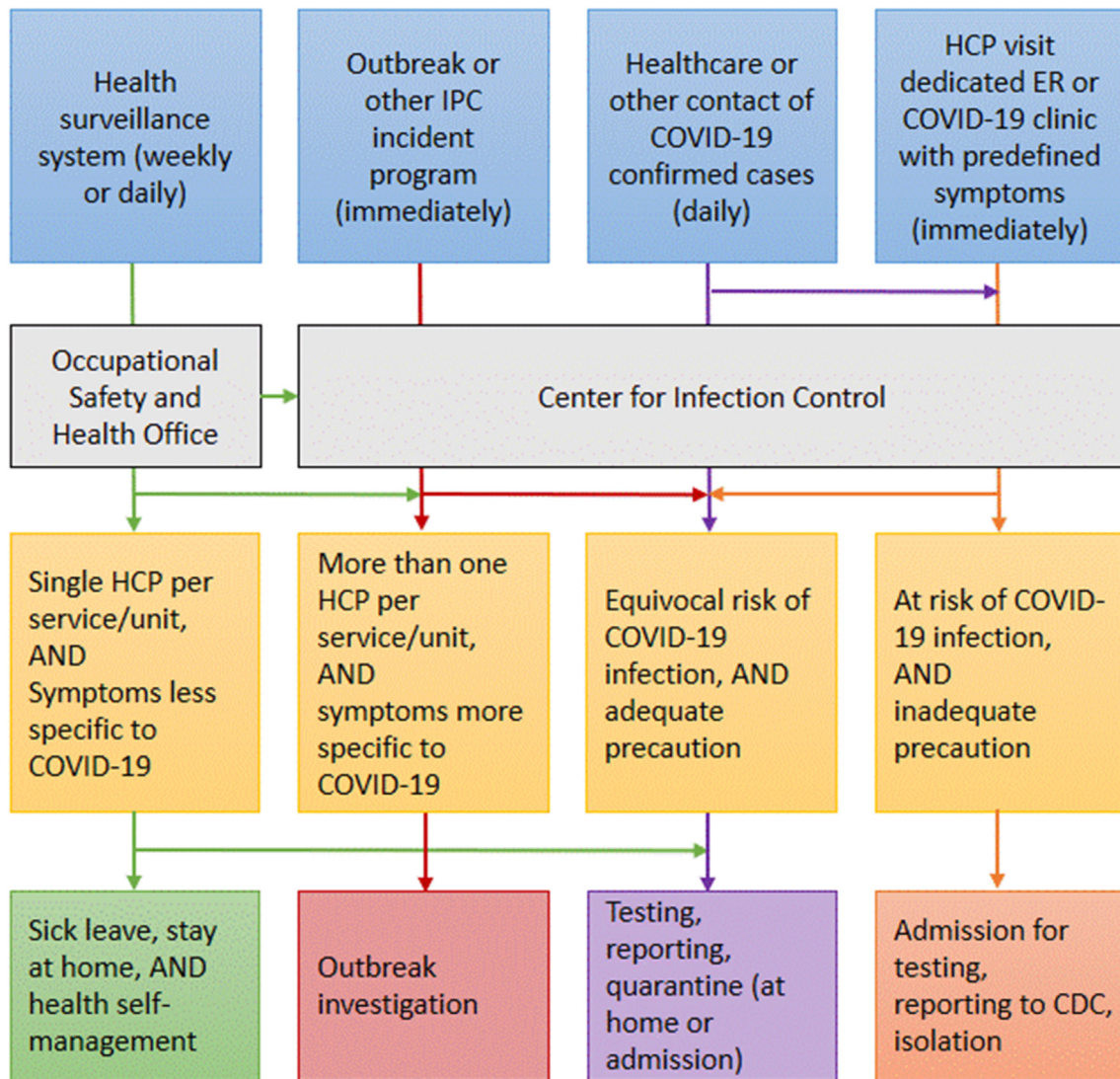


Figure 1 Risk-based management algorithm for healthcare personnel with one or more predefined symptoms.

personnel work together to trace every contact (including HCP, patient and their care givers) for every COVID-19 confirmed cases and adopt risk based stepwise infection control measures based on Taiwan CDC's suggestion.¹⁷ Emergency Department physicians and infection control personnel cross talked for joined decision, updated and announced the policy by 8 am every day. We adapted CDC policies with modification regarding SARS CoV-2 RNA PCR testing and patient isolation/quarantine. This is because the physicians at the front line are more sensitive to the evolution of epidemiology or clinical presentation of the disease. Our practices and findings are efficiently feedback to Taiwan CDC for modifying case definition or other policies accordingly.

Indications for SARS CoV-2 RNA testing

SARS CoV-2 RNA PCR testing was established at NTUH on January 21.¹⁸ There are six indications for COVID-19 testing for HCP at NTUH in addition to national policies, three for

those with symptoms and three for those without symptoms (Table 2). Nasopharyngeal swabs for SARS CoV-2 testing are collected in dedicated area equipped with portable HEPA filters. The HCP take a sick leave and go home wearing surgical mask and avoid public transportation system. Home isolation and prevent contact with household members are suggested before result is available or other suggestion. For indication 1 (staff with symptoms after exposure to confirmed Case), admission was arranged if the primary care team judged as high risk for COVID-19 infection or home isolation was not feasible. The CIC pursue the report and inform the HCP. The policies for returning work place are well defined by the government and hospital.¹⁹

Outbreak or other IPC adverse events investigation

Considering the limitation of hospital wide health surveillance system and limitation of predefined symptoms, the hospital provides a blame-free environment in which HCP can report an incident, including a suspected clustering of

Table 2 Indications for SARS CoV-2 RNA PCR testing for healthcare personnel at National Taiwan University Hospital.

Policy	Category	Symptoms	Indication or clinical scenario	Prerequisite for returning to work place
COVID-19 notified cases ^{a,b}	1	Yes ^c	Close contact to a notified Case without appropriate precaution (PPE and hand hygiene) ^d	If test is negative twice performed 24 h apart and symptoms resolve, HCP can return to workplace after 14 days of isolation and 7 days of self-health management ^e .
	2	Yes ^c	Returning from an overseas travel whose departure occurred before government announce travel ban/restriction	
Extended COVID-19 Screening program ^{b,f}	3	Yes	Pneumonia (national policy since February 16); any symptoms ^c and physicians deem indicated for testing (NTUH policy in late January which has become national policy since March 30) in the concern of community spread of COVID-19. ^g	Test negative twice, and afebrile for more than 24 h in the absence of antipyretic, and improvement of respiratory symptoms ^{f,g}
Hospital policies	4	No	Close contact to a confirmed COVID-19 Case without appropriate precaution (PPE and hand hygiene) ^e	a. Test negative
	5	No	Returning from an overseas travel whose departure occurred before government announce travel ban/restriction (overseas travel before March 19)	b. According to clinical judgment of risk of exposure
	6	No	Compulsory self-health management according to national policy	Test negative after 14 days of home quarantine Test negative after 14 days of self-health management

Abbreviation: PPE, personal protection equipment; TOCC, travel, occupation, contact or cluster.

^a Definitions COVID-19 notified cases are modified timely.

^b Report to Taiwan CDC within 24 h and budget of SARS CoV-2 RNA PCR testing and hospitalization is provided by the government.

^c Symptoms are the clinical criteria of COVID-19 notified cases and include fever ($\geq 38^\circ\text{C}$) or symptoms of acute respiratory tract infection; abnormal sense of smell, abnormal sense of taste, or diarrhea of unknown etiology; community-acquired pneumonia highly suspected to be COVID-19 by doctors.

^d For national surveillance definition, the exposure among healthcare setting was defined as exposed to confirmed COVID-19 patients while HCPs did not wear surgical mask or HCPs who did not wear N95 while perform aerosol inducing procedures for the confirmed patients. <https://fightcovid.edu.tw/cdc-guidelines/clinical-management> (Accessed August 5, 2020).

^e The management algorithm for notified COVID-19 cases <https://www.cdc.gov.tw/File/Get/I7wzpz6abxPz7rfngl30h4w> (Accessed August 5, 2020).

^f The management algorithm for HCP in the Expanded COVID-19 Screening Program. <https://www.cdc.gov.tw/File/Get/gF4KQb15h2Du49KW-sOqA>. "The management algorithm for general population in Expanded COVID-19 Screening Program" https://www.cdc.gov.tw/File/Get/8PLAUhmzG6iZ_CEhmj44Jg. (Accessed August 5, 2020).

^g Return to work Guideline for Healthcare Workers (HCW) Involved in Expanded COVID-19 Screening Program. <https://fightcovid.edu.tw/cdc-guidelines/return-to-work-guidelines-for-healthcare-worker> (Accessed August 5, 2020).

infection in the unit, exposures to blood or bodily fluids, or inadequate compliance of PPE or other IPC during taking care of COVID-19 patients. In addition, the head nurse or chief of each hospital services should inform the CIC immediately if any suspicion of clustering of infection occur involving HCP or patients or bedside care giver in that unit. The CIC will initiate investigation immediately. Reporting tightly incorporated into investigation and management. The government has announced guidance for the situation that any inpatient is diagnosed as COVID-19 during hospitalization or HCP is diagnosed as COVID-19.²⁰

Patient triage and traffic control bundles

During epidemics, identifying and separating patients with exposure risk at first point of contact with the healthcare system is particularly important to prevent and minimize

exposure risk of HCP, other patients, their companion or visitors. Patients are triaged outside the emergency rooms²¹ and at hospital entry of outpatient clinics. Patients are guided by the announcement and instructions which are posted at hospital entry sites and at hospital website, telephone or message. Patients at risk of COVID-19 are directed to a designated area/room where they are placed in individual isolation rooms for further evaluation and/or collecting nasopharyngeal aspirate for SARS CoV-2 testing. Dedicated COVID-19 clinics started since January 29, 2020 for patients with possible COVID symptoms, exposure history, or recent overseas traveling. These clinics are located outside the main hospital buildings and designed as special clinics during pandemic influenza in 2009. Patients were managed based on risk of COVID-19 at emergency rooms or COVID-19 clinics where dedicated environment design, PPE, and standardized management algorithm.

Hospital entry control

Before this pandemic almost all of the hospitals in Taiwan had very limited if any control at hospital entry point except during 9pm and 6am. Three measures are implemented stepwise at hospital entry sites, wearing masks, temperature check, and restricted hospital visits. The government requests all should wear face masks when enter hospital since Jan 31. Temperature check for all patients and visitors is conducted using infrared thermal imaging cameras and/or forehead thermometers. The government restricted hospital visits stepwise to protect healthcare settings.²² These restrictions include the number and duration of visitors or bedside caregivers. The hospital is responsible to keep the name and contact information of these care givers and visitors for 28 days just in Case that they will be informed if a clustering of infection occurs in the unit. Any patient, visitor or HCP who has potential risk such as oversea travel in the preceding 14 days is not allowed to enter the hospital with exemption.

Information technology-aided risk assessment

Risk assessment is conducted for patients or visitor to restrict the hospital entry. For more stringent control and avoid intentional deny important epidemiologic history, the personnel information for international travel and contact of confirmed cases are integrated with the National Health Insurance (NHI) database by the government.^{10,23} We designed working stations at hospital main entry sites and check every visitor's NHI card to confirm aforementioned information. Alternatively, TOCC information is collected using a questionnaire. The patient lists for scheduled admission or selected outpatient service are checked the night before and at 7am at the scheduled day for any COVID-19 risk based on aforementioned database. Scheduled procedure or admission is subjective to postpone and reschedule. Patients with COVID-19 risk and indicated with emergent or urgent healthcare are referred to the emergency department for further management.

Personal protection equipment

The government announced the policy regarding wearing face masks in the community²⁴ and PPE use in the healthcare settings,²⁵ rationing of PPE and surge capacity of PPE production.²⁶ Nevertheless, shortage or unstable supply of PPE occurred during the first few months. The hospital rationing and prioritization of PPE use. PPE use is based on risk categories, due to both the scientific evidence and also the supply. The PPE reuse policy is clearly defined. N95 fit test and seal check are emphasized.

Engineering and environmental control

Notified cases were isolated in negative pressure room or single room with portable HEPA filters before PCR confirmation. The high risk or confirmed cases were allocated in COVID-19 wards. The low risk patients were allocated in negative control pressure room in general wards before test result were available.

Environmental cleaning was strengthened, particularly in dedicated high-risk areas. These include personnel assignment and training, frequency and protocol of cleaning. The quality of cleaning was assured at COVID-19 care area using a fluorescent marker²⁷ and/or SARS CoV-2 RT PCR.

Policy for clean zones

The government announced restriction or precaution for outdoor mass gathering or indoor meeting,²⁸ On-site meeting is limited to 50 persons or less. Webinar or teleconference are encouraged. Participants wear masks and/or keep social distance for 1 m or more. Along with minimal numbers of individuals in any given space, screens were set up to prevent droplet transmission while HCP are unmasked and in close proximity in dining area. All these P&P avoid cross transmission between HCP.

Education

During epidemics the government announces update guidance²⁹ and visits the hospital to check their performance. For example, the government requested the hospital to provide education for all HCP for COVID-19 within one month and visited NTUH in February to check triage process, traffic control and the dedicated units for taking care of patients with suspect COVID-19. Under the challenge of COVID-19 pandemic, CIC organized PPE training on NTUH on-line education system again. To minimize the risk of exposure and spread, clinical care should at all times adhere to standard precautions including hand hygiene. PPE education is included in orientation training course for new employee. Dedicated COVID-19 PPE training is conducted for residents who rotate to intensive care units or COVID specific wards. All residents who would rotate in the ICUs (mainly resident year 2–5) were asked to field exercise putting on and removing PPE under the instruction of their colleague (senior residents or senior nurse practitioners) as a buddy system. In addition, CIC arranged PPE training for HCP of radiology, respiratory care and other supporting personnel and conducted simulations of contaminated PPE removal using a fluorescent marker.³⁰

Data collection and analysis

The following data were prospectively collected for the HCP: predefined incident events reported through health surveillance system, results of SARS CoV-2 RNA PCR tests, and HCP admission for isolation or quarantine. An incident event reported is defined as an HCP with one or more predefined symptoms during a reporting interval (weekly or daily).

Results

Seventeen patients with confirmed COVID-19 infection were admitted to NTUH during the study period. The first confirmed Case was a traveler from Wuhan, China. She was admitted on January 23 through a dedicated emergency department path for COVID-19.¹⁸ All patients survived. The final patient was discharged on June 18, 2020.

Among the 14,210 HCP there were 367 incident events (2.6%), with a median of 2 events per day (range, 0–13). The number of HCP incident reports at the NTUH and concurrent confirmed cases of COVID-19 in Taiwan are shown in Fig. 2A. There was only a small proportional spike among the HCP during the peak of the epidemic.

A total of 283 HCPs were tested for COVID-19 during the course of the study, Fig. 2B. Of these 179 had predefined symptoms and 104 were asymptomatic, but at risk of acquiring infection. Many of the tests, 169/283 (59.7%), were performed as part of the Extended COVID-19 Screening Program. Ten of the 169 (5.6%) HCP with predefined symptoms met the Case definition for COVID-19 infection. The 104 asymptomatic HCP were tested based on hospital policy. These included exposure to confirmed cases before isolation in a negative pressure room ($n = 29$), overseas travel ($n = 64$) and a national self-health management regulation ($n = 11$). None were found to have a positive RNA PCR. Of 64 HCP who were hospitalized for isolation or quarantine, all had mild symptoms and all recovered.

Discussion

Taiwan is a crowded country and close proximity to China, the epicenter of COVID-19. Nevertheless, it is one of the few countries with the lowest number of cases.³¹ As of March 9, 2021, there have been only 977 cases in Taiwan (41 cases per million population), most of which, 861 (88.1%), were

imported from abroad.³² The national infection control program along with our IPC and prospective health surveillance practices in NTUH have achieved zero COVID-19 Case among our HCP. Another small surveillance ($n = 195$) conducted at a medical center in Taiwan also revealed negative infection among HCPs.³³ We attribute the current success to Taiwan's experience to the SARS epidemic in 2003. Besides, we used a hospital-wide web-based health surveillance integrated with a risk-based management algorithm and molecular testing of asymptomatic HCP. This allowed us to rapidly identify HCP at risk of infection and prevent spread to other HCP and patients.

HCP could acquire SARS-CoV-2 at work through direct or indirect contact with infected patients or other HCP, or as a result of ongoing community transmission. Lai X et al. described spread of SARS-CoV-2 to HCP during the early stage of the outbreak in a tertiary care hospital in Wuhan.³⁴ The major routes were contact with infected patients (59%), colleagues (11%), and from the community (13%). Cheng et al. used a bundled approach to escalate the infection control response in Hong Kong.³⁵ Similar to what we have done, these included active and enhanced laboratory surveillance, early airborne infection isolation, rapid molecular diagnostic testing, and contact tracing for HCP with unprotected exposure in the hospitals. On the other hand, a recent data based on whole-genome sequencing of SARS-CoV-2 collected from patients and HCP during the first two weeks in three hospitals in the Netherlands suggested multiple introductions into the hospitals through community-acquired infections.³⁶ Thus, one of the key

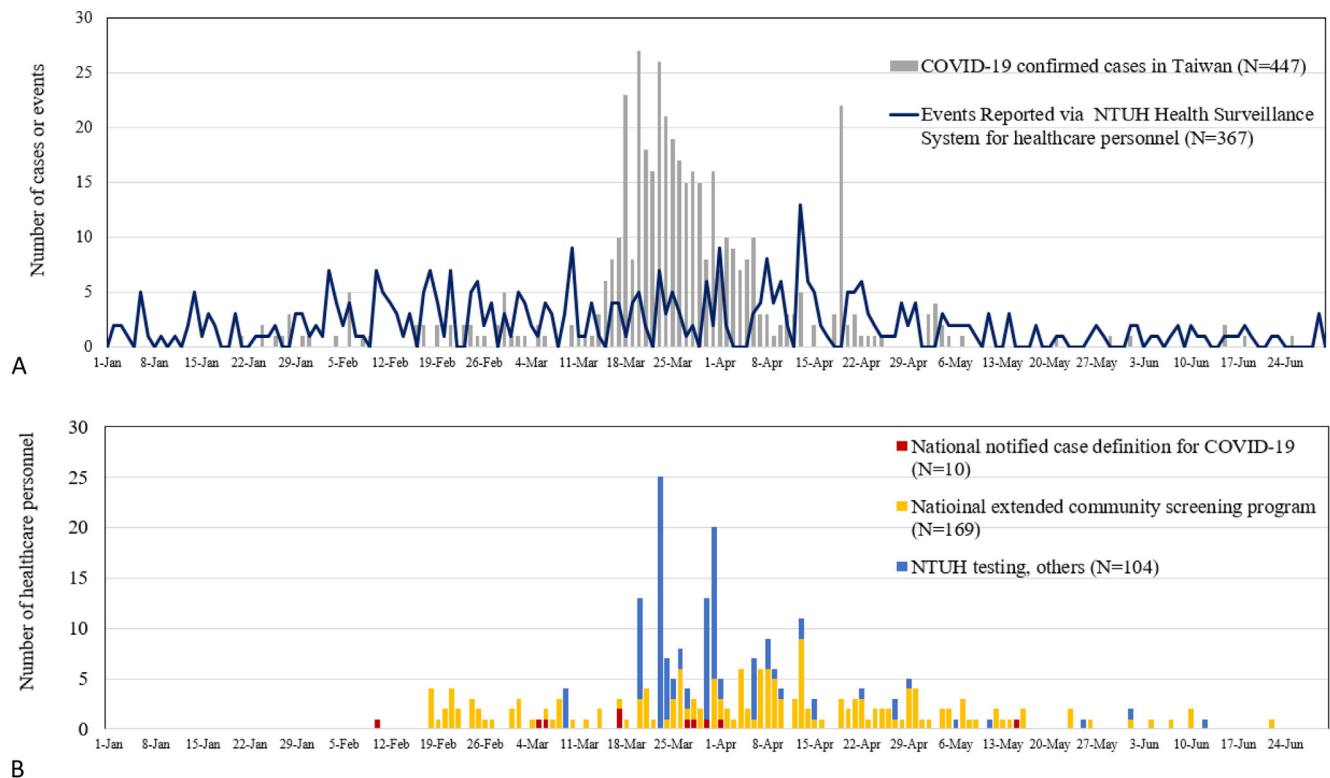


Figure 2 The numbers of healthcare personnel reported with one or more predefined symptoms through web-based hospital-wide health surveillance system (A) and those received SARS CoV-2 RNA PCR testing at National Taiwan University Hospital as of June 30, 2020 (B).

factor to support safety and health of HCP (as well as patients and visitors) is the control of COVID-19 at the source at national level. In addition to border control, travel restriction/ban, contact tracing and home isolation/quarantine in the community, the government recommended the universal use of mask in the healthcare settings and encouraged wearing mask for the public early in the pandemic which might prevent potential asymptomatic or presymptomatic transmission.²²

Several major hospitals in Taiwan had to be completely or partially shut down because of spread of SARS to patients, caregivers and HCP.³⁷ The epidemic exerted a severe negative impact on the economy and trust in government. This led to development of a national initiative to conduct nationwide annual hospital IPC audits. The audits emphasized and strengthened organization, P&P, hand hygiene, bundle cares, health surveillance, outbreak investigation, and EID preparedness. Hand hygiene and wearing masks for respiratory hygiene and cough etiquette were promoted to the public particularly during the influenza season. In addition, the government announce P&P to prevent influx of cases into medical centers. Notified cases were treated at dedicated hospitals well distributed nationwide and transfer need preapproval by commander of regional medical network. Thus, as of June 30, 2020 only 17 (3.8%) of 447 confirmed cases in Taiwan were hospitalized at this hospital. This is contrast to the situation during SARS epidemic in 2003 that NTUH reported 270 cases and treated 180 of 665 cases reported to Taiwan CDC.³⁸ Recent studies suggested late recognition, longer duty hours, sub-optimal compliance to hand hygiene, lack of proper PPE are the risk factors associated with COVID-19 infection among HCP.³⁹ The root cause of these factors is overwhelming influx of patients into hospitals but no countermeasures. This is what we learned from SARS that in the absence of national policy and regional network, it is almost impossible to contain or mitigate outbreaks at hospital levels. On the other hand, there are hospital cluster COVID-19 infections noted in Taiwan during the long fight with COVID-19. These included 21 locally transmitted cases diagnosed during January 2021 and were related to a regional hospital which was designated for COVID-19 care. It highlights the importance and also the difficulties to maintain high suspicious and comply with IPC policy and practice. Thus, while the COVID-19 vaccination campaign started globally, vaccination should be another important infection-control component to protect the health of HCP on the front lines.

The strengths of the current study include our ability to have learned lessons from the SARS outbreak. This stimulated us to prepare, prior to the outbreak, institutional IPC programs, a web-based surveillance of HCP, and using pre-determined criteria which integrate clinical and epidemiological risks to early identify new cases. COVID-19 tests became available shortly after the onset of the outbreak.^{17,40} We believe these zero tolerance measures account for absence of infections in HCP.

This study has several limitations. First of all, the zero hospital-acquired infection during the study period was based both on the compliance of national guidelines and program, as well as the low prevalence of community COVID-19. Thus, the study result may not be generalized in

the presence of high activity of community spread of COVID-19. In that situation, additional strategies are warranted. Second, the HCP were exposed to only 17 confirmed cases during the study period, but 29 HCP were exposed to confirmed cases before they were isolated in negative pressure rooms and 64 HCP returned from countries where COVID-19 outbreak in the community were confirmed. None of the HCP became infected. A study from Korea showed that none of 184 HCP exposed to 13 patients with COVID-19 before recognizing their disease infection was infected based on molecular testing.⁴¹ A recent review based on available data from⁴¹ countries showed the median HCP infection percentage among total cases was 10.04% (range 0–24.09%) and countries in Asia seem to have lower infection rates among HCPs (<3%).⁴² This could possibly be attributed either to the readiness of these countries to deal with outbreaks. The third limitation is that the diagnosis of COVID-19 infection in this study is based on RT-PCR for HCP with symptoms or epidemiological risk. Some may argue there may have asymptomatic infection among the HCP remained undiagnosed in the absence of periodical mass screening program. Through another cross sectional study in this hospital during July 1 to Aug. 31, 2020, all of the participated HCP (n = 194) were seronegative, too.⁴³ Thus, the finding is in line with our study to demonstrate the importance of an IPC policy and practice in the hospital level and national level.

Conclusions

Early initiation and full implementation of a timely risk-adjusted, integrated national and institutional IPC policy and practices were successful in protecting HCP from COVID-19 infections.

Author contributions

YC Chen had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: YC Chen.

National and institutional policy: YC Chen, SC Chen, SC Chang.

Laboratory support: SY Chang.

Acquisition, analysis, or interpretation of data: MC Hsu, HH Chang, YL Lai.

Drafting of the manuscript: YC Chen, SC Pan.

Critical revision of the manuscript for important intellectual content: all other authors.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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