

# Study on the COVID-19 infection status, prevention and control strategies among entry people in Shenzhen

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## Research

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# Abstract

## Background

The overseas COVID-19 confirmed cases continue to rise for months, while people overseas prefer to return China at present. It is risky to have a large number of imported cases which may cause a relapse of COVID-19 outbreak. In order to prevent imported infection, Shenzhen government has implemented the closed-loop management strategy by taking nucleic acid testing (NAT) for severe acute respiratory syndromes coronavirus 2 (SARS-CoV-2) and requiring 14-days medical observation for individuals with overseas tour history (Hong Kong, Macao, Taiwan province and other countries) within 14 days. Our study aim to describe the status of COVID-19 infection among entry people in Shenzhen, and evaluate the effect of closed-loop management strategy.

## Methods

We made a descriptive study and risk analyze by the entry time, reported time, local confirmed cases in origin countries. The NAT were completed in Shenzhen center for disease control and prevention (CDC), ten district-level CDCs, as well as fever clinics.

## Results

A total of 86,844 people overseas entered Shenzhen from January 1 to April 18, 2020, there were 39 imported cases and 293 closed contacts. The infection rate of entry people was 4.49‰ (95% CI: 3.26‰ – 6.05‰). 14 imported cases (35.9%) came from the UK, 9 (23.08%) came from the US. Entry people from the US since Mar 9 or from the UK since Mar 13 are the high-risk population. As of July 17, there have been no new confirmed cases in Shenzhen for 153 days, and the number of confirmed case, close contact, and asymptomatic case are 0. So the closed-loop management is effective to prevent imported infection and control domestic relapse. The distribution of entry time and report time for imported cases overseas was similar. So it is important to take closed-loop management at the port.

## Conclusions

The risk of imported infection from the US and UK were higher that other countries and regions in Shenzhen. The closed-loop management is effective to prevent imported infection and control domestic relapse. Every country is closely connected under the background of globalization. In order to control COVID-19 outbreak, we need the collaboration and cooperation at the global, national, and subnational levels to prevent, detect, and respond effectively.

## Background

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In December 2019, the coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndromes coronavirus 2 (SARS-CoV-2) emerged from Wuhan. China reported to World Health Organization (WHO) and issued to other countries immediately [1, 2]. COVID-19 is characterized by fever, cough, fatigue, shortness of breath, pneumonia, and other respiratory tract symptoms [3, 4]. Infection via respiratory droplets or secretions from infected individuals are thought to be the predominant mode of human-to-human transmission [5–8]. The absence of fever in SARS-CoV-2 was more frequent than in SARS-CoV (1%) and Middle East Respiratory Syndrome coronavirus (MERS-CoV) infections (2%), so the afebrile patients may be missed, and it is common to have asymptomatic cases [9]. No specific antiviral therapies are available, and efforts to develop antivirals and a vaccine continue [10]. All these have brought difficulties to prevent and control COVID-19. The policies of “early detection, early report, early diagnosis, early quarantine and early treatment”, and “concentrate patients, concentrate experts, concentrate resources, concentrate treatment” are effective to prevent and control the spread of COVID-19 in China with the cooperation of government and society departments. After 76 days, China lifted lockdown on Wuhan and allowed people to leave the city on April 8, 2020. The number of severe cases is 0 from April 24, and the number of hospitalized cases is 0 from April 26. The nationwide intervention of COVID-19 had a real effect.

But the overseas confirmed cases continued to rise. On 11th March 2020, WHO declared the outbreak of COVID-19 could be characterized as a pandemic [11]. As of April 18, 2020, there are more than 2.1 million confirmed cases of COVID-19, and more than 140,000 deaths reported worldwide [12]. People work or study overseas prefer to return China at present. It is risky to have a large number of imported cases which may cause a relapse of COVID-19 outbreak. The first imported case overseas in China was reported in Shenzhen on 1st March 2020. As of April 25, the number of outbreak in clusters associated with imported cases overseas is about 60 which affected more than 10 provinces, including Guangdong. Shenzhen is situated in Guangdong province and at the border to Hong Kong, and there are more people-to-people exchanges, overseas students and transnational workers. As economic activity continues to resume in the coming weeks, the main control purpose has turned to prevent imported cases overseas and domestic relapse at present. In order to prevent imported infection, Shenzhen government has implemented the closed-loop management strategy with the cooperation of customs, immigration, health bureau and other departments by taking nucleic acid testing (NAT) for SARS-CoV-2 and requiring 14-days medical observation for individuals with overseas tour history (Hong Kong, Macao, Taiwan province and other countries) within 14 days. Our study aim to describe the status of COVID-19 infection among entry people in Shenzhen, and evaluated the effect of closed-loop management strategy.

## Methods

### Closed-loop management

On March 1, 2020, Shenzhen Center for Disease Control and Prevention (CDC) reported the first imported case from United Kingdom. In order to prevent imported infection, Shenzhen government has

strategy with the cooperation of customs, immigration, health

bureau and other departments by taking nucleic acid testing (NAT) for SARS-CoV-2 and requiring 14-days medical observation for individuals with overseas tour history (Hong Kong, Macao, Taiwan province and other countries) within 14 days.

The first step is to divide the entry people overseas into three categories for management according to the Prevention and Control Plan for Coronavirus Disease 2019 (the sixth Edition) (Fig. 1): 1. Confirmed cases, suspected cases, and the individuals who have fever and respiratory tract symptoms in quarantine at the port shall take medical treatment in the designate hospital (Such as the third people hospital of Shenzhen). 2. The close contact individuals shall take isolation in the designate centralized medical observation places. They shall take medical treatment in the designate hospital if they are positive in the NAT or the detection of serum specific antibody, and have symptoms like fever, cough and fatigue during the quarantine. 3. The special individuals who are under 14 or over 70 years old, pregnant woman, or not suitable for centralized observation with basal disease shall take home isolation for 14 days, but they are required to take NAT for SARS-CoV-2 at the designate centralized medical observation places before home isolation. The trinity cooperation community work group shall manager the home quarantine people by health surveillance (The trinity cooperation community work group, including medical staff from community health service centers, community workers, and community police. They can provide the order maintenance, medical and life service for every person. They also have been screening the entry people in Shenzhen from January 1, 2020 in every neighborhood committee.). Other entry individuals shall take isolation in the centralized observation places.

The individuals can release from quarantine if they are negative in NAT at the end of medical observation. The suspected cases who are positive in the NAT or in the detection of serum specific antibody, and have symptoms like fever, cough and fatigue during the quarantine shall take medical treatment in the designate hospital. Close contacts were identified through contact tracing of a confirmed, suspected or asymptomatic case and were defined as those who did not take an effective protection and contact with an index case 2 days before symptom onset according to the Prevention and Control Plan for Coronavirus Disease 2019 (the sixth Edition). This kind of closed-loop management can ensure that entry people have no chance to contact with other domestic people to prevent COVID-19 imported infection within 14-days medical observation.

Guangdong-Hong Kong-Macao Greater Bay Area (GBA) have implemented the mutual recognition measures for the medical quarantine observation results in GBA. The individuals are negative in NAT at the end of medical observation can receive the notification and release from quarantine. The notification issued by local primary medical and health institutions is mutual recognition in GBA. The trinity cooperation community work group in neighborhood committee shall manager the individuals who have completed the medical observation in Hong Kong or Macao by providing health and consultation service, taking temperature surveillance, checking the self-health declaration, and taking the guidance for somebody have the symptoms of fever, cough, and fatigue to the designated hospital.

## Date collection and analysis

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This was a descriptive research, supported by Shenzhen government based on the policies. The government shared the data (from January 1 to April 18, 2020) with us, so our data was the secondary and public data, and can be referenced. The study was approved by the Ethics Committees of Shenzhen CDC, and the need for consent was waived by approving ethics committee. The individuals who have epidemic history (Hong Kong, Macao, Taiwan province and other countries) within 14 days shall take NAT for SARS-CoV-2 by Reverse Transcription-Polymerase Chain Reaction (RT-PCR) of nasal swabs at 52 fever clinics, ten district-level CDCs, and Shenzhen CDC.

Based on the assumption that the emigration population conforms to the distribution of the origin population, we believe that the incidence of origin population can represent the risk of emigration population. So we can calculate the imported risk ( $Risk_{in}$ ). Case means the number of new confirmed cases in the origin place per day, and the cases data came from WHO Novel coronavirus (2019-NCoV) situation reports.  $Pop_1$  means the number of population in the origin place, and the data came from the origin country's official website.  $Pop_2$  means the number of people entering Shenzhen from the origin place per day.  $Pop_3$  means the total number of people entering Shenzhen per day.  $Pop_2$  and  $Pop_3$  came from Shenzhen government.  $C$  is the constant and it values for 1000000.

$$Risk_{in} = \frac{Case}{Pop_1} \times \frac{Pop_2}{Pop_3} \times c$$

## Results

A total of 86,844 people overseas entered Shenzhen from January 1 to April 18, 2020, and 77.09% have Chinese nationality. The rest of 22.91% have foreign nationalities. The main age of the population was 32, and 52.6% were male. Figure 2 is the distribution of these people in Shenzhen by ARCGIS10.2, including Shenshan special cooperation zone. The risk of imported infection in Nanshan, Futian and Luohu districts were higher than others. The risk of imported infection in southwest was higher than northeast in Shenzhen.

We made a rank on the origin countries according to the number of entry people (Fig. 3). 15.73% of the population came from United States of America (the US), 15.39% came from Thailand (THA), and 12.67% came from United Kingdom (the UK). So we analyzed the imported risk ( $Risk_{in}$ ) of the US, THA and the UK and made Fig. 4 because the number of entry people from these top three countries are larger than other places, so the imported risk from these three countries are higher than other places. Figure 4 (a) and (b) show that the imported risk of the US and the UK are higher than THA. So we analyzed entry people from the US and UK and the local confirmed cases and made Figs. 5 and 6. We excluded the data before Mar 1 due to the entry people and new local confirmed cases are small in these countries, and the imported risks are low.

Figure 5 indicates that there were two main peaks among entry people number from the US, one peak concentrated on Apr 14. The first confirmed case in the US

reported on Jan 23 according to WHO Novel coronavirus (2019-NCoV) situation report 3 (accessed Jan 23, 2020). There were three main peaks among the new local confirmed cases in the US, first one concentrated on Mar 23(16354 confirmed new cases), second one concentrated on Apr 6(33510 confirmed new cases), and third one concentrated on Apr 11(35386 confirmed new cases). We ignored the peak on Apr 18 according to the incomplete data since Apr 18. More entry people came from the US around Mar 18, and the new local confirmed cases turned to the first main peak 5 days later on Mar 23. The incubation of COVID-19 can range from 1 to 14 days according to the recommendation by WHO. The interval between Mar 9 and Mar 23 was 14 days, and there were still two peaks concentrated on Apr 6 and Apr 11. The entry people from the US since Mar 9 were the high-risk population of imported infection.

As of April 18, 2020, there were 39 imported cases and 293 close contacts detected and reported. 82.05% of the imported cases have Chinese nationality. The rest of 17.95% have foreign nationalities. The main age of the population was 33, and 71.79% were male. The infection rate of individuals entering Shenzhen from January 1 to April 18, 2020 is 4.49‰ (95% confidence interval [CI], 3.26‰ to 6.05‰).

Figure 7 is the distribution of 39 imported cases in Shenzhen by ARCGIS10.2, including Shenshan special cooperation zone. The number of imported cases in Nanshan district was the highest in Shenzhen. All 39 imported cases and 293 close contacts took the closed-loop management by centralized medical observation when they entered Shenzhen, they can receive the medical treatment in the designated hospital when they were positive in the NATs. As of July 17, there have been no new confirmed cases in Shenzhen for 153 days, and the number of confirmed case, close contact, and asymptomatic case are 0. So the closed-loop management is effective to prevent imported infection and control domestic relapse.

We have made a rank on origin countries based on the number of imported cases (Fig. 8). There were 14 imported cases (35.9%) from the UK, 9 (23.08%) from the US, 4 (10.26%) from France, 3 (7.69%) from Philippines, 2 (5.13%) from Brazil, 2 (5.13%) from Spain. The imported cases in Shenzhen mainly came from the UK and US.

As of Apr 18, the total number of confirmed cases in Shenzhen was 461, including 309 imported cases from Hubei province, 38 imported cases from other provinces in China, 39 imported cases from abroad, and 75 local cases by multiple infection mode in Shenzhen (the local close contacts, the locals contacted with people in affected areas, and other exposure methods). Figure 9 indicates that the new confirmed cases in Shenzhen from Jan 19 to Apr 25, 2020. The blue one means the domestic confirmed cases, including imported cases from Hubei and other province in China, and the local confirmed cases in Shenzhen. The first confirmed case in Shenzhen reported on Jan 19, and he came from Hubei. The new confirmed cases in Shenzhen mainly concentrated on the period between Jan 20 and Feb 15. The red one means the imported cases overseas. The first imported confirmed case from the UK reported on Mar 1. The imported cases from abroad mainly concentrated on the period between Mar 14 and Apr 7. There were no tailings on the blue and red epidemiological curve because the prevention and control management is effective.

## Discussion

The findings from our study indicated that there were 86,844 entry people from abroad to Shenzhen, and there were 39 imported cases and 293 closed contacts among them as of April 18, 2020, so the infection rate of entry people is 4.49‰ (95% CI: 3.26‰ – 6.05‰). The risk of imported infection from the US and UK were higher than other countries and regions in Shenzhen. Entry people from the US since Mar 9 or from the UK since Mar 13 are the high-risk population. All 39 imported cases and 293 close contacts took the closed-loop management by centralized medical observation when they entered Shenzhen, they can receive the medical treatment in the designated hospital when they were positive in the NATs. As of July 17, there have been no new confirmed cases in Shenzhen for 153 days, and the number of confirmed case, close contact, and asymptomatic case are 0. So the closed-loop management is effective to prevent imported infection and control domestic relapse. The difference between entry time and report time of imported cases overseas was small, the distribution of entry time and report time were similar. So it is important to take closed-loop management at the port to prevent imported cases and control domestic relapse.

Shenzhen is a mega city, immigrant city, and port city with a population of more than 20 million and thus had a high proportion of imported cases from Hubei or other provinces in China [13, 14]. It is also one of the cities with the largest population flow and the highest population density in China, so it is stressful to prevent and control COVID-19 imported infection in Shenzhen. So we implement the closed-loop management, and is proved to be effective in practice. The closed-loop management also requires additional assistance like “ACT” community control and prevention mode. A means the coordination by administration. C means the profession service by community health service center. T means cooperation by trinity community control and prevention mode, including medical staff from community health service centers, community workers, and community police. The “ACT” community control and prevention mode in Shenzhen is effective and highly recognized by WHO experts.

This work has some limitations. Asymptomatic travelers will be missed by symptom-based surveillance, even if they are tested, some asymptomatic contacts might be missed because of the imperfect sensitivity of the RT-PCR test [15]. The epidemic logical investigations are dependent on individuals’ recall of places visited, people seen, and symptom onset, so the investigation might not have identified all individuals with potential exposure to SARS-CoV-2.

The recent COVID-19 outbreak has been deemed a global health emergency, internationally, the number of confirmed reports has continued to rise [16]. By April 18, 2020, there were more than 2.1 million confirmed cases of COVID-19, and more than 140,000 deaths reported worldwide [12]. Strict containment measures have been effectively implemented throughout China, particularly in infected regions, preventing uncontrolled spreading, and the reproduction number has been on a declining trend [17–19]. Every country is closely connected under the background of globalization. In the past several years, multisectoral coordination and collaboration for health security strengthening had improved substantially [10]. The COVID-19 outbreak requires a robust mechanism of collaboration and cooperation at the global,

national, and subnational levels to prevent, detect, and respond effectively [10]. The finding of our study can provide important reference information and experience for imported infection surveillance and public health strategy.

## Conclusion

The risk of imported infection from the US and UK were higher than other countries and regions in Shenzhen. The closed-loop management is effective to prevent imported infection and control domestic relapse. Every country is closely connected under the background of globalization. In order to control COVID-19 outbreak, we need the collaboration and cooperation at the global, national, and subnational levels to prevent, detect, and respond effectively.

## List Of Abbreviations

Center for Disease Control and Prevention, (CDC).

Corona Virus Disease 2019, (COVID-19).

Guangdong-Hong Kong-Macao Greater Bay Area, (GBA)

Middle East Respiratory Syndrome coronavirus, (MERS-CoV).

Nucleic Acid Testing (NAT).

Reverse Transcription-Polymerase Chain Reaction (RT-PCR).

Severe Acute Respiratory Syndrome (SARS).

Severe Acute Respiratory Syndromes Coronavirus 2, (SARS-CoV-2).

Thailand, (THA).

United Kingdom, (UK)

United States of America, (USA or US)

World Health Organization (WHO).

## Declarations

### -Ethics approval and consent to participate

The study was approved by the Ethics Committee of Shenzhen Center for Disease Control and Prevention [2020, code (039A)]

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## **-Consent for publication**

Not applicable

## **-Availability of data and materials**

The datasets used and analysed during the study are available from Shenzhen Municipal Health Commission.

## **-Competing interests**

The authors declare that they have no competing interests

## **-Funding**

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The Three Famous Medical and Health Projects: Shenzhen authorities launched the “Three Famous Medical and Health Projects” since 2014 in order to improve the shortage of high-quality medical resources. The projects focused on introducing the talent of “Famous Doctors (Famous Medical Departments), Famous Hospitals and Famous Clinics”.

## **-Authors’ contributions**

ZX participated in liaison and coordination with government and data collection. XZQ participated in data analysis and drafted the manuscript. WJZ and HJF conceived of the design and coordination of the study. WHR performed the statistical analysis. WBX guided the statistical analysis and revisions of the manuscript. All authors read and approved the final manuscript.

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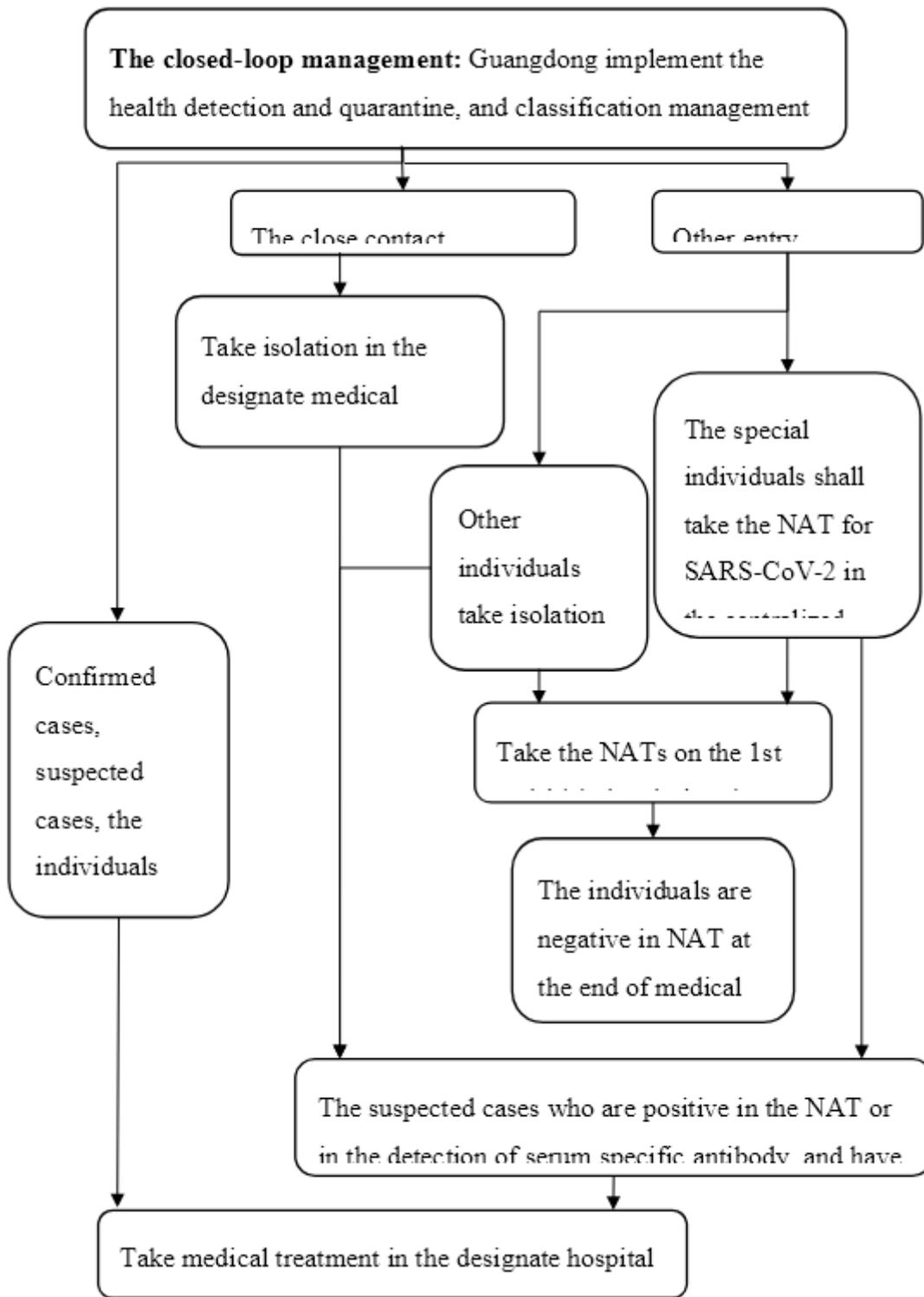
Xuan Zou and Zi-Qian Xu are co-first authors of the article, Xuan Zou and Zi-Qian Xu contribute equally to the article.

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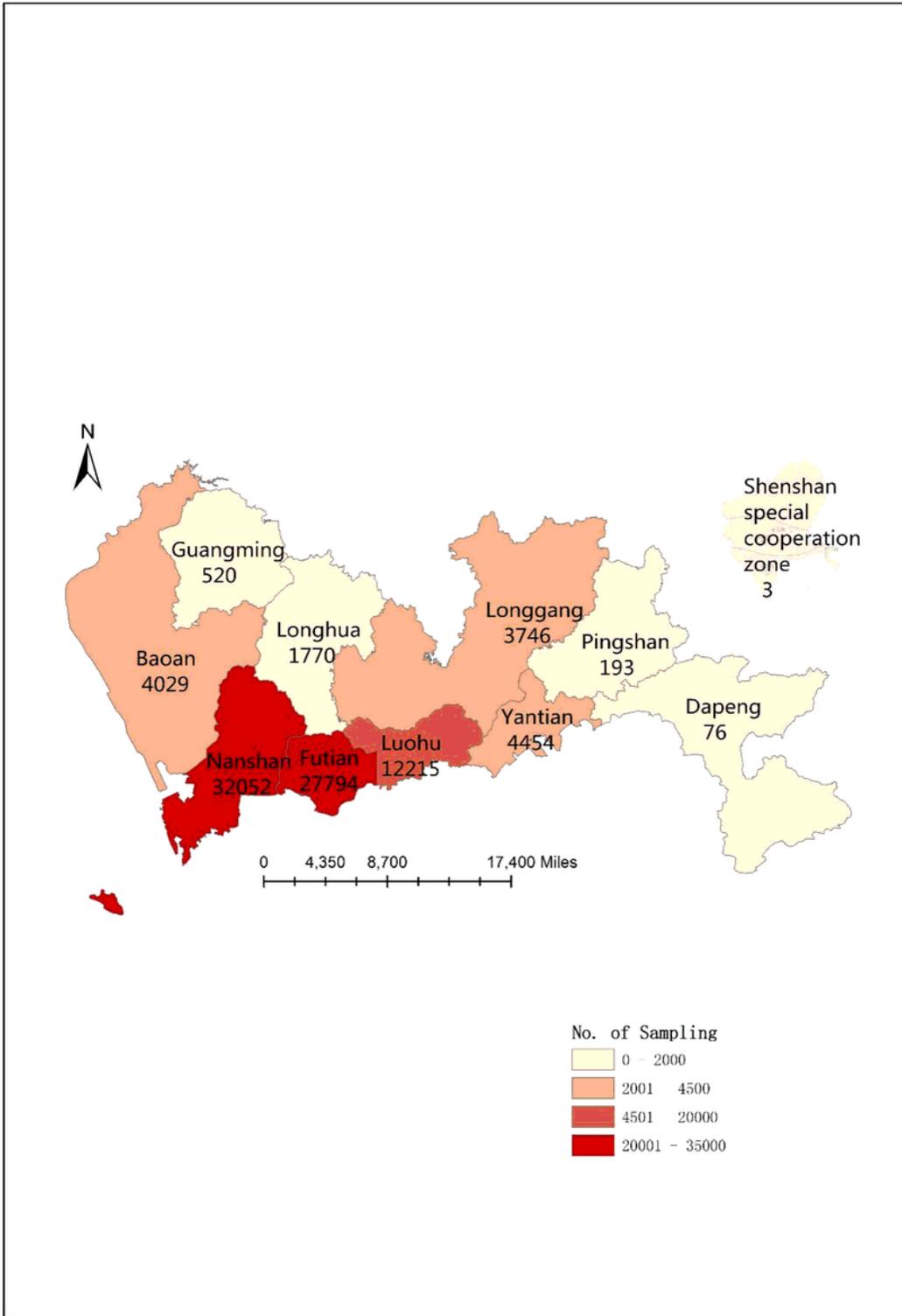
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## Figures



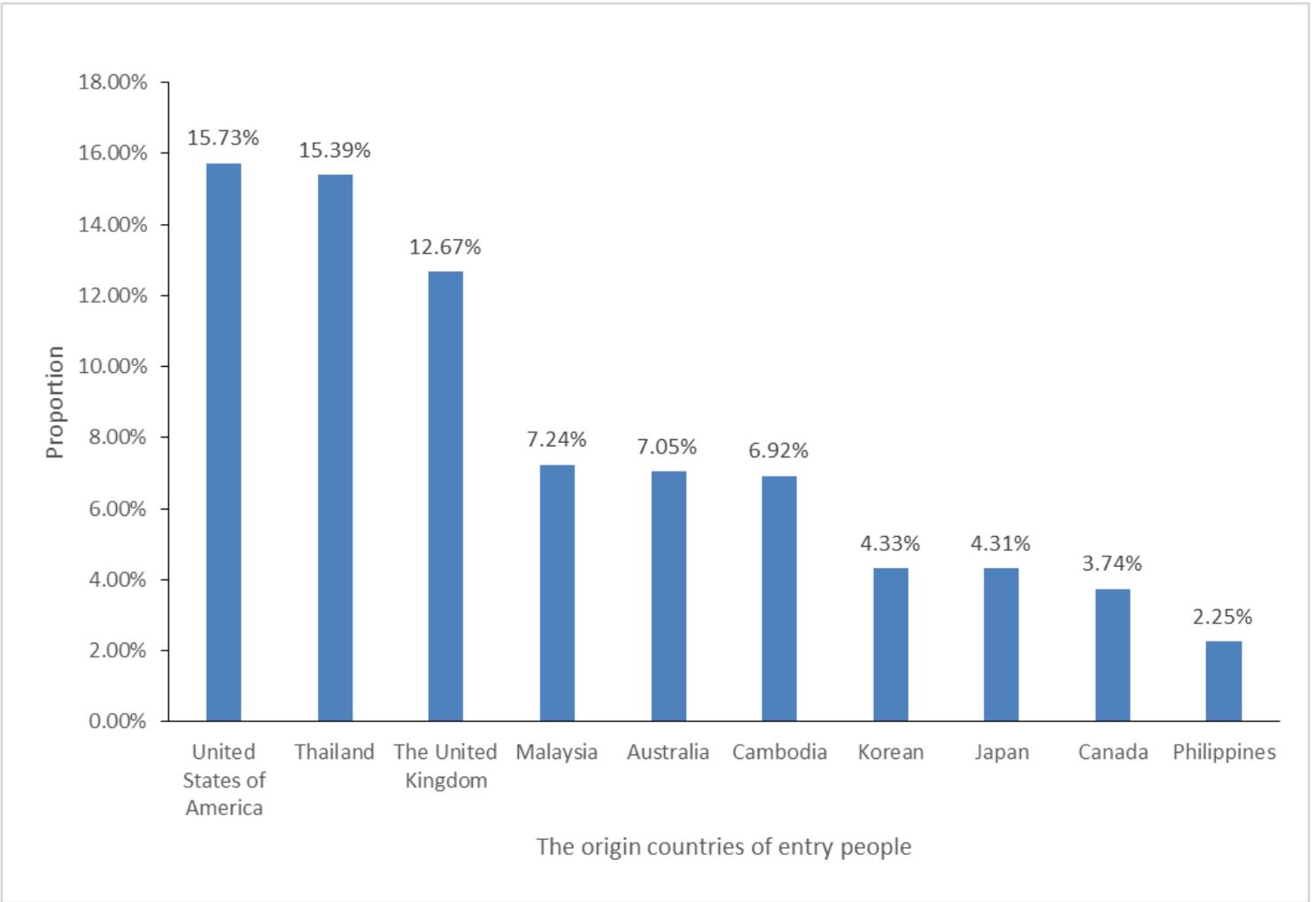
**Figure 1**

Flowchart of the closed-loop management in Shenzhen



**Figure 2**

The distribution of all entry people in Shenzhen. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.



**Figure 3**

The top 10 countries of origin countries based on the number of entry people

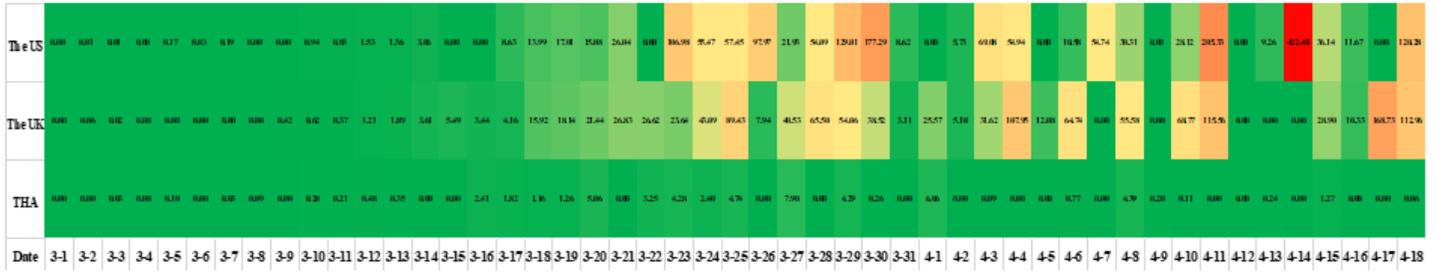


Figure 4(a). Imported risk map (From Jan 3 to Apr 18)

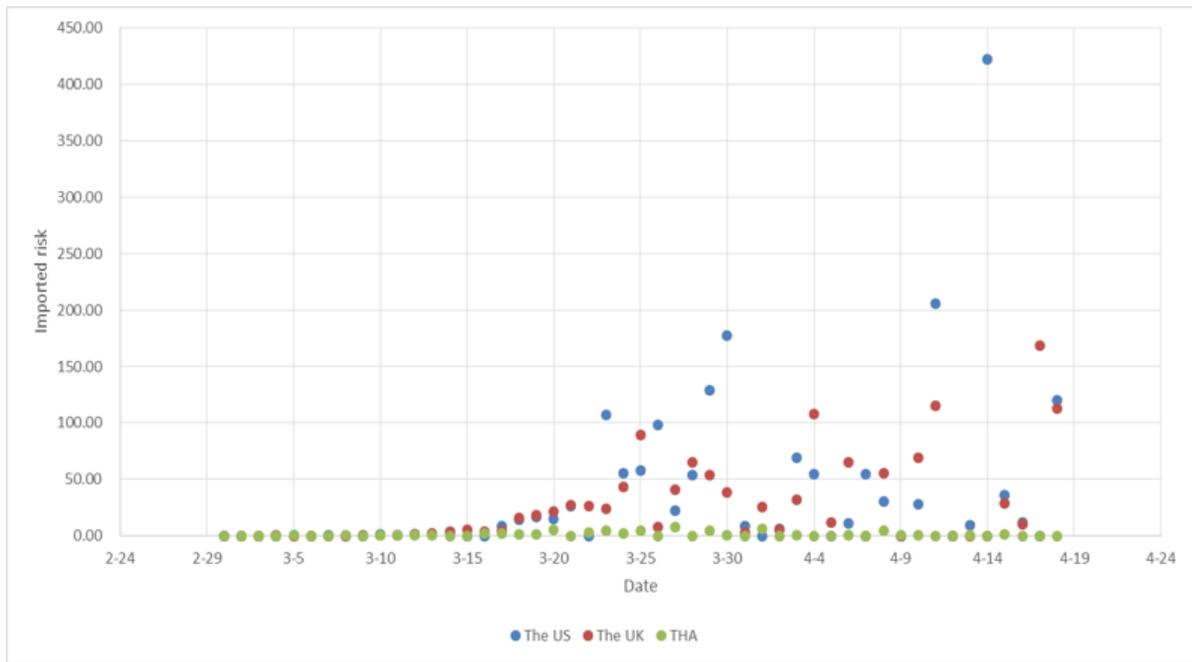
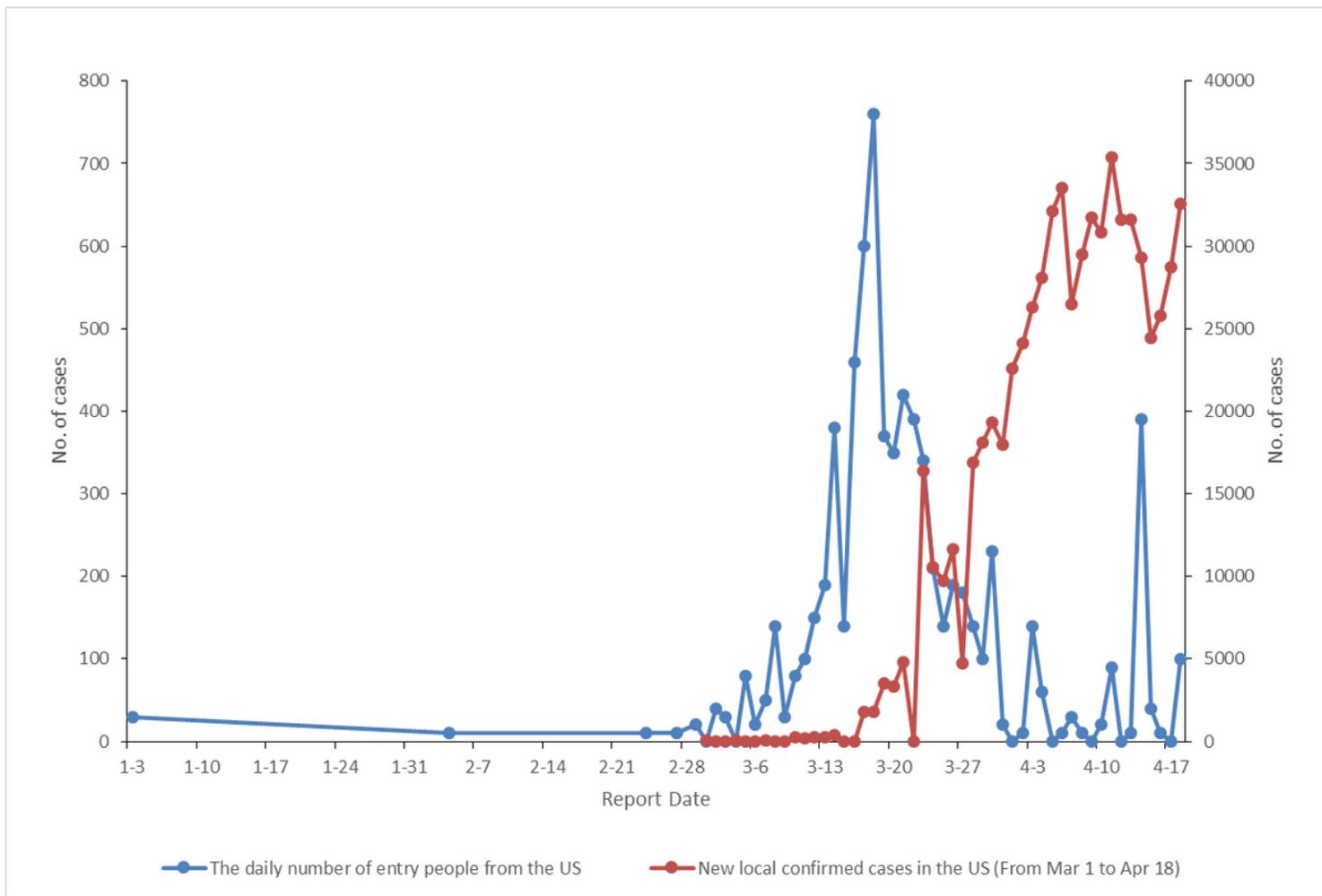


Figure 4(b). Imported risk (From Jan 3 to Apr 18)

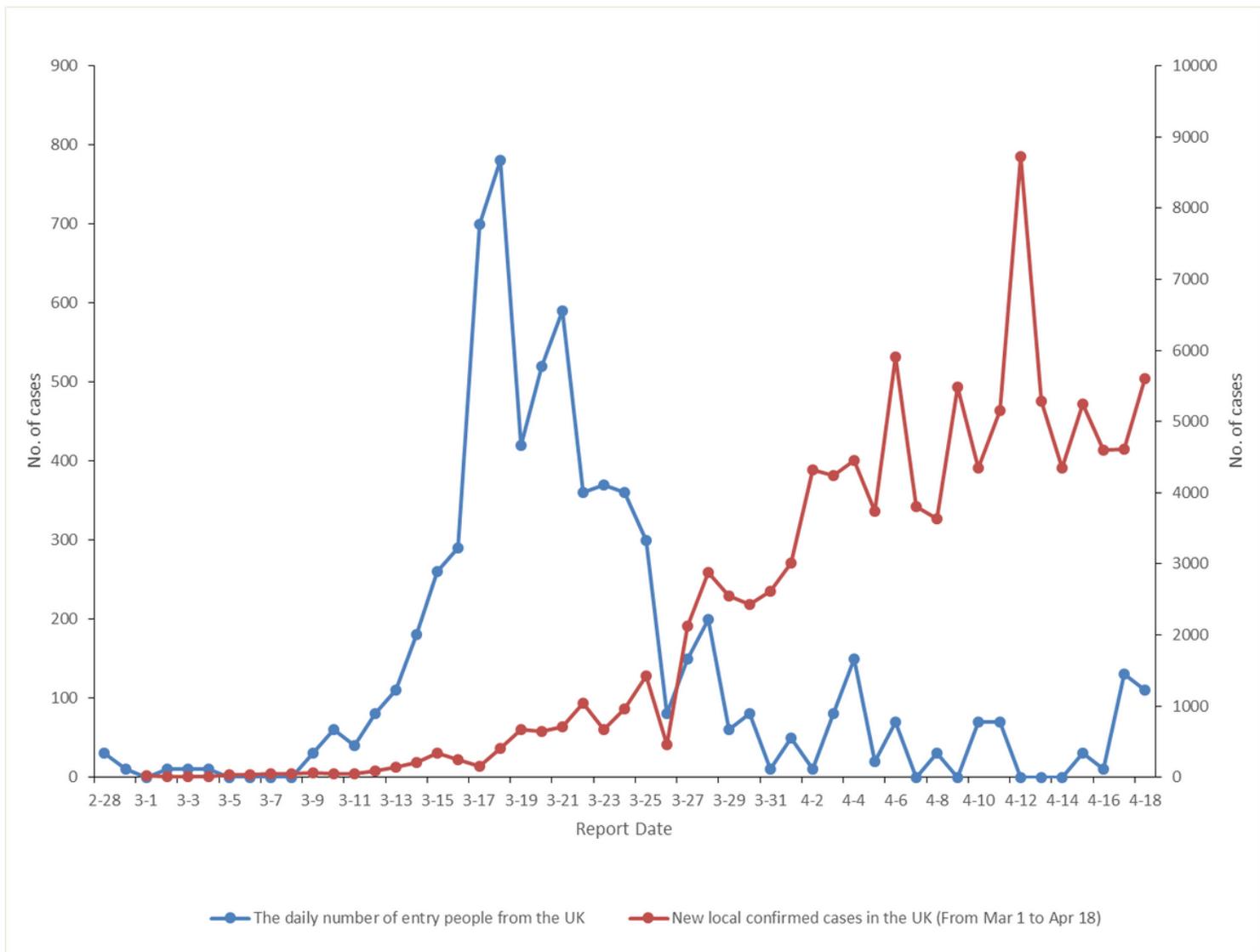
## Figure 4

(a). Imported risk map (From Jan 3 to Apr 18). (b). Imported risk (From Jan 3 to Apr 18)



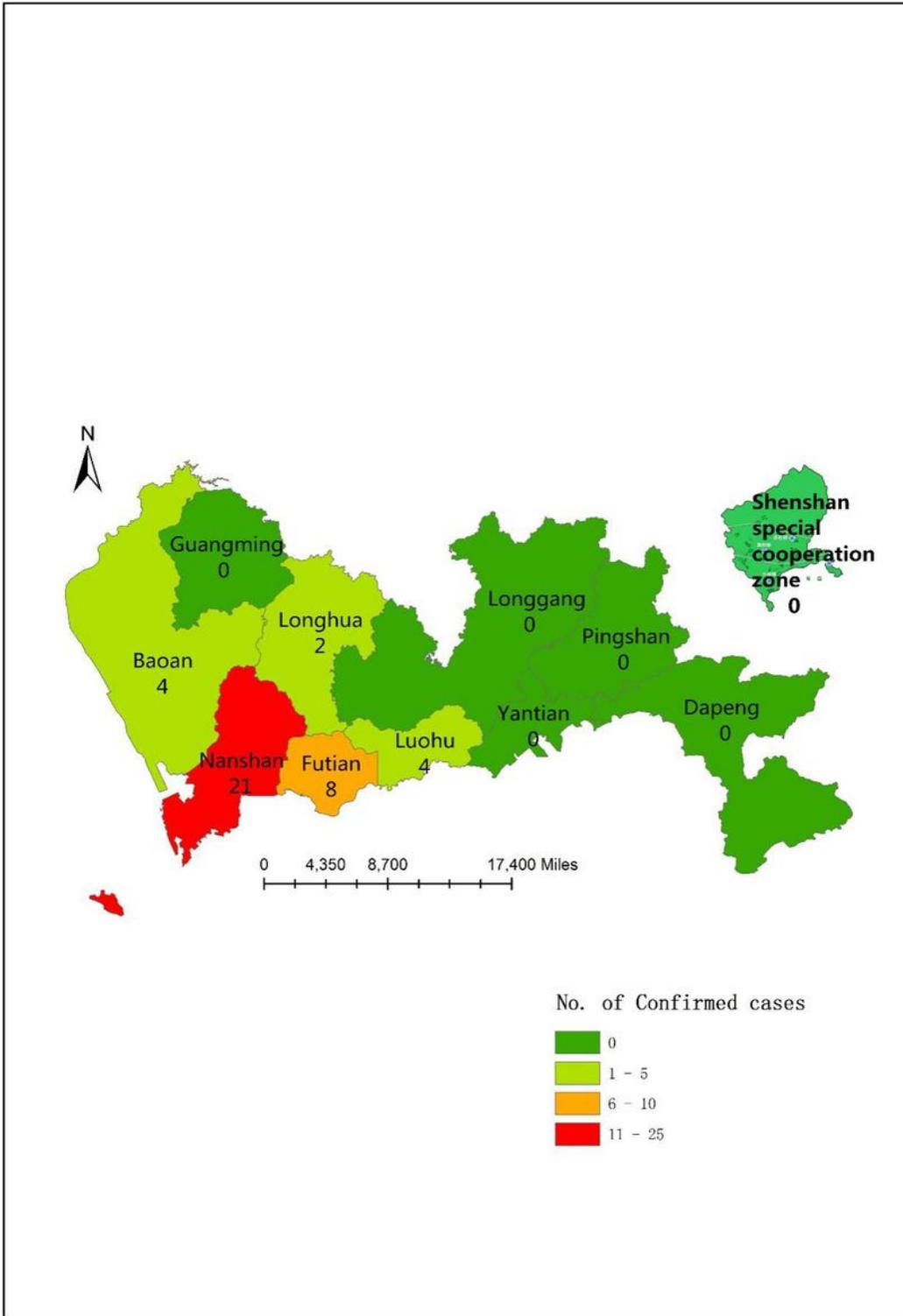
**Figure 5**

The daily number of entry people from the US (From Jan 3 to Apr 18) and new local confirmed cases in the US (From Mar 1 to Apr 18)



**Figure 6**

The daily number of entry people from the UK (From Feb 28 to Apr 18) and new local confirmed cases in the UK (From Mar 1 to Apr 18)



**Figure 7**

The distribution of imported cases in Shenzhen. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

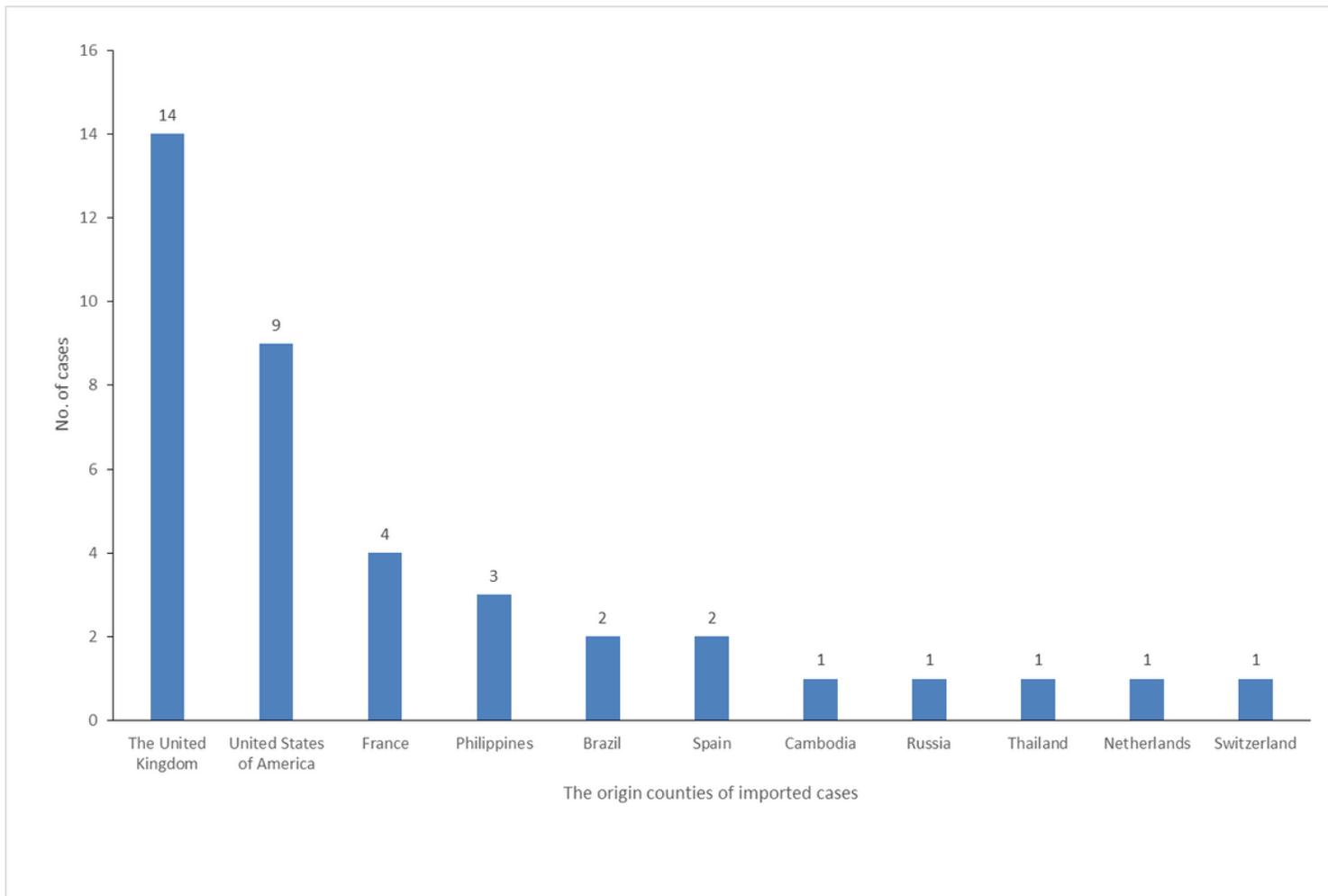
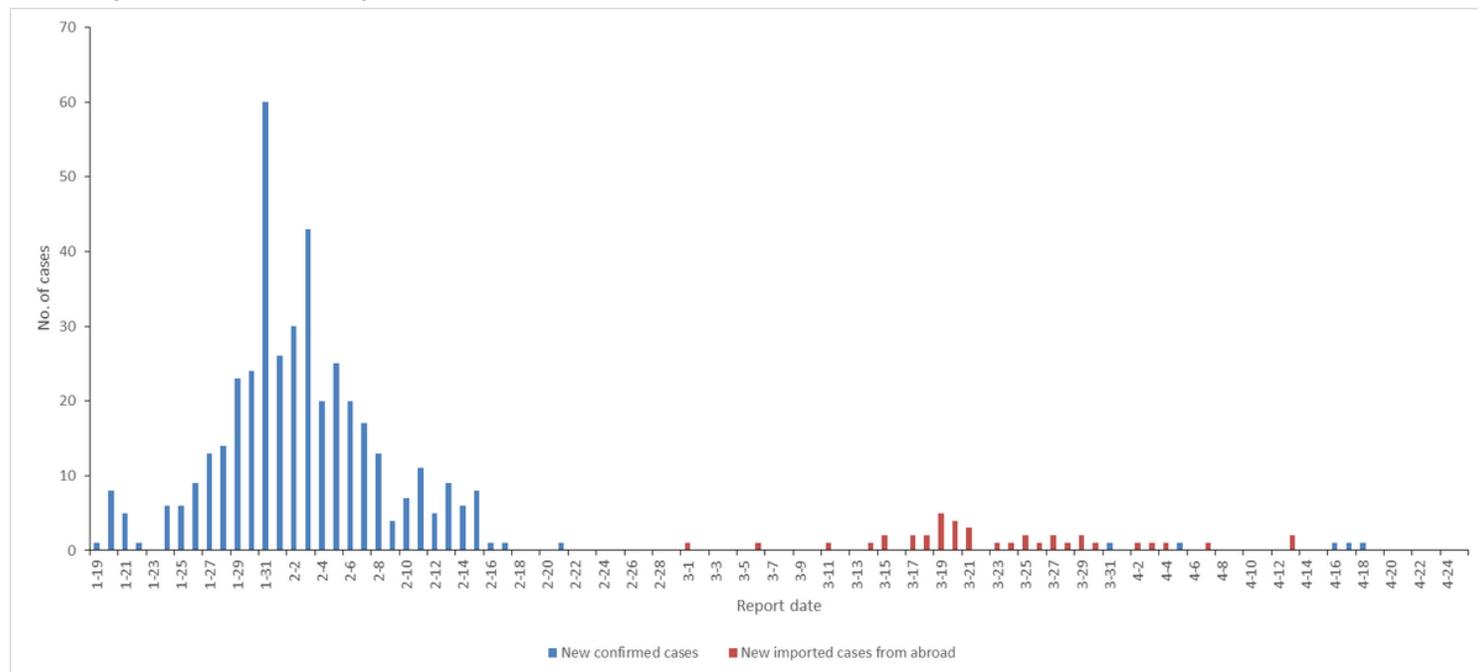


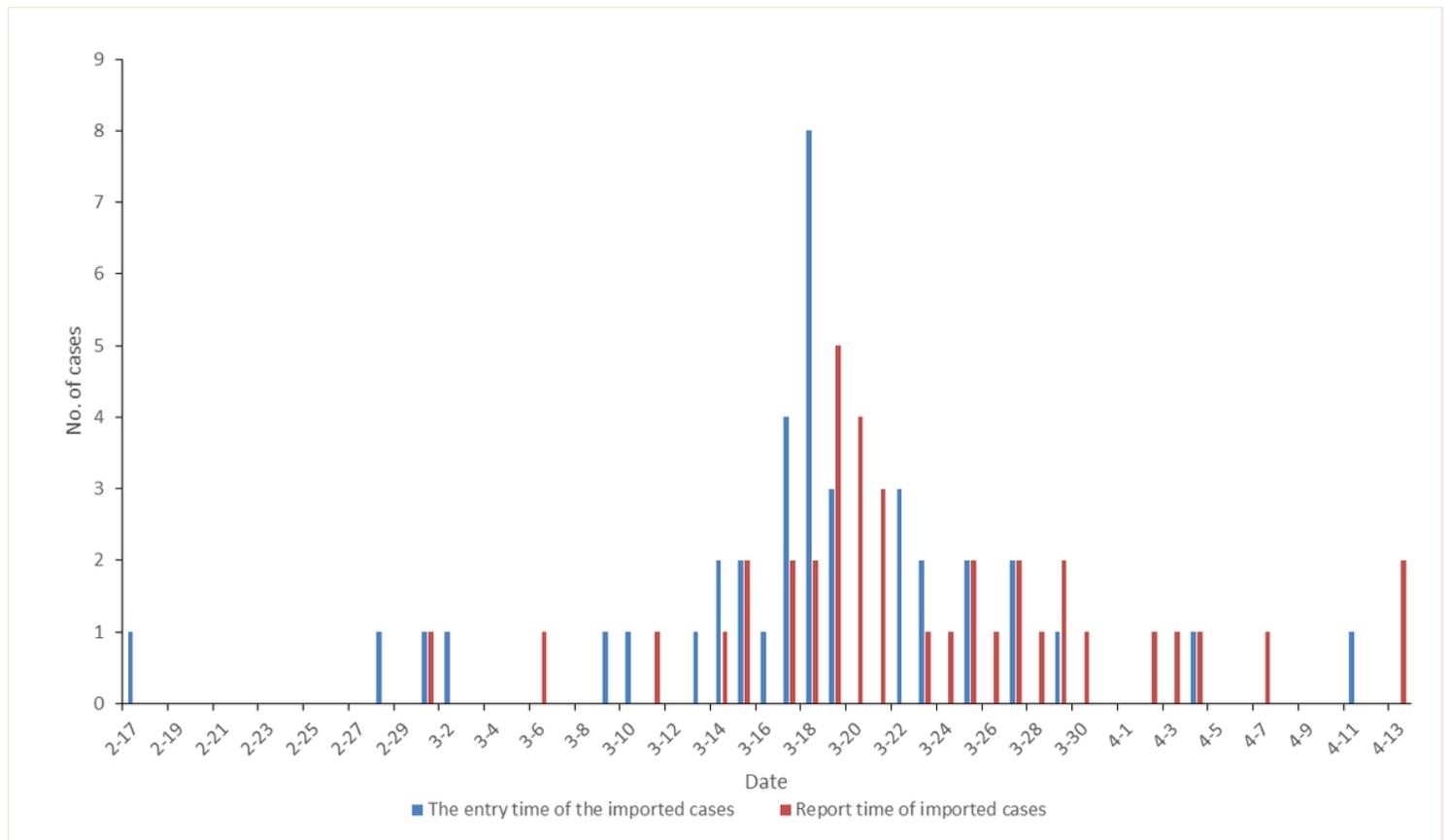
Figure 8

The origin counties of imported cases



**Figure 9**

New confirmed cases in Shenzhen



**Figure 10**

The entry and report time of imported cases from abroad in Shenzhen