Effects of home quarantine for COVID-19 community control in Shenzhen, China, 2020

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Abstract

Background: Shenzhen implement classification management to prevent and control coronavirus disease 2019 (COVID-19) outbreak. Individuals with epidemic histories (came from Hubei and any other affected regions), but without symptoms were instructed to take home quarantine for 14 days and nucleic acid testing (NAT) for SARS-CoV-2. We described the infection status of the home-quarantined individuals, and effects of community control strategies in the three incubations after Wuhan closure in Shenzhen.

Methods: This was a descriptive research, the sample size was 2,004 individuals based on multistage sampling during the pre-investigation. And the formal investigation expanded the sample size to 57,012 individuals based on pre-investigation. A single throat swab was collected from each individual for nucleic acid testing (NAT) by reverse transcription-polymerase chain reaction (RT-PCR). NAT was performed by a third-party institution. We collected information related to demographics, disease history, travel history, and personal protective measures before home quarantine, and monitored close-contact histories using the We Chat questionnaire.

Results: The total infection rate of home-quarantined individuals was 0.12‰ (95% CI: 0.05‰−0.24‰) out of the total sample size of 59,016. The detection period for seven confirmed cases was primarily concentrated between February 8 and 18, 2020, which was during the second incubation period after Wuhan's closure. The home quarantined individuals with epidemic histories (came from Hubei and any other affected regions) were considered the high risk population during the first two incubations after Wuhan's closure. No positive cases were detected from February 25 to March 5(the third incubation after Wuhan's closure). The number of newly-confirmed cases per day was 0 for eight consecutive days from February 22 to 29 in Shenzhen.

Conclusions: The community control strategies for home-quarantined individuals with epidemic histories (came from Hubei and any other affected regions), but without symptoms to take the NAT in the first two incubations is effective to control COVID-19. But it is not advocating for home-quarantined person to take the NAT since the third incubation.

Background

Since December 2019, a cluster of patients with coronavirus disease 2019 (COVID-19) have been identified in Wuhan, a large city of 11 million people in central China [1-4]. The first four cases reported were linked to Huanan Seafood Wholesale Market, and were identified by local hospitals using a surveillance mechanism for "pneumonia of unknown etiology", which was established for identifying novel pathogens timely such as SARS-CoV-2 [5, 6]. Compared to Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS), COVID-19 resulted in a much lower case-fatality rate (about 2.67%) among confirmed cases [7]. Infection via respiratory droplets or secretions from infected individuals are thought to be the predominant mode of human-to-human transmission [8-11]. The mean incubation period of COVID-19 was 5.2 days (95% confidence interval [CI], 4.1 to 7.0 days),

World Health Organization (WHO) stated that most estimates of the incubation period ranged from 1 to 14 days, and the basic reproductive number was estimated to be 2.2 (95% CI, 1.4 to 3.9) [12,13]. The main interpersonal transmission in China was due to home outbreaks (78%-85%) [13], so it is important to prevent COVID-19 home outbreak by community control.

Wuhan is an important transportation hub in China and COVID-19 appeared 1 month before the Spring Festival. Thus, infected individuals could cause the outbreak by travelling to all parts of the country which have close relationships with Hubei. Lockdown was initiated in Wuhan on January 23 to prevent the spread of COVID-19, but there were still so many people returned to Shenzhen from Hubei. According to the research from China Medical Treatment Expert Group for COVID-19, fever was present in 43.8% of the patients on admission, but developed in 88.7% of individuals during hospitalization [15]. The absence of fever in SARS-CoV-2 was more frequent than in SARS-CoV (1%) and MERS-CoV infections (2%) [16], and afebrile patients may be missed if the surveillance case definitions focus on fever detection [17]. So individuals with epidemic histories (came from Hubei and any other affected regions), but without symptoms were considered the high risk population and need to take home quarantine for 14 days and nucleic acid testing (NAT) for SARS-CoV-2. There were three incubations between January 23 and March 5. Our research was performed to understand the infection status of home-quarantined individuals with epidemic histories (came from Hubei and any other affected regions), but without symptoms, and effects of community control strategies in the three incubations after Wuhan's closure in Shenzhen.

Methods

Study design and data collection

Our descriptive research was supported by Shenzhen Municipal Health Commission (MHC), which was responsible for questionnaire design, data collecting and reporting, and they shared those data timely with Shenzhen Center for Disease Control and Prevention (CDC). So we used secondary and public data form MHC, which can also be referenced. Our study was approved by the Ethics Committee of Shenzhen CDC [2020, code (039A)]. The statement indicated that the need for consent was waived by approving ethics committee. The identifying information and all methods were performed in accordance with the relevant guidelines and regulations.

Shenzhen started the work of NAT for home-quarantined individuals on January 31. The pre-investigation period was during the first incubation after the closure of Wuhan (14 days after Wuhan's closure, between January 31 and February 11). The sample size was 2,004 individuals based on multistage sampling during the pre-investigation. The formal investigation was divided into two parts by the date of Guangdong province turned down to level-2 public health emergency response on 24 February. Part 1 was between February 12 and 24 (the second incubation after Wuhan closure), and part 2 was between February 25 and March 5 (the third incubation after Wuhan closure). The formal investigation expanded the sample size to 57,012 individuals based on pre-investigation. The respondents were home-quarantined individuals with epidemic histories (came from Hubei and any other affected regions), but

without symptom in Shenzhen, according to the Prevention and Control Plan for Coronavirus Disease 2019 (the Fourth Edition) outlined by the National Health Commission (NHC).

Multistage sampling process: The COVID-19 infection rate (P) was 5%, = 10%, and α = 0.05. The calculated sample size was 1,825, but the actual sample size was 2,004 considering the 90% response rate. The first stage was to select two streets from ten districts in Shenzhen with completely random sampling. The second stage was to select two committees from the selected streets with completely random sampling. If the total number of home-quarantined individuals in the committee was less than 50, we could merge the committees to ensure that the total number of home-quarantined individuals in the sampling unit was more than 50. The third stage was to select 50 home-quarantined individuals from each committee (or the merged committees) by simple random sampling. A single throat swab was collected from each individual for NAT by reverse transcription-polymerase chain reaction (RT-PCR). NAT was performed by a third-party institution, BGI (The Beijing Genomics Institute). We collected information related to demographics, disease history, travel history, personal protective measures before home quarantine, and close contact history using the We Chat questionnaire.

$$n = \left(\frac{Z_{\alpha/2}}{P \cdot \delta}\right)^2 P(1 - P)$$

Prevention strategies

After COVID-19 outbreak in Wuhan, thirty-one provinces in China initiated level-1 public health emergency response to prevent and control the epidemic [14]. COVID-19 was included as a notifiable disease in the Infectious Disease Law, and the Health and Quarantine Law on January 20. Lockdown was initiated in Wuhan on January 23 to prevent the spread of COVID-19. China established the Central Leading Group to respond to the COVID-19 outbreak on January 25 (Figure 1), and also implemented the classification management by cooperation with multiple departments. 1. Case-free areas should prevent the imported cases by establishing transport hub quarantine stations, temperature surveillance, strengthening appointment triage. 2. The sporadic-case areas should reduce imported cases, prevent spread and provide medical treatment. 3. Areas with clustered epidemic communities should strengthen medical treatment to prevent spread and exporting cases. 4. The community-transmission areas implemented the strictest prevention and control strategies to prevent turnover, strengthen public health and medical treatment.

As of March 5, the number of confirmed cases was 418, including one imported case from abroad, four severe cases, three critical cases, three fatalities, and 358 people were cured and discharged from hospitals in Shenzhen. The first reported case in Shenzhen was the imported case from Hubei on 19 January 2020, and the number of confirmed cases related to Hubei was 41 (about 96.49%) on 27 January (Figure 2). The number of confirmed cases related to Hubei was 304 (about 72.9%) since February 18. In order to prevent imported cases from Hubei and control community outbreak, Shenzhen implemented the trinity cooperation community mode which include medical staff from community

health service centers, community workers, and community police to prevent home outbreaks, imported cases, and inner cases spread. Everyone who visits Shenzhen shall be required to submit a self-health declaration from the system named "Shenzhen I you-independent declaration platform". The government implemented four categories of classification management for individuals according to the Prevention and Control Plan for Coronavirus Disease 2019 (the Third Edition) and the declaration results.1. Individuals without epidemic histories (came Hubei and any other affected regions) were instructed to wear masks, assess temperatures twice per day, and enhance self-protection. 2. Individuals with epidemic histories (came from Hubei and any other affected regions), but without symptoms were instructed to take 14 days of home quarantine by the life support from community. 3. Individuals who had close contact with confirmed or suspected cases were required to take centralized quarantine in the centralized medical observation places. 4. Patients with symptoms, such as fever, cough, and breath with difficulty were required to attend fever clinics and designated hospitals, such as the Third People's Hospital of Shenzhen.

Results

The pre-investigation (between January 31 and February 11)

Of the 2,004 individuals tested, COVID-19 was detected in three patients, including a father and his daughter living in Yantian district, and one patient living in Nanshan district. All patients had been to Hubei and had different initial symptoms. The father and his daughter had dry cough for 2 weeks. The third patient had a single temperature reading above 37.3°C, but presented with a normal temperature and was asymptomatic during the other assessment times as of the date to get NAT on 8 February. The three patients never contacted with any suspicious case during the period in Hubei. The infection rate of home-quarantined individuals was 1.5‰ (95% CI: 0.31‰–4.37‰) based on the results of the pre-investigation. The period of pre-investigation was conducted (between January 31 and February 11) during the first incubation after Wuhan was placed on lockdown. The home-quarantined individuals with epidemic histories (came from Hubei and any other affected regions), but without symptoms remained as the high risk population. The pre-investigation implemented the policy of "early detection, early report, early diagnosis, early quarantine and early treatment" for the high risk population to control and prevent the spread of COVID-19.

The formal investigation – Part 1 (between February 12 and 24)

The formal investigation was divided into two parts by the date of Guangdong province turned down to level-2 public health emergency response on 24 February. Part 1 was between February 12 and 24 (the second incubation after Wuhan closure) and part 2 was between February 25 and March 5 (the third incubation after Wuhan closure). Part 1 expanded the sample size to 44,021 based on the results of the pre-investigation. Figure 3 is the sampling and detection distribution among the 11 districts (including the Shenshan special cooperation zone) in Shenzhen by ARCGIS10.2. There were five positive cases detected from the sample of 44,021 individuals. The 4 of the 5 positive cases including two patients living in

Longgang district, two patients living in Futian district. The fifth positive case in Nanshan is asymptomatic and hasn't been onset so far, so we excluded this case considering the sensitivity of NAT. Thus, the infection rate of home quarantined individuals was 0.09‰ (95% CI: 0.03‰–0.22‰) based on the results of formal investigation part 1. The median age of the respondents was 34 years (range, 0 to 95 years), and 57.1% were male (Figure 4). The proportion of children under 15-years-old was 11.83%, while the proportion of individuals aged over 60-years-old was 3.28%. Among the overall population, 8.4% had at least one coexisting illness (e.g., cardiovascular and cerebrovascular disease, hypertension, chronic obstructive pulmonary disease diabetes, liver disease, blood disease, or malignant tumors).

A total of 40% individuals had an epidemic history (came from Hubei and any other affected regions), and the remaining 60% were their family members. Among the epidemic histories, 93.21% had been to Hubei province, including 21.68% that visited Huanggang, 16.85% that visited Jingzhou, and 11.41% that visited Xianning. The dates of return to Shenzhen were mainly concentrated the period between January 23 and February 26 (Figure 5). There were two peaks in figure 5, the first of which concentrated on January 25, which indicated that many people left Hubei for Shenzhen after the Wuhan closure on January 23, and those individuals are the high risk group and were required to take immediate quarantine observation. The second peak concentrated on February 24, which Guangdong turn down to level-2 public health emergency response. This showed that prevention and control strategies were effective to control the epidemic in the early stage. Meanwhile, Shenzhen started to work on February 9. Many people returned to Shenzhen to begin working after COVID-19 was effectively controlled.

Considering the epidemic histories, 97.32% of individuals stayed in Hubei less than 100 days, and the mean duration was 0.37 days. A total of 2.18% lived in Hubei (more than 1 year), and 6.31% stayed in Hubei less than 24 hours as they were passing through or in transit. There were two peaks in Figure 6, the first one concentrated on 4 days, and the second one concentrated on 34 days. The most common mode of transportation was driving a private vehicle (86.58%). The advantages of private vehicles include reducing the number of close contacts and the risk of transmission. The second most common mode of transportation included riding high-speed trains/bullet trains/other types of trains (10.32%). The third one was plane (1.99%), and the fourth one was taking long-distance buses (0.21%). Only 0.6% of individuals had been exposed to individuals with fever and respiratory symptoms, 0.37% were exposed to confirmed cases, mild cases or asymptomatic cases, and 0.61% were exposed to suspected cases, confirmed cases or fever patients in their family, friends and colleagues.

In order to protect vulnerable populations, prevent and control the epidemic, the government advocated to everyone to take home quarantine, wear masks outdoors, wash hands frequently, leave homes less frequently, cancel parties, dinners, and other visits, and cover the mouth and nose with paper or towels when sneezing or coughing. The government also strengthened public health surveillance and hygiene knowledge to improve public health awareness and behavior. The results of our research indicated that the rate of health self-protection awareness among home-quarantined individuals with epidemic histories (came from Hubei and any other affected regions) was more than 80%, and females have a higher rate than males (Table 1).

The formal investigation - Part 2 (between February 25 and March 5)

No positive cases were detected in the 12,991 individuals tested during part 2 (the third incubation). So the infection rate of home quarantined individuals was 0. Additionally, the number of new confirmed cases per day had been 0 for eight consecutive days from February 22 to 29 in Shenzhen. Thus, the prevention and control strategies as well as the national cooperation mechanisms were effective at controlling COVID-19 during the early stage.

Seven confirmed cases

The total sample size for this investigation (including the pre-investigation, and the formal investigation) was 59,016 individuals. Of which seven cases were confirmed positive. Therefore, the infection rate of home-quarantined individuals was 0.12‰ (95% CI: 0.05‰-0.24‰).The seven patients age from 13 to 66 and had been to Hubei(Figure 7), which included a father (Case 1) and his daughter (Case 2). There were four patients with different initial symptoms, including Case 3 who had a temperature higher than 37.3°C once, but exhibited a normal temperature and was asymptomatic during the other assessments as of the date to get NAT on 8 February (Table 2). Case 1 and Case 2 had dry coughs for 2 weeks. Case 7 had a runny nose for 4 days. Six patients did not exhibit fever, and three patients were asymptomatic. These seven patients received medical treatment in the Third People's Hospital of Shenzhen (designated hospitals) immediately following positive NAT results. They were mostly detected between February 8 and 18, which was during the second incubation period after Wuhan closure. So the home-quarantined individuals with epidemic histories (came from Hubei and any other affected regions), but without symptoms were still at high risk of infection and transmission. Shenzhen started to work on February 9 which means businesses began to reopen, and more people returned to Shenzhen during this time. We still needs to be vigilant to prevent and control COVID-19.

Discussion

COVID-19 appeared 1 month before the Spring Festival in Wuhan, China. The primary mode of human-to-human transmission is respiration [9,18]. WHO stated that predominantly interpersonal transmission was due to home outbreaks (about 78%-85%) [13]. There is no specific medicine, so it is an urgent need to prevent and control COVID-19. China established the Central Leading Group on responding COVID-19, they closed Wholesale Market, cut off transmission and identified the pathogen immediately. NHC notified COVID-19 to the WHO and relevant countries and regions on January 3. China CDC publicly shared the gene sequence of the novel coronavirus and developed the diagnostic PCR reagents and test on January 10. They also issued medical treatment, surveillance and epidemiological investigations, close-contact management and laboratory examination plans. COVID-19 was added as a Category B infectious disease and managed as a Category A infectious disease in the Laws of the People's Republic of China for the Prevention and Treatment of Infectious Diseases on January 20. The government established policies surrounding medical insurance payments to settle the medical expenses in different districts with financial support for the patients. Wuhan was under lockdown on January 23, because the

cumulative confirmed cases in other provinces was positively correlated with the migration index derived from Hubei, the correlation coefficients were 0.84 and 0.81[19,20].

Here we provided a research about the effects of community control strategies for COVID-19, and infection status of home-quarantined individuals with epidemic histories (came from Hubei and any other affected regions), but without symptoms during the three incubations after Wuhan closure. The infection rate of home-quarantined individuals was 1.5‰ (95% CI: 0.31‰-4.37‰) based on the results of the pre-investigation (between January 31 and February 11; the first incubation after Wuhan closure). The infection rate of home-quarantined individuals was 0.09‰ (95% CI: 0.03‰−0.22‰) based on the results of part 1 of the formal investigation (between February 12 and 24; the second incubation after Wuhan closure), which was lower than the results of the pre-investigation. The detection of the seven confirmed cases was mostly concentrated between February 8 and 18, which was during the second incubation period after Wuhan's closure. Home-quarantined individuals with epidemic histories (came from Hubei and any other affected regions) were considered the high risk population in the first two incubations. Shenzhen started to work on February 9 which means businesses reopened, and more people returned to Shenzhen during this time. Our research can implement the policies of "early detection, early report, early diagnosis, early quarantine and early treatment", and "concentrate patients, concentrate experts, concentrate resources, concentrate treatment" (5 early and 4 concentrate policies) in the high risk population to control and prevent COVID-19 outbreak.

There was no positive case detected within the cohort of 12,991 individuals in part 2 (between February 25 and March 5; the third incubation after Wuhan's closure). The total infection rate of home-quarantined individuals was 0.12‰ (95% CI: 0.05‰−0.24‰) from a total sample size of 59,016 individuals. The number of newly-confirmed case per day had been 0 for eight consecutive days from February 22 to 29 in Shenzhen. So the community control strategies were effective in the early stage. The government ensured the supply of medical and living resources for home quarantined individuals in accordance with the law under the jurisdiction to maintain social stability. The health education and notification of cases by government also improved health self-protection awareness and knowledge [21-23]. Guangdong implemented the level-2 public health emergency response on February 24 due to the prevention and control work had been kept on track.

We advocate the trinity cooperation community control and prevention mode, and self-health declaration strategy in Shenzhen. The trinity work mode included medical staff from community health service centers, community workers, and community police. As of February 1, there were 75 streets (include Sino-British Street Authority) and 660 communities that established the trinity cooperation control and prevention groups. Everyone who visits Shenzhen shall be required to submit a self-health declaration from the system named "Shenzhen I you-independent declaration platform". People shall be managed as five classifications: 1.Non-local residence: The individuals came from other places after January 1, 2020, and stayed in hotels or friends and relatives' home. 2. Residence returned to Shenzhen: The local residents returned to Shenzhen after January 1, 2020. 3. Self-conscious discomfort cases: The individuals felt sick but hadn't left Shenzhen after January 1, 2020. 4. Home quarantine cases: The

individuals need home isolation medical observation within the quarantine and had been confirmed by relevant departments. 5. Contact cases: The individuals may have close contact with confirmed cases or suspected diseases. Classification management can supply medical treatment for patients timely, provide close contacts with centralized quarantine effectively, and controlled the high risk population by home quarantine accurately.

The community control strategies for home-quarantined individuals with epidemic histories (came from Hubei and any other affected regions), but without symptoms to take the NAT in the first two incubations can implement the policies of 5 early and 4 concentrate policies, and it is effective to control COVID-19. But it is not advocating for home quarantine person to take the NAT since the third incubation. This work has some limitations. Individuals should take NAT twice during 14 days medical observation, and two test intervals should be more than one day. However, our research implemented NAT only once for each home-quarantined individual. NAT also has multiple limitations, including a high false negative rate [24]. Our research may be more complete by combining NAT and antibody detection results.

Tables

Table 1 Proportion of home-quarantined individuals taking self-protection measures

Sex	Wearing mask outside	Wash your hands frequently	Going out less frequently	Cancel parties, dinners, and visits	Cover your mouth and nose with a tissue or towel when you cough / sneeze
Male-%	91.4	87.2	84.7	87.5	85.3
Female-%	93.3	90.8	87.5	89.5	87.9

Table 2 Epidemiological characteristics of the seven patients

Number	Gender	The interval between initial symptom and NAT (Days)	Initial symptom
Case 1	M	14	Dry cough occasionally
Case 2	F	14	Dry cough occasionally
Case 3	M	9	Only had 37.4°Conce and normal temperature frequently
Case 4	F	-	-
Case 5	M	-	-
Case 6	F	-	-
Case 7	M	5	Runny nose

Abbreviations

Center for Disease Control and Prevention, CDC.

Corona Virus Disease 2019, COVID-19.

Middle East Respiratory Syndrome (MERS).

Nucleic Acid Testing (NAT).

National Health Commission (NHC).

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

Severe Acute Respiratory Syndrome (SARS).

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)]

-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.

-Authors' contributions

XZQ participated in data analysis and drafted the manuscript. WJZ and HJF participated in the data collection. ZX participated in liaison and coordination with government. LJH and HJF conceived of the design and coordination of the study. WHR, WB, SLX, LMM and FSY performed the statistical analysis. YYC, XHX and ZYD guided the statistical analysis and revisions of the manuscript. All authors read and approved the final manuscript.

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Figures
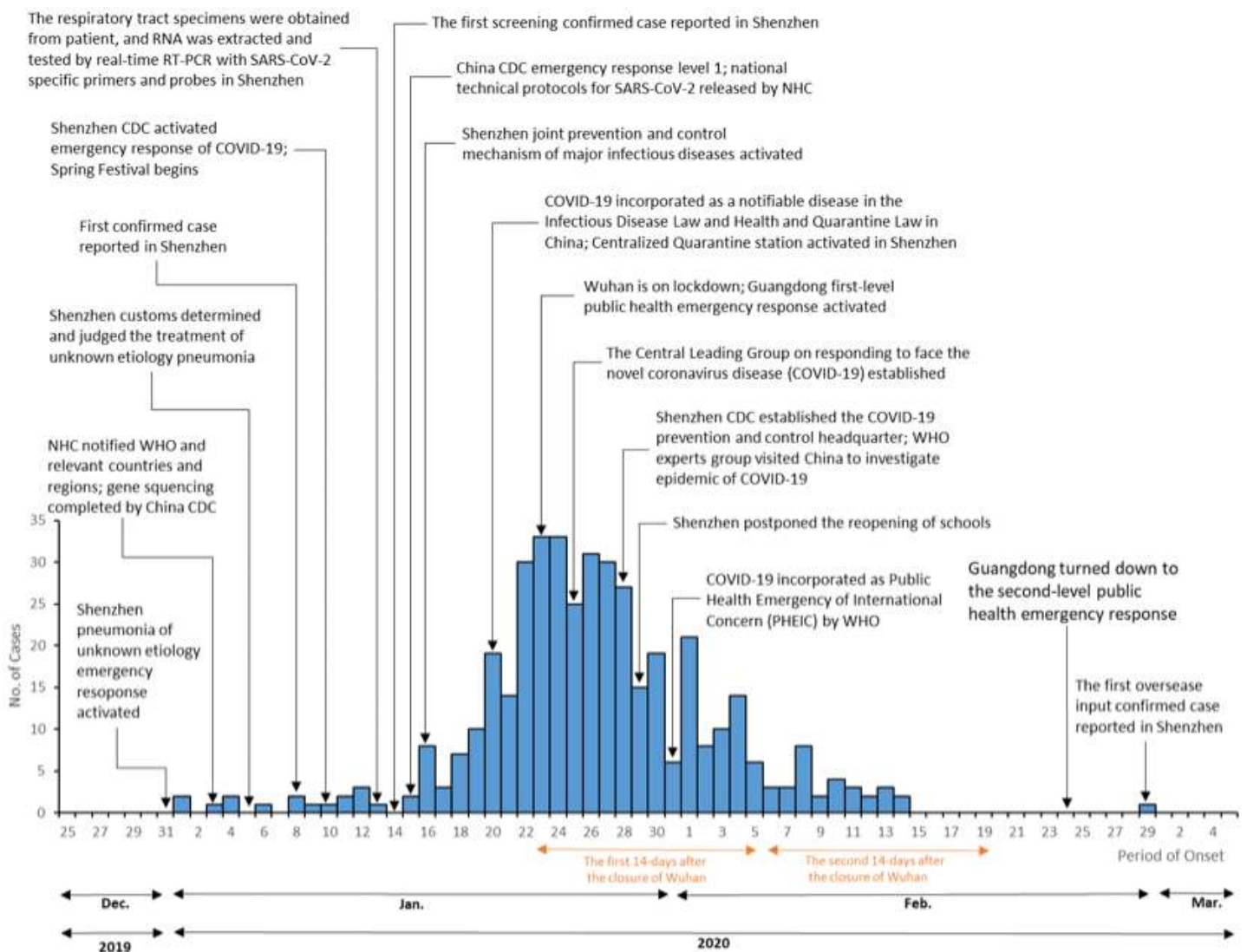
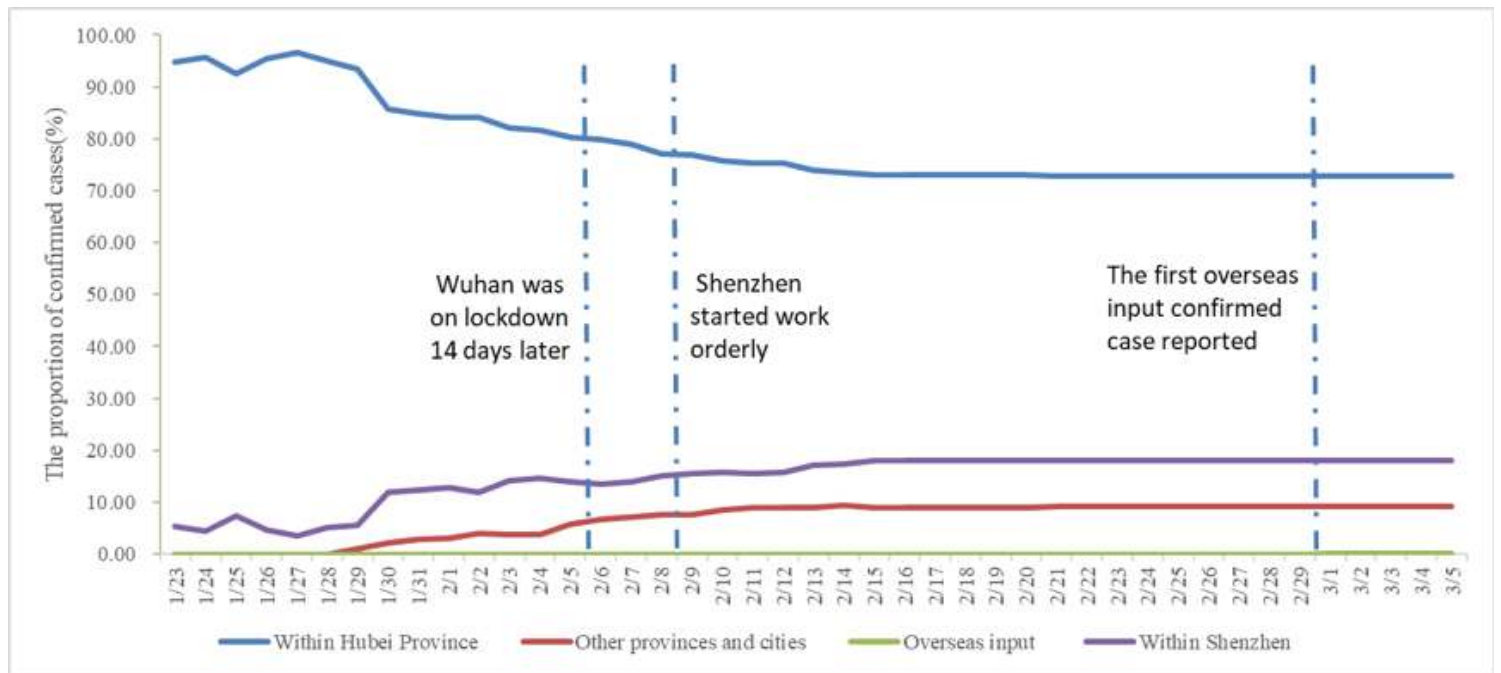## Figure 1

The timeline of COVID-19

Figure 2

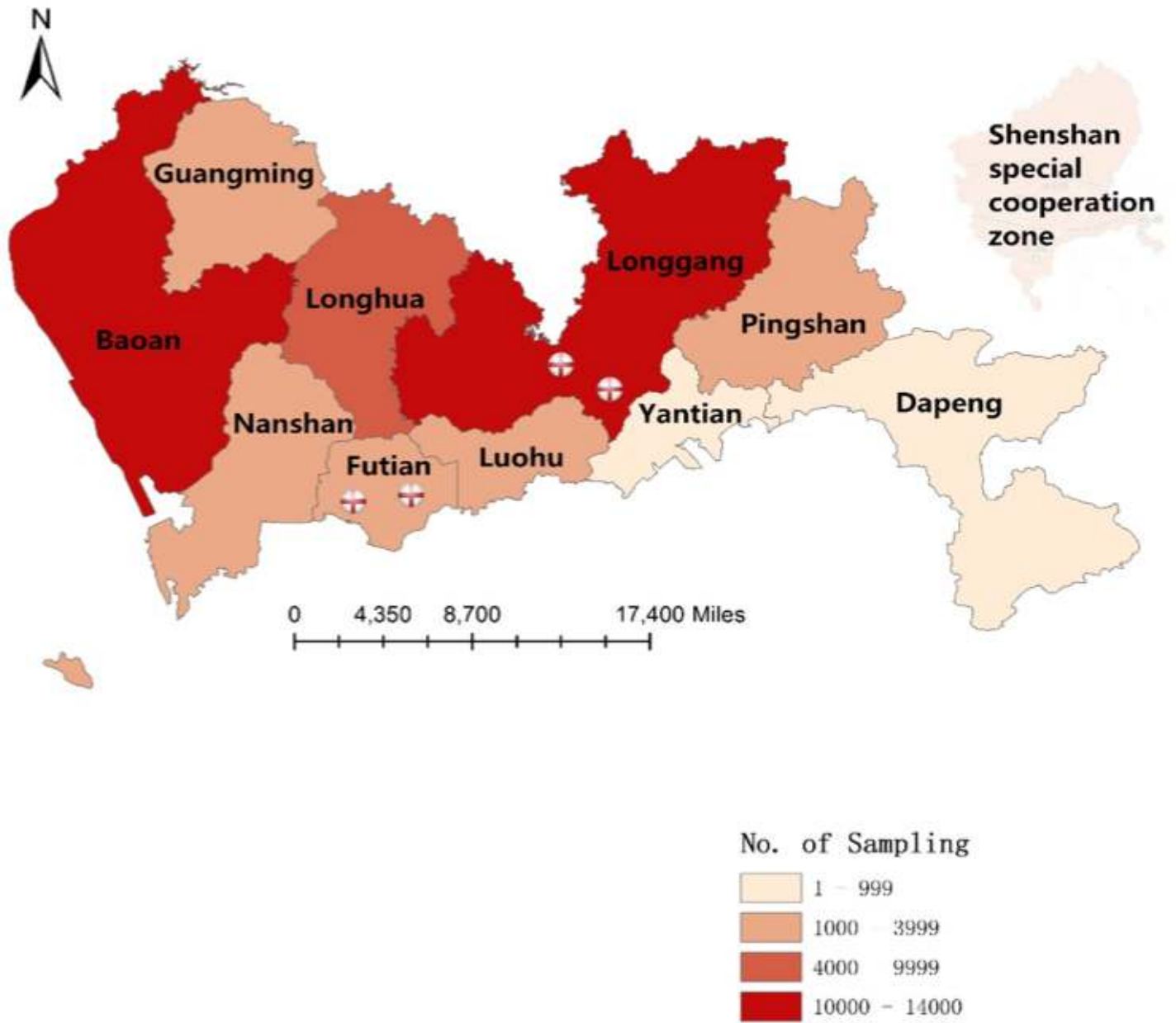The proportion of 418 confirmed cases source in Shenzhen

Figure 3

Sampling and detecting confirmed cases distribution. 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.
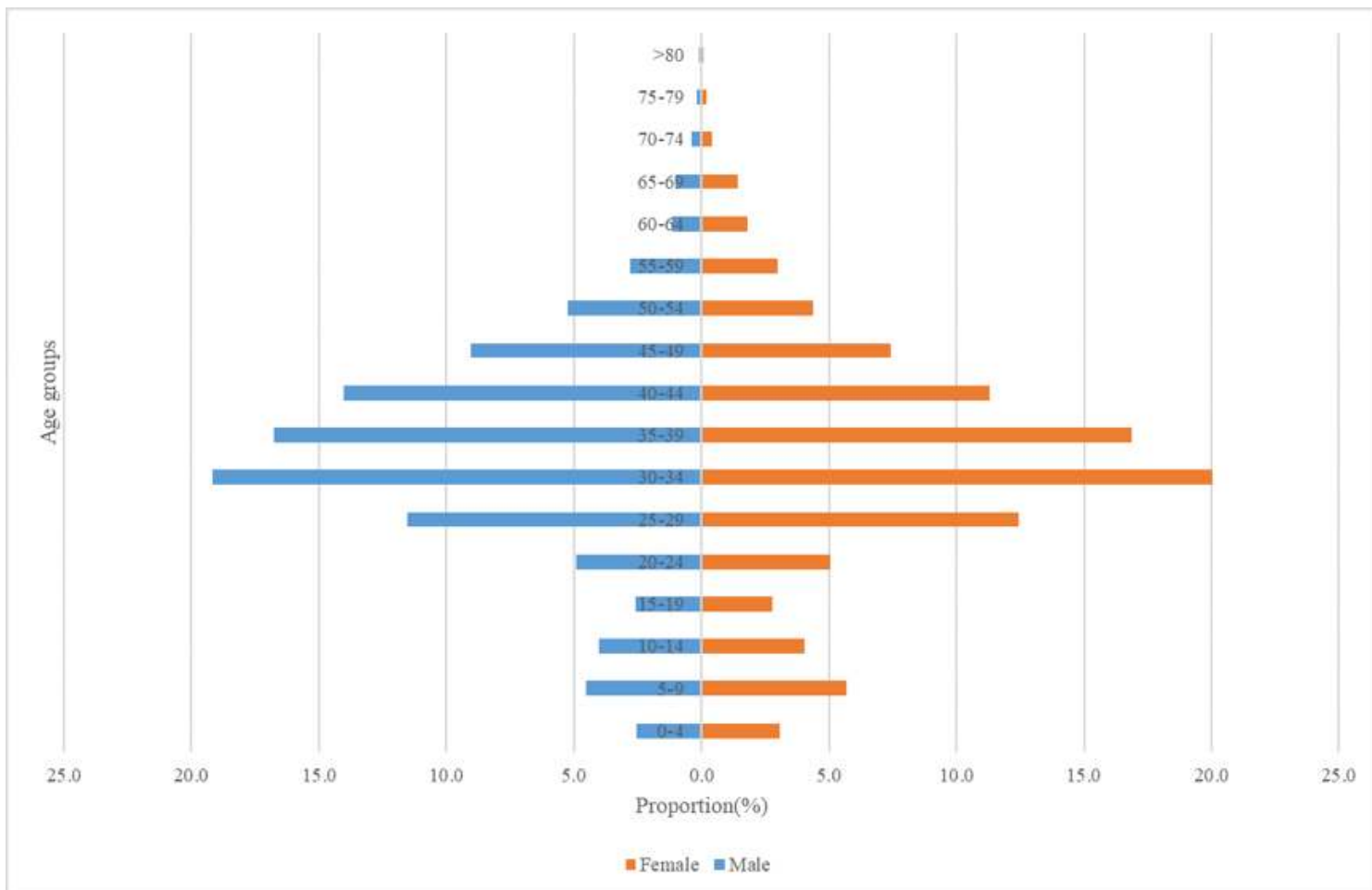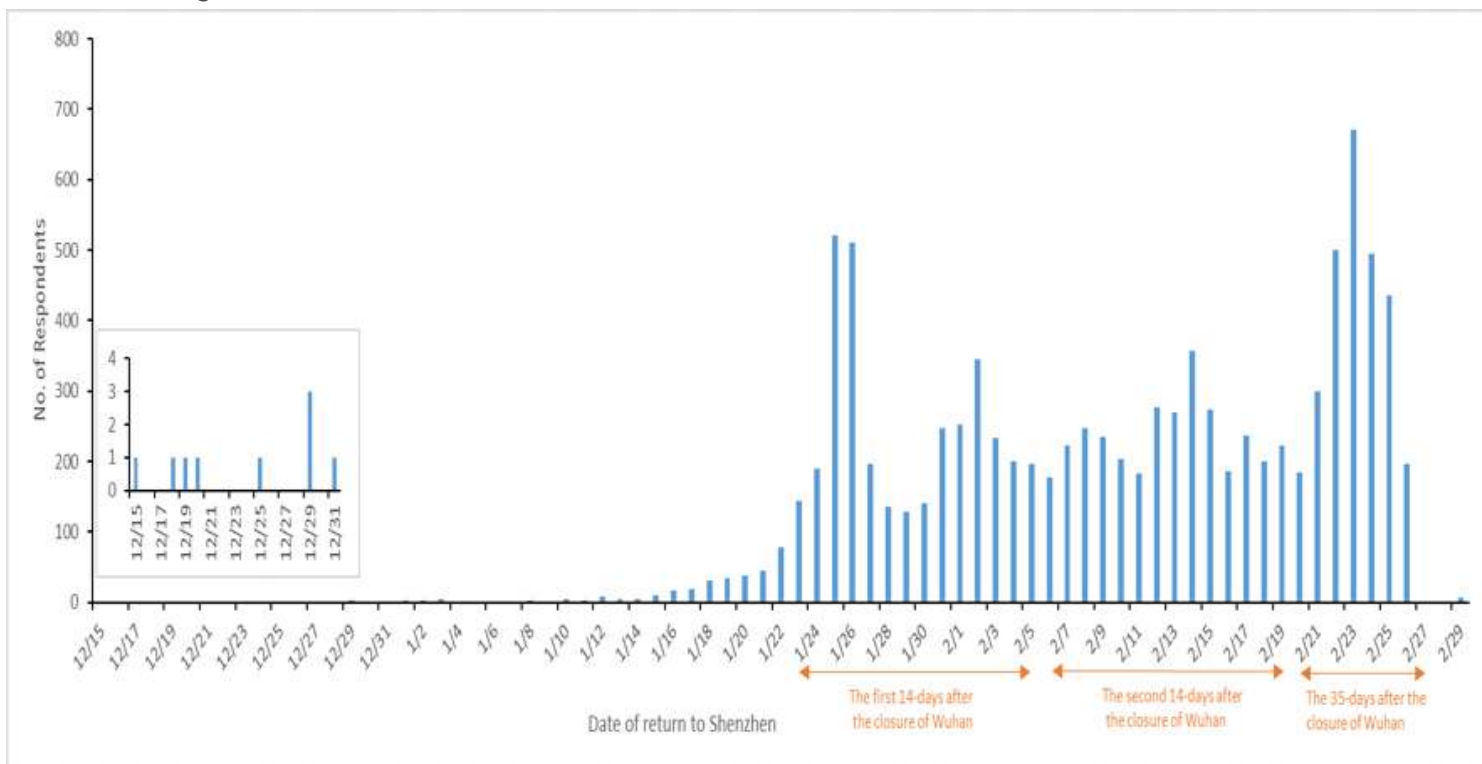
Figure 4

Gender and age distribution
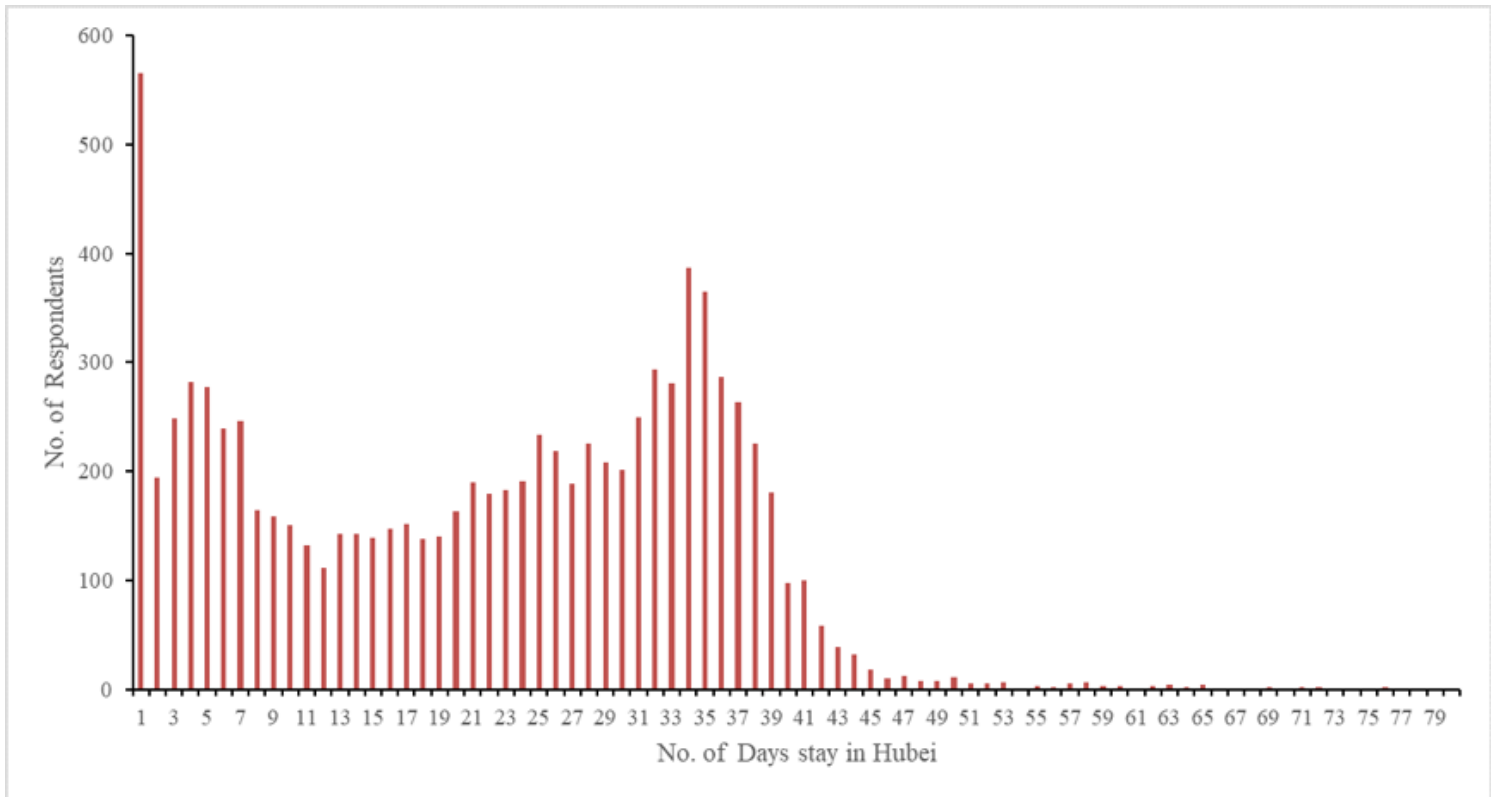
Figure 5

The distribution of return date

Figure caption: No. of Respondents (y-axis) vs No. of Days stay in Hubei (x-axis)
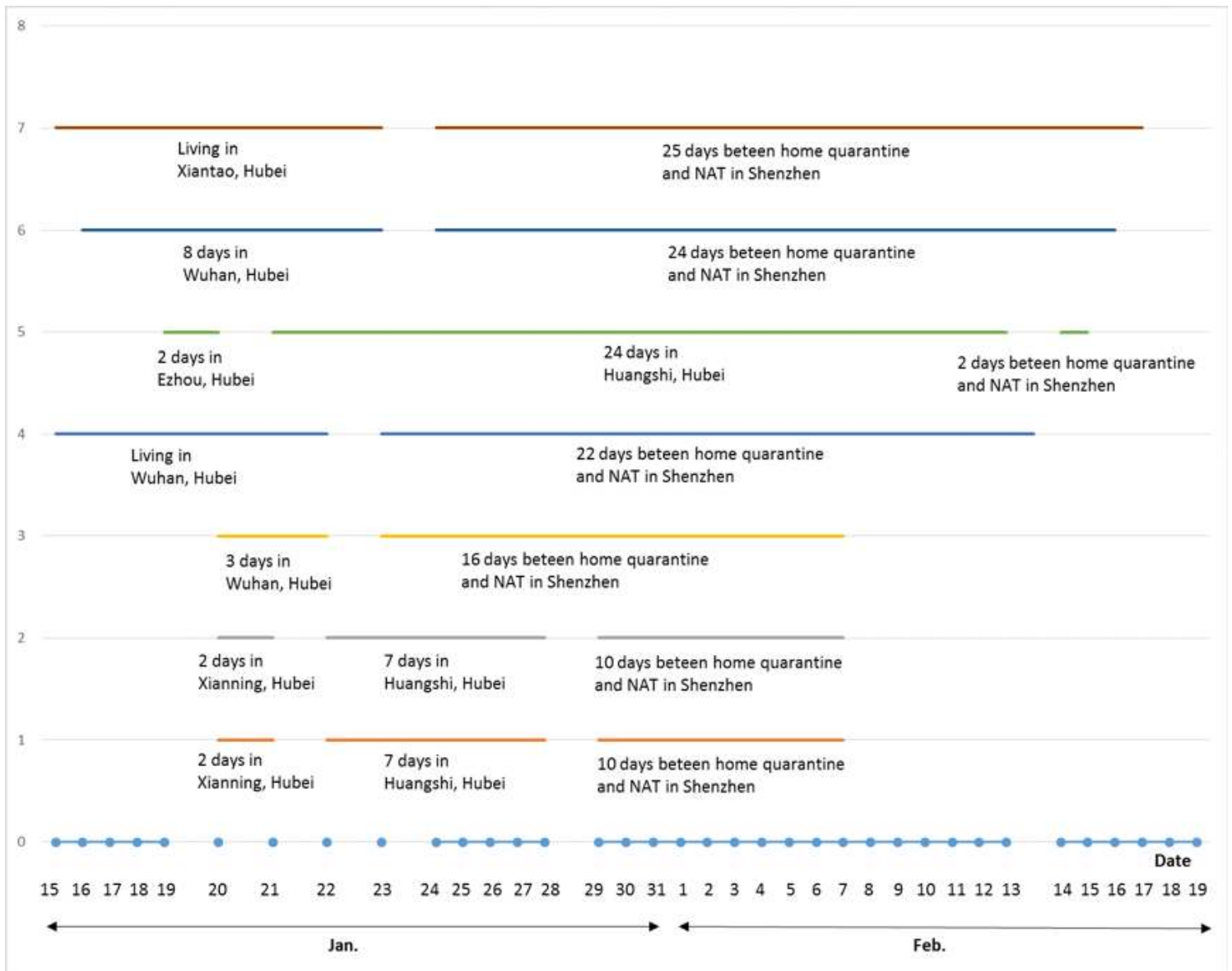
Figure 6

The distribution of duration

Figure 7

Epidemiologic features of the 7 patients