

Geographical and Epidemiological Characteristics of Case Series With COVID-19 Outbreaks Caused by Asymptomatic Carriers From June 2020 to January 2021 in China: A Narrative Research

Cheng Liu

Tongji Medical College of Huazhong University of Science and Technology: Huazhong University of Science and Technology
Tongji Medical College

Hongbing Xiang

Tongji Medical College of Huazhong University of Science and Technology: Huazhong University of Science and Technology
Tongji Medical College

Anne Manyande

University of West London

Weiguo Xu

Tongji Medical College of Huazhong University of Science and Technology: Huazhong University of Science and Technology
Tongji Medical College

Li Fan

Union Hospital of Tongji Medical College

Boqi Xiang (✉ bqxiang@ucdavis.edu)

Rutgers University New Brunswick

Research

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Abstract

With the COVID-19 epidemic quickly under control in China within the early months of 2020, importing the SARS-CoV-2 virus to the country now poses great challenges in epidemic control and prevention. Asymptomatic carriers play a critical role in the transmission of the virus and transmission on a large-scale poses enormous concern. We obtained data from new cluster outbreak regions with COVID-19 caused by asymptomatic carriers from June 2020 to January 2021, and reported the epidemiological characteristics, clinical data and the possible routes of viral transmission and infection. These results indicate the importance of regularly screening high-risk populations critical for epidemic control and provide the basis for suppressing the spread of the SARS-CoV-2 virus.

Introduction

Since December 2019, a new type of coronavirus pneumonia (coronavirus disease 2019, COVID-19) was identified and developed into a global epidemic. This was later declared a pandemic by the World Health Organization (WHO) on March 11, 2020. By the end of January 2021, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the new coronavirus behind the disease COVID-19, had infected over 100 million people around the world and caused about more than 2 million deaths. Facing the biggest global COVID-19 pandemic of this century, led governments and the scientific community in various countries to work hard to uncover the public health strategy for effective scientific solutions¹⁻⁴.

It is well-known that the typical three transmission routes of infectious respiratory viruses, include the droplet-borne route transmitted by appropriate droplets⁵, suitable fomite route through contacts with contaminated object surface^{6,7}, and airborne route through aerosols that can remain suspended in air for longer periods^{8,9}. The transmission of SARS-CoV-2 through fomite and droplet-borne routes was considered as the main pathway, but more and more recent studies have revealed the possibility of airborne transmission¹⁰⁻¹⁸, particularly in crowded and inadequately ventilated indoor spaces¹⁹⁻²¹. Fennelly et al²² measured particle size distribution of infectious aerosols and observed that pathogens were more commonly found in small particles (<5 μ m). Some studies have identified airborne transmission as a likely major pathway for asymptomatic transmission of SARS-CoV-2^{23,24} and the superspreading events that play a significant role in spreading the virus²⁵.

With the epidemic COVID-19 quickly under control in China within the early months of 2020, the Chinese public strategy and related health research have greatly advanced our understanding of sporadic COVID-19 outbreaks and strengthened the preparedness and combat against COVID-19 disease all over the world. We collected and analyzed data on geographical and epidemiological characteristics of case series with COVID-19 outbreaks caused by asymptomatic carriers from June 2020 to January 2021 in China.

Methods

At the beginning of June 1, 2020, we prospectively gathered COVID-19 epidemic data from the Chinese Center for Disease Control and Prevention every day. Once we obtained the new report of confirmed or asymptomatic cases, we tracked this epidemic and collected its epidemiological characteristics from announcements by the local Health Commission, and presented a narrative research for geographical and epidemiological characteristics of case series with COVID-19 outbreaks caused by asymptomatic carriers.

We searched epidemiologic data published on the website of WHO, the China Center for Disease Control and Prevention, National Health Commission, the Health Commission of Beijing and Tianjin city, Jilin, Shandong, and Heilongjiang Province from June 2020 to January 2021. Using the keywords "asymptomatic", "COVID-19", "SARS-CoV-2", "2019-nCoV", and we periodically searched the published medical literature using the PubMed service maintained by the U.S. National Library of Medicine of NIH. Confirmed COVID-19 cases are defined as persons who tested positive for SARS-CoV-2 and had clinical symptoms. Asymptomatic carriers refer to persons without clinical symptoms who tested positive for SARS-CoV-2.

Table 1: Data of case series in new sporadic COVID-19 outbreak regions

	Date	Regular screening	Occupation of Case 1	Transmission route of Case 1	Diagnosis of Case 1	Main source of COVID infection
Case A (Qingdao)	Sep. 24	yes	transportation worker	environment-to-human	Asymptomatic case	yes
Case B (Tianjin)	Nov. 10	yes	transportation worker	environment-to-human	Asymptomatic case	no
Case C (Beijing)	Dec. 10	yes	imported businessman	human-to-human	Asymptomatic case	yes
Case D (Dalian)	Dec. 15	yes	cold-chain transportation workers	environment-to-human	Asymptomatic case	yes
Case E (Jilin)	Jan. 5	yes	individual marketer	human-to-human	Asymptomatic case	yes

Main source of COVID-19 infection stands for a person who transmits COVID-19 to an unexpectedly or unusually large number of other people.

Results

Geographical and epidemiological characteristics of case series with COVID-19 outbreaks

The geographical and occupational distribution of case series in local sporadic outbreak regions with COVID-19 is illustrated in Figure 1. Data of epidemiological characteristics in new sporadic outbreak regions is presented in Table 1. Data from 5 cities showed that asymptomatic SARS-CoV-2 carriers induced local sporadic outbreaks (Table 1) due to regular screening of high-risk groups, which was key to COVID-19 surveillance. Four cities reported their main source of COVID-19 infection, and indicated that a person could transmit COVID-19 to an unexpectedly or unusually large number of other people. Furthermore, case 1 in 3 cities mode of transmission of SARS-CoV-2 was the environment-to-human route, whereas case 1 in the other 2 cities was the human-to-human route.

Transmission chain analysis of case A (Qingdao city)

Cases 1 and 2 who were quarantined in hospital when they tested positive for SARS-CoV-2 nucleic acid on September 24, were determined to have asymptomatic infection (Figure 2)²⁶. During further investigation and treatment, they underwent chest computed tomography (CT) scans in the CT suite and were visited by Case 3 (a hospitalized patient) and Case 4 (a nursing assistant). Case 1 later developed symptoms on October 14.

All persons associated with Cases 3 and 4, including those who were in the same Ward Area and had close contact with SARS-CoV-2-positive patients, were tested for SARS-CoV-2 nucleic acids. Contact tracing results indicated that 9 cases were infected with SARSCoV-2, including 4 confirmed cases (Case 3-6) and 5 asymptomatic cases (Case 7-11) on October 12.

In addition, the Chinese Center for Disease Control and Prevention sequenced the entire genomes of 11 samples from this cluster. Viral genomes were identical in 11 cases, indicating that SARS-CoV-2 came from the same point of origin.

By October 16, Qingdao city had reported 13 confirmed cases since the asymptomatic cases were first detected on September 24.

Transmission chain analysis of case B (Tianjin)

On November 10, Case 1, an asymptomatic carrier first tested positive for SARS-CoV-2 in No. 4 Building (Figure 3). Cases 1-3 shared the same room. Case 2 (asymptomatic case) and 3 (confirmed case) tested positive for SARS-CoV-2 on November 17. Cases 1-4 lived in No. 4 Building, and Case 4 tested positive for SARS-CoV-2 (asymptomatic case) on November 18.

On November 19, Case 6, his parents (Cases 7 and 8), and Case 5 were confirmed as COVID-19 case. Cases 5-8 lived in No. 19 Building.

The surveillance video from No. 9 Building demonstrated that Case 1 searched for his colleague in No. 9 Building on the evening of November 9, and he coughed and sneezed in the elevator without wearing a mask; On November 10, Case 5 tried to find his colleague in No. 9 Building using the same elevator, and then returned to No. 19 Building. In addition, the samples of the elevator surface in No. 9 Building tested positive for the SARS-CoV-2 nucleic acid at multiple points, which confirmed that this elevator was contaminated. These data suggest that there was an epidemiological link between No. 4 Building and No. 19 Building.

The Disease Control and Prevention of Tianjin Province sequenced the entire genomes of 8 samples from No. 4, No. 9, and No. 19 Buildings. The results showed that these viruses belonged to the European family branch 1 of the L genotype, indicating that SARS-CoV-2 among these three buildings came from the same point of origin.

Transmission chain analysis of case C (Beijing)

On December 10, A0 (Case 1), an Indonesian national, returned to Shunyi District, Beijing after 14 days of isolation in the Fujian Province and had a negative nucleic acid test result. He was in close contact with a person (asymptomatic case) on the same flight from Indonesia on November 26. He had negative SARS-CoV-2 nucleic acid and positive serum IgM antibody results on December 26, and the detection of SARS-CoV-2 nucleic acid in the environment of his residence and workplace was also positive. His SARS-CoV-2 nucleic acid test was positive on December 28. In essence, these data indicate that he was diagnosed with asymptomatic infection (Figure 4).

Case 2 was Case 1's tenant in a shared house, and thus the virus of Case 1 spread to Case 2. Case 1 also spread the virus to a Supermarket employee (Case 3) during shopping.

Case 3 spread via a snowball effect to her customer Case 4 (the first reported confirmed case of this epidemic), her husband Case 5, an online ride-hailing driver Case 6, and her friends Case 7 and 8. Case 6 spread to a driver Case 11 through a shared meal. Cases 7 and 8 transmitted to their husbands (case 9 and case 10). Cases 5, 7, 9, and 10 worked in the same Industrial District, and their collective activities resulted in Cases 12-16 infection.

Furthermore, Beijing CDC conducted a whole-genome sequencing analysis of Cases 1-16 and related environmental samples of the virus and the results demonstrated that the viruses all came from the European family branch 2.3 of the L genotype, which is the same transmission chain.

Transmission chain analysis of case D (Dalian city)

On December 15, Cases 1-4 were found positive for SARS-CoV-2 nucleic acid during regular COVID-19 testing of cold-chain transportation workers (Figure 5). Their close contacts, Cases 5 and 6, subsequently tested positive for SARS-CoV-2 on December 16 or 17. In addition, Cases 1-4 and Cases 7-10 had gathered in Restaurant 1 on December 12. Cases 7-10 had positive SARS-CoV-2 nucleic acid tests on December 17. After nucleic acid testing of all employees in Case 7's local community on December 19, Case 11 tested positive for SARS-CoV-2 nucleic acid on December 20.

Investigators learned that Case 5 had ever been to Commercial Building 1 on December 11 (Figure 5). At the beginning of December 20, a mass COVID-19 testing programme was launched on all staff of Commercial Building 1 and Case 11's big community. A cluster of 65 COVID-19 cases (including case 12) was identified from December 11 to 21. Epidemiological investigation showed that the 65 cases were associated with Commercial Building 1, which is located in Case 11's big community.

After Case 12 took part in a family gathering, a total of 10 other persons were infected with SARSCoV-2. All persons associated with the 10 cases, including those who lived in the same community and had close contact with SARS-CoV-2-positive cases or visited the hospital during December 1-20, were tested for SARS-CoV-2 nucleic acids. Results showed that 33 cases were infected with SARSCoV-2, including 21 confirmed and 12 asymptomatic cases. Among 33 cases, 10 were nosocomial infection. By January 3, 2021, Cases 1-5 remained asymptomatic.

Transmission chain analysis of case E (Jilin)

On January 5, 2021, case-patient A0, an individual marketer, came to Changchun city, Jilin Province from Wangkui County, Heilongjiang Province. He gave speeches in Market-training Hall 1 and 2 of different cities on January 8 and 10, respectively (Figure

6).

Patient B1, B2 and A0 were in the same train carriage on January 5. Both B1 and B2 tested positive for SARS-CoV-2 on January 11, and remained asymptomatic, indicating that B1 and B2 were previously infected with SARS-CoV-2 and were asymptomatic carriers. Based on epidemiological surveillance, A0 tested positive for SARS-CoV-2 nucleic acid on January 12 and symptoms of COVID-19 were noted on January 16, suggesting that A0 was the first confirmed case in this cluster, raising Jilin's health commission concerns.

Jilin, therefore, launched a mass COVID-19 testing programme in some areas including Market-training Hall 1 and 2 on January 11. From 11 to 18 January, 34 new COVID-19 cases and 80 asymptomatic carriers had been identified in the Jilin Province. Among these cases, 102 were related to case-patient A0. By February 9, Jilin Province had reported 3 deaths among 573 confirmed cases since the asymptomatic cases were first detected in the Changchun city on 11 January.

Discussion

A main finding of new sporadic outbreaks with COVID-19 from June 2020 to January 2021 in China was as a result of regular screening of high-risk groups, which was key to COVID-19 surveillance. Here we offered a narrative research of SARS-CoV-2 transmission chain in 5 case series with COVID-19 outbreaks. In addition, we described the occupational distribution of high-risk groups, epidemiological characteristics and the occupational distribution of asymptomatic carriers in 5 COVID-19 outbreak regions. Chinese management measures including regular screening of high-risk populations, aggressive contact tracing and quarantine of close contacts of people with asymptomatic or confirmed infection, were found to be effective in mounting a rapid response and minimizing the impact of a new outbreak.

Regular screening of high-risk populations provides a standardized model for early identification of asymptomatic SARS-CoV-2 carriers²⁶. SARS-CoV-2 testing of high-risk groups may identify asymptomatic carriers and infected individuals before widespread transmission of the highly contagious COVID-19 occurs. However, screening millions of people for SARS-CoV-2 in a short period of time is challenging and requires understanding the occupational distribution of high-risk populations. Our results have shown that the occupational distribution of high-risk populations includes cold-chain transportation workers, a travelling businessman and individual marketer. To minimize testing time and conserve health resources, a pooled testing approach has attracted worldwide attention^{26, 27}.

The asymptomatic carrier with causative pathogen is well-known to cause the rapid spread of SARS-CoV-2²⁸⁻³¹. During the early months of 2020, Chinese physicians quickly identified the importance of asymptomatic carriers in the local rapid spread of SARS-CoV-2. Some studies have identified asymptomatic transmission of SARS-CoV-2 as a likely major factor in the super spreader events²⁵. Our data reported the main source of COVID-19 infection in 4 cities, and noted that there exist super spreader events in China. Such super spreaders are of particular concern in COVID-19 outbreaks^{32, 33}. The superspreading phenomenon is an important outbreak alarm, and requires careful planning in order to facilitate the coordinated management of COVID-19 outbreaks, including effective coordination and execution in the community, along with the cooperation of residents.

Although human-to-human is the main transmission route of COVID-19, our data showed environment-to-human transmission in 3 cities. Environment-to-human transmission is defined as the transfer of the virus from virus-laden objects to humans upon contact. It is well known that the environment may play an important role in the transmission and spread of the coronavirus^{34, 35}. This transmission can only occur under the following three conditions: (1) The object is seriously contaminated by the virus; (2) The object's surface is able to keep the virus alive for a fairly long time; (3) The person coming in contact with virus-laden objects does not take adequate protection measures. There have been multiple reports that most cases of environment-to-human transmission in China are linked to imported products, such as frozen foods^{6, 7, 36}.

In conclusion, China has ignited tremendous efforts to unravel the epidemiological characteristics of SARS-CoV-2, which constitutes the foundation for international public health development strategies. Our results indicate the importance of regular screening of high-risk populations, aggressive contact tracing and quarantine of close contacts of people with asymptomatic infection for epidemic control and the basis for suppressing the spread of the SARS-CoV-2 virus.

Declarations

Authors contribution

All the authors contributed to the methodology and conceptualization of the presented paper. They also contributed to data analysis and paper writing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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Figures

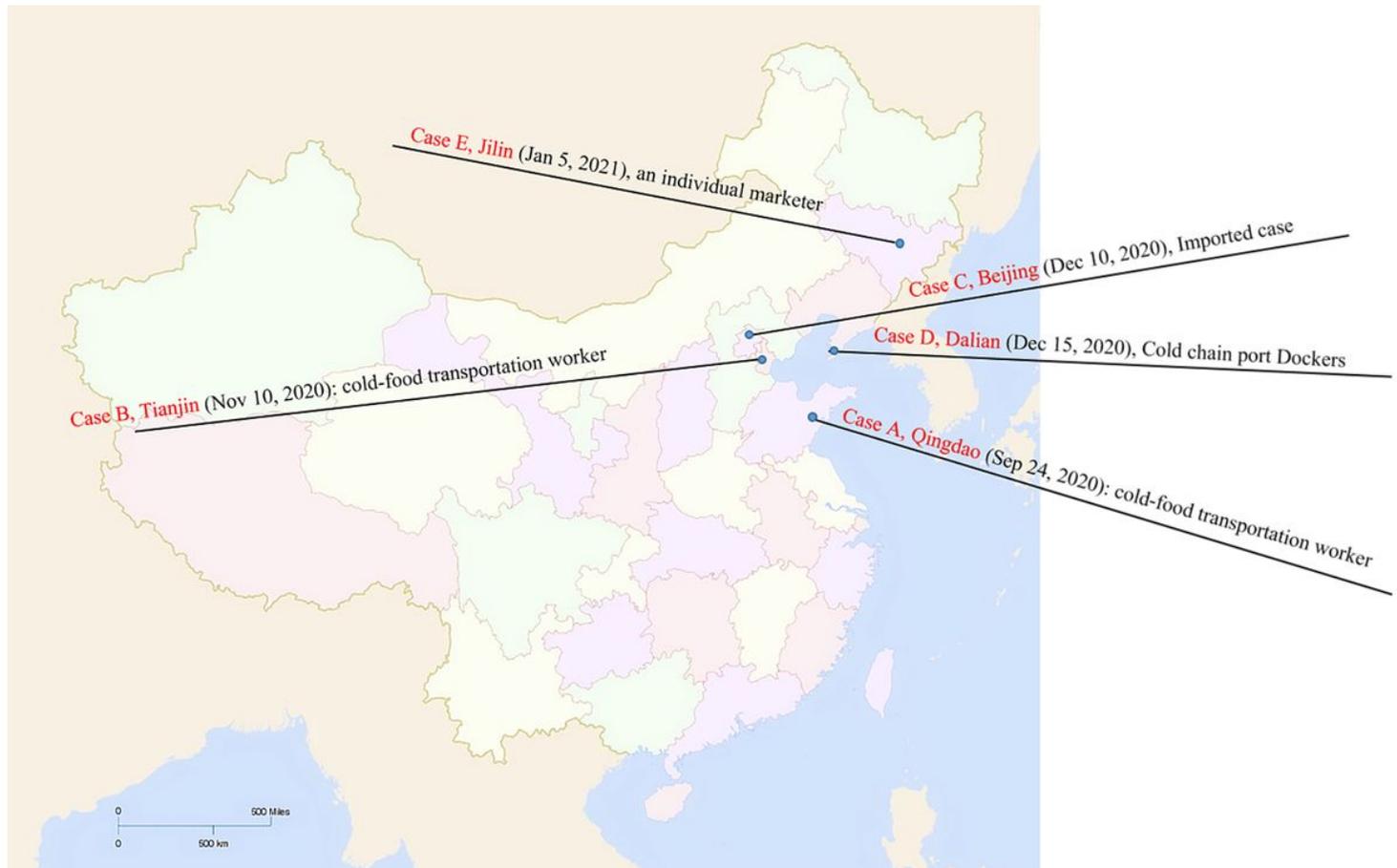


Figure 1

Geographical and occupational distribution of case series in local sporadic outbreak regions with COVID-19 from June 2020 to January 2021.

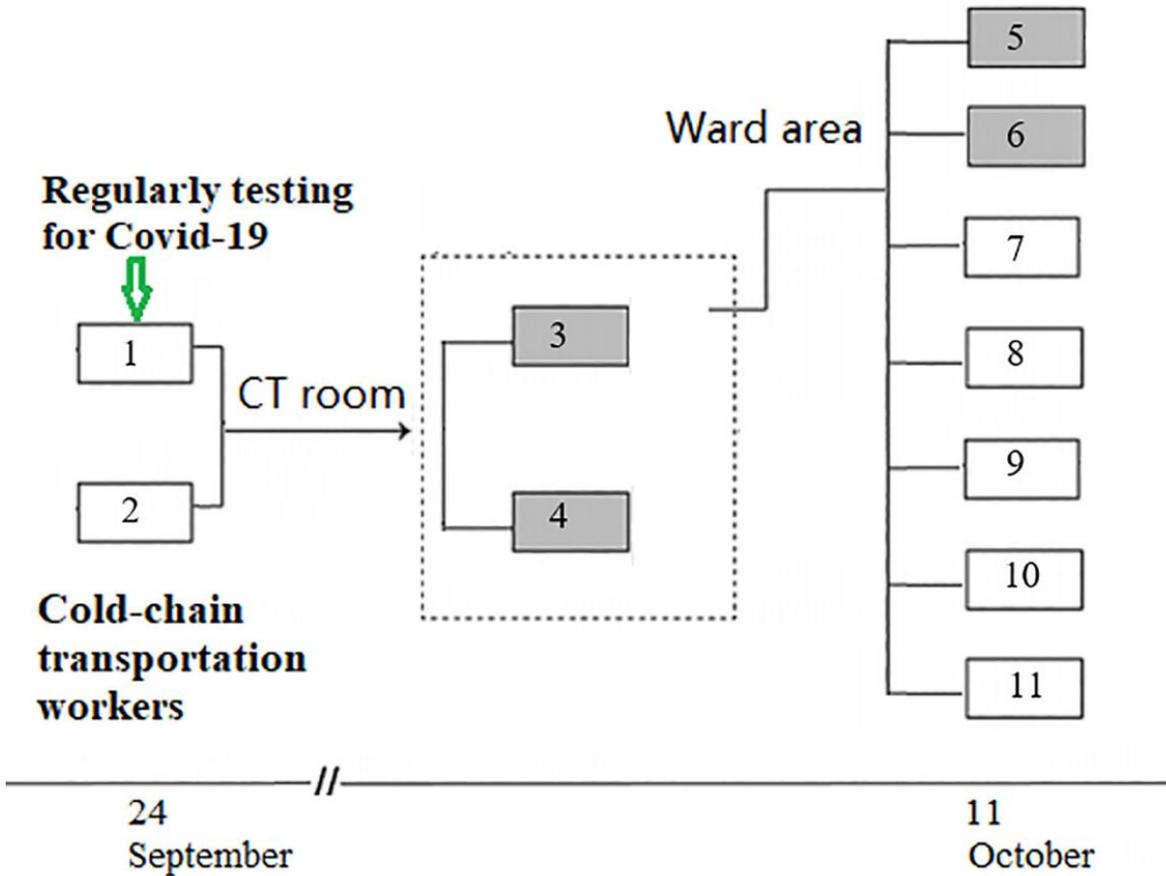
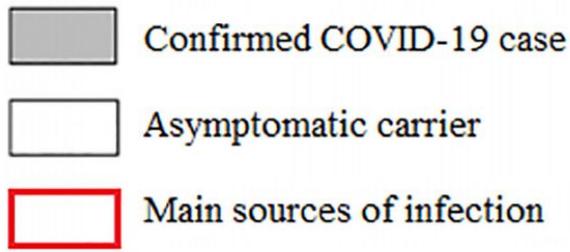


Figure 2

Timeline of exposure and connections between SARS-CoV-2 cases among persons in Qingdao, China. Cases 1 and 2 were quarantined in hospital when they tested positive for SARS-CoV-2 nucleic acid on September 24, 2020, and were determined to have asymptomatic infection. By October 16, 2020, Qingdao city had reported 13 confirmed cases since the asymptomatic cases were first detected on September 24, 2020.

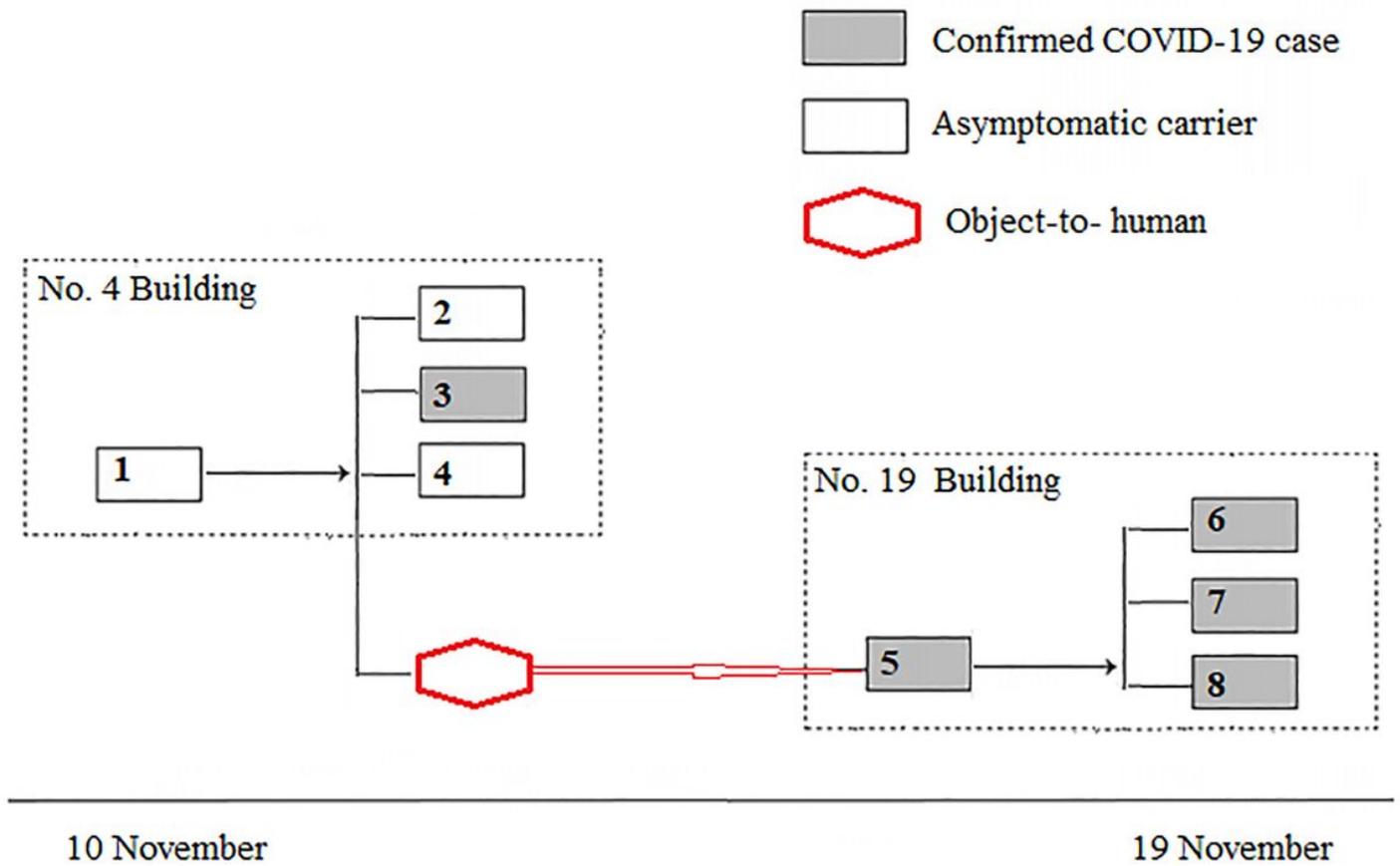


Figure 3

Timeline of exposure and connections between SARS-CoV-2 cases among persons in Tianjin, China. Case 1 in No. 4 Building first tested positive for SARS-CoV-2 on November 10, 2020, and was an asymptomatic carrier. Cases 5-8 in No. 19 Building were confirmed as COVID-19 cases on November 19, 2020. Epidemiological investigation showed that there was a SARS-CoV-2 transmission chain between No. 4 Building and No. 19 Building.

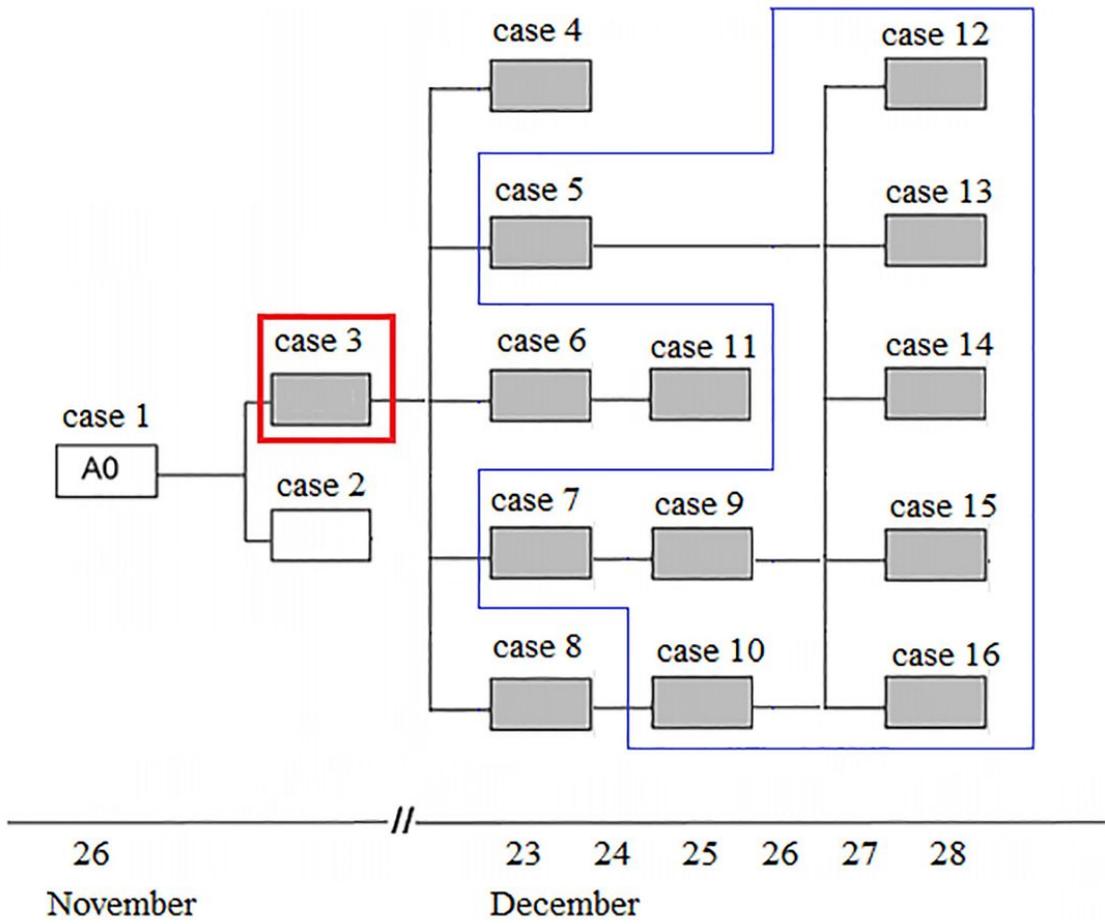
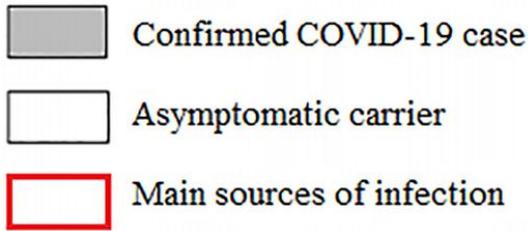
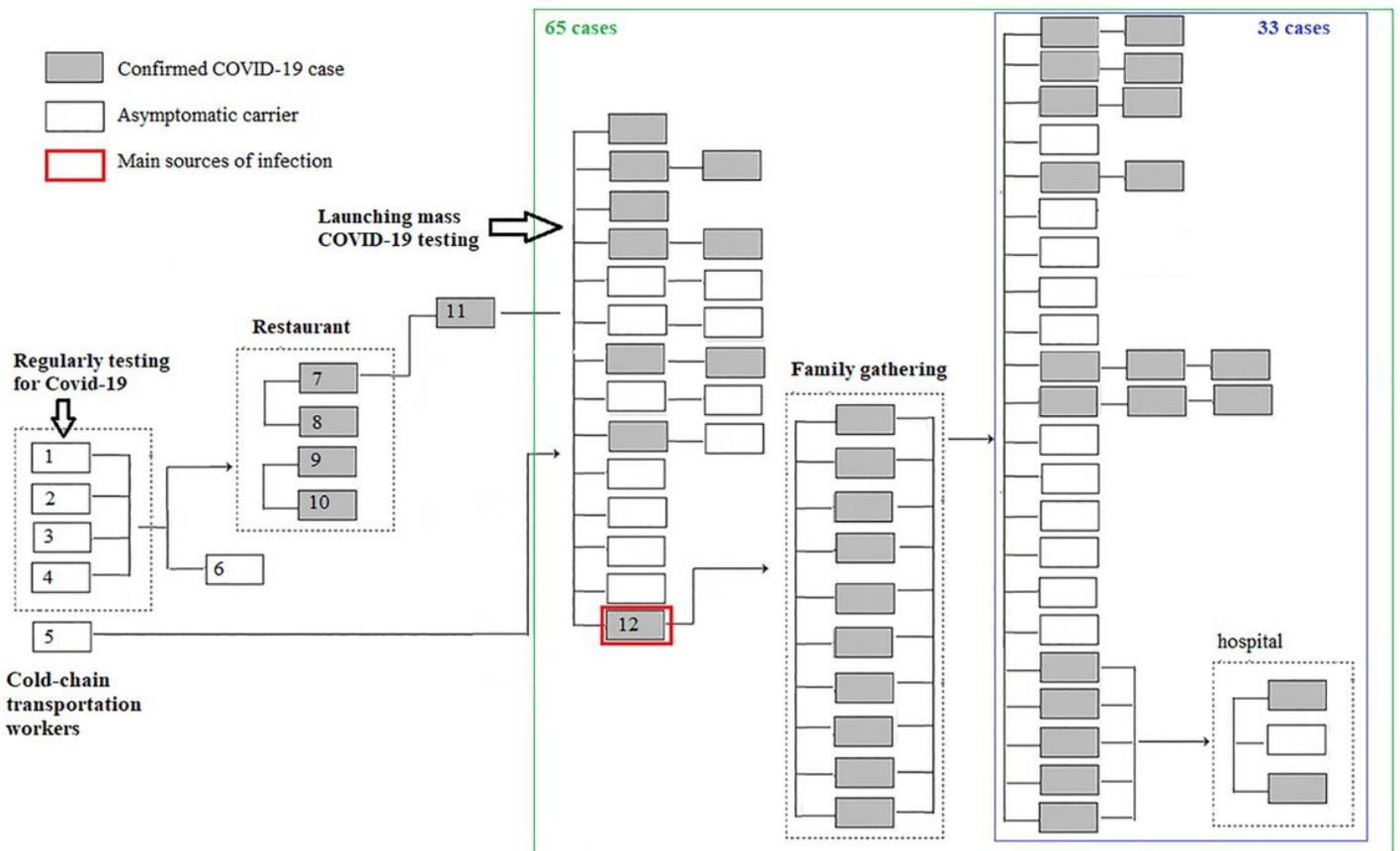


Figure 4

Timeline of exposure and connections between SARS-CoV-2 cases among persons in Beijing, China. On December 10, 2020, A0 (Case 1), an Indonesian national, returned to Shunyi District, Beijing after 14 days of isolation in Fujian Province and had a negative nucleic acid test. He was diagnosed with an asymptomatic infection on December 28. Case 1 was the source of a clustered epidemic and Case 3 is a key case in the transmission chain. Note: The data is based on public reports and might be incomplete.



11 Dec, 2020

3 Jan. 2021

Figure 5

Timeline of exposure and connections between SARS-CoV-2 cases among persons in Dalian, China. During regular COVID-19 testing of cold-chain transportation workers, Cases 1-4 had positive SARS-CoV-2 nucleic acid tests on December 15, 2020. Their close contacts, Cases 5-10, subsequently tested positive for SARS-CoV-2. Cases 5, 7 and 11 brought the SARS-CoV-2 virus to the Commercial Building 1 and multiple communities, leading to further infections. As of January 3, 2021, Cases 1-5 remained asymptomatic.

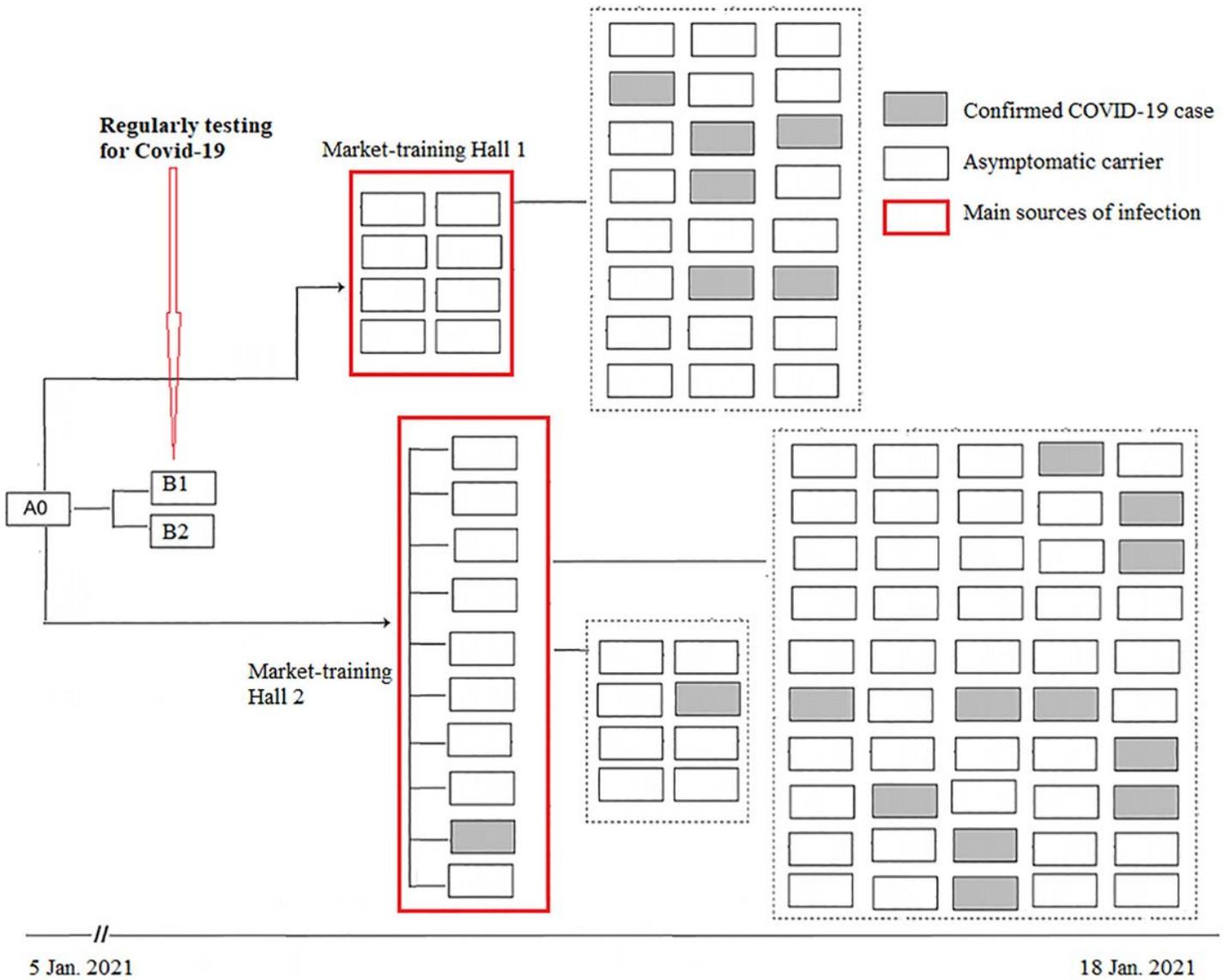


Figure 6

Timeline of exposure and connections between SARS-CoV-2 cases among persons in Jilin Province, China. A0 came to Changchun city from Heilongjiang Province on January 5, and A0, B1 and B2 were in the same train carriage. Both B1 and B2 had positive SARS-CoV-2 nucleic acid tests on January 11 and remained asymptomatic, indicating that B1 and B2 were previously infected with SARS-CoV-2 and were likely asymptomatic carriers. Based on epidemiological surveillance, A0 tested positive for SARS-CoV-2 nucleic acid on January 12 and noted symptoms of COVID-19 on January 16, suggesting that A0 was the first confirmed case in this cluster.