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Prevention and Control Measures for Imported SARS-CoV-2 Transmission During the Postpandemic Period in Shenzhen, China

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Abstract

In China, most cities have gradually controlled the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and brought coronavirus disease 2019 (COVID-19) under control locally. This means that crucial work has shifted from internal management of the pandemic to external prevention and control, especially management of international travelers and imported goods. There is much uncertainty about variants of concern for SARS-CoV-2, which pose challenges to the steady resumption of social and economic life once the mutant strains begin to spread. The sporadic outbreaks of COVID-19 in different provinces of China caused by these mutant strains emphasizes the need for both prevention and control measures. Therefore, we introduce China's experience with preventing and controlling COVID-19 in the postpandemic period, which may serve as a reference in various settings.

Import-Related Transmission Challenges That a Country in the Postpandemic Period Might Face

In the postpandemic period of coronavirus disease 2019 (COVID-19) in China, the domestic spread of severe acute respiratory syndrome 2 coronavirus (SARS-CoV-2) has been controlled in general; however, the imported-related spread has become a challenge to the resumption of social and commercial life.

In the postpandemic period, imported cases of the virus have become a major obstacle to the eradication of COVID-19. Increased global air travel greatly expedited the spread of COVID-19 throughout the world, even faster than it did for SARS.¹ At the end of February 2020, the number of imported COVID-19 cases in China had increased dramatically. By March 13, 2020, it had become a major challenge, as the number of new imported cases exceeded new indigenous cases (7 vs 4). Subsequently, all 39 new cases on March 19, 2020, were imported cases. Moreover, the first secondary infection from an imported case was reported on March 21, 2020, in Guangdong Province, followed by 2 more secondary cases in Shanghai and Beijing 2 d later.²

Additionally, with the resumption of social and economic activities in mainland China where the domestic epidemic was generally controlled, the number of cluster activities involving families and/or friends began to increase. If management of imported COVID-19 cases failed to be strict or to enforce precautions, citizens would likely be exposed to foreign strains of the virus flowing into their communities and, thus, start a new transmission chain.

After the government called for the resumption of normal social and commercial activities with appropriate personal protective equipment (PPE), there were intermittent viral outbreaks at the city level. Most of the index cases in these sporadic outbreaks were found to be highly homologous with mutant strains of the virus that appeared in foreign areas and were confirmed by genome sequencing. This indicated that the management of imported cases had become the priority in preventing and controlling COVID-19 in China.

The May 2021 Outbreak in Guangdong Province Caused by Imported Viral Strains

Recent outbreaks of COVID-19 occurred sporadically in Guangdong Province. On May 21, 2021, Guangzhou reported domestically symptomatic cases,³ while Shenzhen reported a domestically asymptomatic case.⁴ However, the strains of the virus in the 2 cities were tested with genome sequencing and found to be different. The viral strains in Guangzhou were highly homologous with the mutant strains of the virus in India, and all the symptomatic and asymptomatic cases diagnosed through mass screening in the city in the following days were found to be infected by the same mutant strains of virus. Nevertheless, the source of transmission in

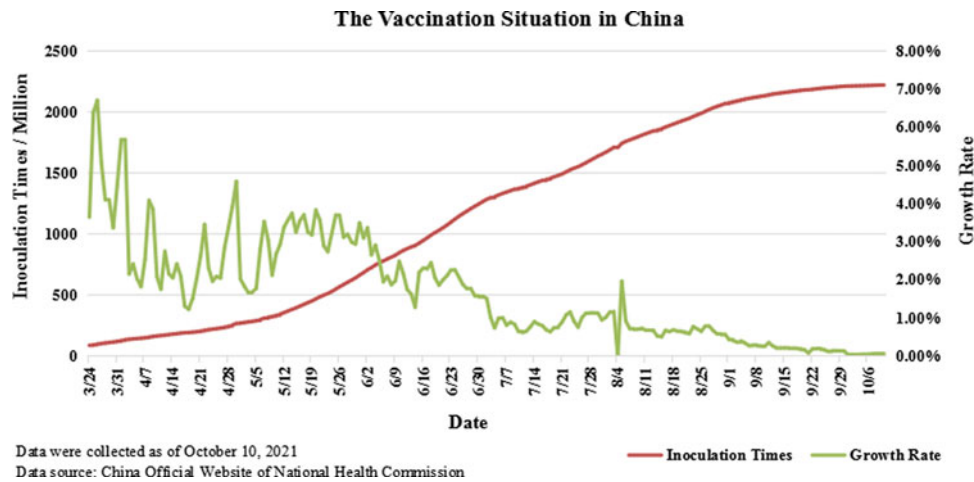


Figure 1. Vaccination inoculation and growth rate in China since March 24, 2021.

Guangzhou City was difficult to define, whereas the source and chain of transmission in Shenzhen City were easier to identify and to trace because transmission occurred among a focused population group and workplace where nucleic acid testing was performed at 7-d intervals. Notably, the source of transmission in Shenzhen City was a mutated strain from the United Kingdom, pointing to an international freighter named the Oriental Vancouver that had arrived in Yantian Port on May 17; all 6 infected employees of Yantian Port had participated in the same operation on the freighter, and after their exposure at work, the virus was introduced into the community. The outbreak in Guangzhou indicated that the foreign mutant virus had been spread by person-to-person transmission, while the outbreak in Shenzhen suggested the possibility of an object-to-person transmission of the imported mutant virus, which pointed out a new challenge to import-related management.

Management of Import-Related Transmission in Mainland China

The Necessity of Implementing Strict Import-Related Management

The main transmission mechanisms of SARS-CoV-2 have been confirmed to be droplet transmission and contact transmission. However, the possibility of other transmission pathways could not be eliminated. In January 2020, there were 5 diagnosed cases of COVID-19 among the residents of 2 apartments in the same building but on different floors in Hong Kong. In a similar incident, the COVID-19 outbreak on the Diamond Princess Cruise reported on February 26, 2020, resulted in more than 700 cases, although all the passengers on board had kept physical distance from each other. These cases with remote transmission elucidated the possibility of aerosol transmission. Additionally, the possibility of indirect transmission can be proven by recent evidence from published literature that indicates the virus can live on material surfaces from hours to days,^{5,6} which means that people can become infected by touching something polluted by an infectious source or talking closely with infected persons. Thus, it is necessary to adopt strict protective approaches such as proper PPE, frequent hand washing, and regular environmental decontamination. In

addition, the diverse transmission pathways force prevention and control measures to be more comprehensive to cut off transmission as soon as possible.

Additionally, since the vaccines for COVID-19 were introduced and inoculations began in early 2021, Figure 1 shows that the number of inoculations has exceeded 2.2 billion in China at the end of September; however, that number should be at least 2.82 billion (2 times per person and 1.41 billion people totally in China). Figure 1 also presents that the growth rate of vaccination inoculation has become slowed since September, there is a long way to achieve herd immunity.

Although the vaccine for COVID-19 was developed and delivered worldwide, the vaccination rate is not high enough to achieve herd immunity, and persistent mutation of the virus might impact the efficacy of the vaccines.⁷ Prevention and control measures for foreign visitors and imported goods should be strictly applied before the effectiveness of vaccines can be identified to what extent influenced by the SARS-CoV-2 variants of concern (VOCs) and herd immunity can be achieved. These measures are necessary at this stage to prevent a secondary outbreak of COVID-19.

Policies and Guidelines for Management of Potential Imported COVID-19 Cases

In terms of the prevention and control measures around the world, awareness of import-related management is constantly growing. Since April 2020, a total of 96% of destinations with international airports or cross-border ports have implemented importation-related restrictions.⁸ An increasing number of countries require individuals who have traveled outside of their borders to undergo 14 d of self-isolation at home after they return and complete customs inspections.

In China, a series of official guidelines are published and updated alongside the pandemic development process to provide standardized guidance at the country level. Importation management content appeared in the 7th edition of official guidelines published in September 2020, adding the definition of imported cases, the details of importation control measures, and the healthcare management in communities. The latest version (the 8th edition) issued on May 14, 2021, clearly emphasized the requirements of managing international arrivals and imported goods equally (see Table 1).

Table 1. The evolution of official countermeasure guidance published in China regarding the importation management of COVID-19

Edition	Date	Involvement of importation-related control		Recommendation of quarantine approach for imported case		Gene sequencing required for the index domestic case	Equally managing international arrivals and imported goods
		Mentioned	Details of measure	Home-quarantine	Quarantine in central		
2 nd	22/01/2020	-	-	✓	✓	-	-
3 rd	28/01/2020	-	-	✓	✓	-	-
4 th	12/02/2020	-	-	-	✓	-	-
5 th	22/02/2020	-	-	-	✓	-	-
6 th	07/03/2020	✓	-	-	✓	-	-
7 th	15/09/2020	✓	✓	-	✓	✓	-
8 th	14/05/2021	✓	✓	✓	✓	✓	✓

Results

Developing a Series of Measures for Importation Management in Shenzhen

In the postpandemic period, the biggest challenge is to allow normal social and economic activities while carrying out pandemic prevention and control work, which also requires the city or the community to be able to cope with an outbreak. Thus, in this section, the study will introduce countermeasures for pandemic prevention and control involving the multisector efforts in Shenzhen, which focus mainly on importation management. The greatest difference between prevention and control is that the former is a series of tasks taken before an outbreak, while the latter is a series of containment measures taken after the outbreak.

Preventive Measures

The continuous process of preventing imported virus transmission in Shenzhen can be found in [Figure 2](#) and [Table 2](#), which consists of 4 steps and involves multiple governmental departments and social institutions.

First, at all international airports in China, the Civil Aviation Administration of China (CAAC) reduced the number of international flights according to the infectious risk classification of foreign countries and limited the number of passengers to no more than 75% of capacity for each flight. The international airport of Shenzhen dynamically adjusted the number of international flights per these requirements and effectively supports the pandemic prevention work. The local customs office and local Center for Disease Control and Prevention (CDC) are responsible for arranging temporary areas for importation-related checking and complete epidemiological investigation for international arrivals, respectively. After clearing customs, all international arrivals are required to undergo nucleic acid testing in isolated areas separated from domestic airline gates. Then, depending upon test results, these passengers will be processed accordingly. Statistics available from the official local government website from March 1, 2020, to September 14, 2021, the number of positive cases and asymptomatic cases among passengers on these flights has totaled 146 and 317, respectively.

Second, the local government receives arrivals' information and arrival times and sends the list to regional shuttle teams who are responsible for arranging and transferring them to designated quarantine places or local residential areas for home quarantine. Arrivals who obtain positive results are transported immediately

by negative-pressure ambulance to the locally designated hospital for further examination and medical treatment; others who test negative are quarantined for a 14-d medical observation in designated places.

Third, when individuals arrive at the centralized quarantine location, the responsibilities are handed over to multisectors including the medical staff team, health supervision and management team, security team, and support team. The health management and supervision team is responsible for the overall coordination of work at the quarantine site as well as supervising and standardizing the prevention and control tasks. The medical staff team is appointed by the health management and supervision team and is composed of individuals from regional primary care and medical institutions, who monitor the health conditions of those in quarantine. The security team is composed of police personnel and security guards, who mainly focus on the safety and access control of the designated quarantine site. To guarantee sufficient daily materials and environmental cleaning, there is a support team consisting of original hotel staff, street office specialists, and professional companies specializing in environmental disinfection and medical waste disposal. Notably, arrivals during the centralized quarantine period undergo at least 2 mandatory nucleic acid tests.

Finally, community management is the last measure of transmission prevention. International arrivals with a negative result on nucleic acid testing by the end of quarantine can proceed to community management. In the normalization period, community management plays a significant role in preventing pandemic outbreaks as the number of asymptomatic cases increases and the incubation lengthens. In addition to usual community management, different durations of home quarantine will be implemented according to the risk posed by the areas the individual came from.

The community gridding management system has been widely adopted in normalized prevention and control periods, and a cooperative model called Trinity is used in several cities.

Each Trinity team in the community involves 3 persons, including 1 community workstation staff, 1 community police officer, and 1 medical staff member from a primary care institution. If home quarantine is required, the street administration office will receive a list and then allocate the follow-up mission to the corresponding Trinity team. In addition, the government encourages residents to register as local volunteers and assist quarantined returnees in obtaining the things they need while isolated.

After the community workstation issues the notice of home-quarantine requirements, the Trinity team will visit the

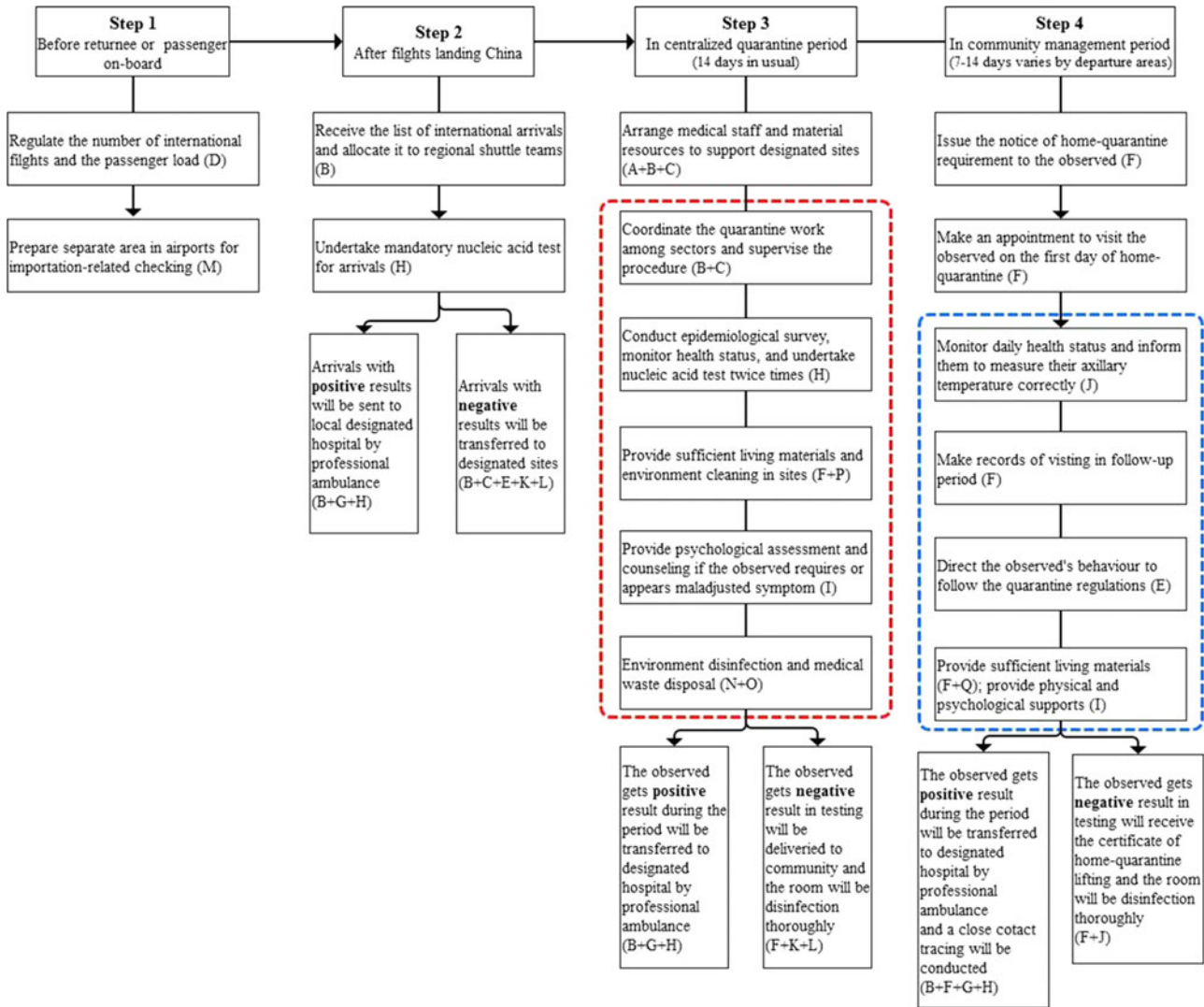


Figure 2. The process of importation preventative management and the departments involved. Please refer to Table 2 for details about the codes using capital letters that represent personnel from multiple sectors. The measures within the dotted line are carried out simultaneously.

quarantined individuals. The medical staff from primary care institutions are responsible for monitoring the daily health status of those being observed, guiding them to monitor their body temperatures more sensitively and emphasizing the precautions of quarantine at home. The community station specialist makes detailed follow-up records while the police officer reminds those in home isolation to comply with the quarantine regulations and the quarantine.

If the patient has a fever and respiratory symptoms during the isolation period, the Trinity will arrange to transfer them to a regional fever clinic for nucleic acid testing and temporary medical observation. Those who test positive will be delivered by negative pressure ambulance to the local designated hospital for treatment.

Control Measures

If there were any positive symptomatic or asymptomatic cases that failed to be screened out in the prevention phase, emergent control measures come into play. The implemented control measures in Shenzhen are close contact tracing, area risk classification, and large-sample screening.

Once a positive nucleic acid test result appears, the Trinity team in the community coordinates the regional CDC and local public security bureau to carry out close contact tracing for epidemiological investigation. After completing the tracing, a list containing the key screening population is generated and delivered to the local medical care system and community workstation so that they can conduct a mass screening with different frequencies based on the disease situation. The process requires not only sufficient human and material resources to be gathered within a short time but also a highly efficient ability to screen a large number of people in a timely manner. For instance, in the May 2021 outbreak in Guangdong, Guangzhou and Shenzhen conducted mass screenings to detect infected residents to cut off the transmission chain. The source of the Shenzhen outbreak was relatively clear; thus, daily mass screening was adopted for residents living in the district. However, it could only confirm that the strain of virus popularized in Guangzhou was the mutant virus from India, so the residents in Guangzhou were required to undergo nucleic acid testing twice in 3 d.

In addition, the risk classification evaluation is applied to each subdistrict in China to decide on tailored prevention and control

Table 2. Details and codes of multiple sectors involved in importation control procedures

Category of Job content	Related department	Personnel (code)
Management and coordination	Hospitals	Administrative manager (A)
	COVID-19 emergency command department	local government staff (B)
	Health supervision and enforcement department	Health supervision and enforcement personnel (C)
	Civil Aviation Administration	Specialist (D)
	Security department	Policeman and Security staff (E)
	Community workstation	Staff in workstation (F)
Medical and health care	Centers for Disease Control (CDC)	CDC specialist (G)
	Hospitals	Medical staff (doctor and nurse) (H)
		Psychologist (I)
	Primary care institutions	Medical staff (GP and nurse) (J)
Supporting sectors	Local government departments	Foreign affairs officer (K)
		Driver (L)
	International airports	Airlines staff (M)
	Professional disinfection company	Professional staff (N)
	Professional medical waste disposal company	Professional staff (O)
	Hotels	Hotel attendant (P)
	Volunteer Association	Residents (Q)

strategies. Three classes of risk are demonstrated in China, and the risk level of the subdistrict is rated according to the local situations of whether a newly diagnosed case and recent clustering transmission are present. In detail, the low-risk level is defined as no new domestic symptomatic or asymptomatic cases and can be adjusted when there has been no new diagnosed case for 14 d; the middle-risk level is defined as newly confirmed cases within the past 14 d but less than 50, or the cumulative number of confirmed cases is more than 50 and there is no clustering transmission in the past 14 d; then the high-risk level is defined as more than 50 new cases and clustering transmission within the past 14 d. In the postpandemic period, the majority of areas in China were classified as low-risk, and the classification was modified when a domestic outbreak occurred. For example, the latest domestic outbreak in Guangdong Province, because the mutant SARS-CoV-2 imported and spread without taking careful precautions, has adjusted 2 subdistricts to a high-risk level and 12 subdistricts to a middle-risk level. The low-risk area focuses on importation control, while the other 2 types concentrate on local pandemic control.

How About the Results of Importation Management in Shenzhen

The Luohu district in Shenzhen integrated medical resources within its jurisdiction to establish an integrated care system known as the Luohu Model in a city setting. This model shifts from curative treatment for patients to health promotion for residents. To achieve this change in medical behavior, the capability and working environment of primary care in districts should be strengthened as a priority.

The integrated medical care system, also named the Medical Group, is responsible for regional health problems. During the postpandemic period of COVID-19, the Medical Group involved a great number of medical staff and materials in battling COVID-19 to maintain normal social and economic life.

First, although importation-related management in airports is mainly controlled by governmental or medical departments, at the city level, the Medical Group has fully managed importation

controls at 5 ports connecting to Hong Kong in Shenzhen since April 2020. From April 10, 2020 to September 14, 2021, a total of 1,374,662 SARS-CoV-2 nucleic acid tests have been performed, in which 4 cross-border individuals with positive results were identified. After the customs check in at airports or ports, international arrivals and cross-borders will go through the same prevention management procedure. Nine centralized quarantine places had been established as of September 2021 in Luohu District, which has completed more than 178,000 compulsory quarantines and has detected 29 positive cases among individuals who might be arrived during the incubation period of SARS-CoV-2. In support of community management, the Medical Group devoted 877 medical staff at primary care institutions to be part of the Trinity team.

Unfortunately, some sporadic COVID-19 events induced by imported sources occurred as pandemic control measures were being put into place. Since May 2020, the Medical Group has participated in 5 contact tracing and large-sample screening programs, in which a total of 256,120 medical staff person-hours were contributed, and approximately 3.66 million nucleic acid testing samples were collected and tested. Specifically, 1 medical staff member finished the collection and testing of 114 samples in 1 working day to help avert the spread of COVID-19 in the postpandemic period.

Limitations

Each country or city has a unique characteristic that would be difficult to duplicate because of different political backgrounds, economic situations, and medical resources. This study focuses on mainland China, which has a large labor force and sufficient productivity to support rapid and mass disease or pandemic screenings and manage centralized quarantine in designated hotels and residences for 14 d to prevent and control the viral outbreaks. Although some measures or practices realized in China may not be useful to other countries, the strategies practiced in China combined with the conditions in other nations could serve as a reference and help to formulate tailored measures against COVID-19,

such as multisectoral cooperation, community management, import precautions, and detailed screening strategy.

Discussion

Although the prevention and control measures are different in various countries, there are various combinations of interventions with different intensities and time nodes that can be used.

At first, COVID-19 spread across the globe because the highly infectious ability of SARS-CoV-2 was unknown and travelers did not wear PPE onboard aircraft or ships. Because masking has become mandatory in air travel, the on-board transmission rates have declined sharply. However, the number of secondary cases of infection is increasing after international arrivals and cross-border who infected with the virus return to their communities and participate in clustering activities.⁹ This result is similar to a finding from another previous study; modeling the disease trajectory under different scenarios, the authors found that travel restrictions and onboard precautions contribute only slightly to controlling disease spread without cooperation in the effective control of community transmission.¹⁰

Prevention and control approaches play a crucial role in preventing the spread of viruses resulting from clustering activities involving international arrivals.¹¹ Specifically, it has been commonly recommended that a 14-d quarantine should be required of people from endemic areas or those who had contact with confirmed cases; the effectiveness of such a quarantine was proven by the Japanese government, which realized a significant decline in the local reproduction number of COVID-19 after implementing advanced quarantine controls.¹² Additionally, adopting quarantine in the central places further suppressed the spread of COVID-19 by providing professional medical services and management, because the majority of infected cases arrived in the incubation period¹³ and might have received negative results for the first test at the airport or port. In terms of community-based contact tracing, the effectiveness was evaluated by a study in the United Kingdom, in which the basic reproduction number decreased by 2.82 (from 3 to 0.18) through rapid contact tracing to contain the outbreak.¹⁴ However, it was suggested that each intervention acting alone could not have suppressed the outbreak. For example, the ultimate success of contact tracing is strongly associated with the speed and efficacy with which suspect contacts are identified, and hence infected cases with longer incubation durations pose a greater threat to others.¹⁴ Thus, a single intervention needs be complemented by other interventions.

According to a systematic review, the integration of interventions achieves better preventive outcomes than adopting specific interventions.¹⁵ For instance, intensive contact tracing followed by quarantine and isolation could be more effective in reducing the local reproduction number of COVID-19 to lower the transmission risk.¹⁶ An integrated prevention strategy in Singapore effectively suppresses the spread of COVID-19 through rapid screening, quarantine of the diagnosed cases and their close contacts, and active monitoring of relevant residents at the community level.¹⁷

Therefore, the significance of imported management of international arrivals in the postpandemic period and comprehensive coverage of close contact tracing when infected cases occur should be emphasized¹⁸ to prevent secondary outbreaks in a country.

Conclusions

This study introduces prevention and control practices for importation management against the COVID-19 pandemic in Shenzhen, which could be referenced for importation-related management measures in other locations during the postpandemic period. It is a continuous importation-related management strategy involving multiple sectors to screen for potential cases of infection from overseas and ensure public health as social and economic activities resume. A well-coordinated partnership among multiple sectors is required to develop systematic and standardized prevention and control procedures against the COVID-19. Notably, the advantages of being well prepared for outbreaks and the significance of strengthening community management should be valued in addition to testing and quarantine interventions.

Conflicts of interest. None.

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