


# Epidemiological study on severe acute respiratory syndrome coronavirus 2 virus transmission network in northeast China

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## Abstract

In this study, corona virus disease 2019 (COVID-19) transmission networks were built to analyze the epidemic situation of COVID-19 in Liaoning and Jilin provinces in early 2020. We explore the characteristics of the spread of COVID-19, and put forward effective recommendations for epidemic prevention and control. We collected demographic characteristics, exposure history, and course of action of COVID-19 cases. We described the demographic and case characteristics of these cases to show the basic characteristics of COVID-19 cases in both provinces. Combined with the spatial analysis of confirmed cases, the distribution law of the number of confirmed cases in different regions was analyzed. We exhibit the relationship among COVID-19 cases with a transmission network. The transmission characteristics of COVID-19 were analyzed through the transmission network. Mainly cases in Liaoning and Jilin provinces were imported cases from other provinces and the vast majority of these cases were related to Hubei province. The number of confirmed cases in different regions was positively correlated with their GDP and population. The main clinical symptoms of the cases were fever. Judge from the transmission network relationship between the 2 provinces, the transmission chain in Liaoning province contains fewer cases than that in Jilin province. The main transmission routes of the local cases in the 2 provinces were the family members, and the infection of the imported cases were mainly occurred in public places. It was estimated that the unidentified asymptomatic infected cases in the 2 provinces account for approximately 7.3% of the total number of infected cases. The length of the transmission chain suggests that the spread of COVID-19 can be effectively controlled with effective prevention measures.

**Abbreviations:** CDC = center for disease control, COVID-19 = corona virus disease 2019, SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2, WHO = World Health Organization.

**Keywords:** asymptomatic infected cases, corona virus disease 2019, epidemiological survey, transmission network, transmission routes

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TF and YZ contributed equally to this work.

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## 1. Introduction

In December 2019, a case of pneumonia caused by new coronavirus (severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2]) infection emerged in Wuhan, Hubei province, China.<sup>[1-3]</sup> The outbreak began in China during the December 2019, when the number of floating people surged and a large number of undiagnosed cases spread across the country. As of January 25 (Chinese Spring Festival), the total number of confirmed corona virus disease 2019 (COVID-19) cases in China had reached 1975. Thailand, Japan, South Korea, and other countries had reported a number of confirmed cases of COVID-19.<sup>[4-6]</sup> On March 13, the World Health Organization (WHO) declared that COVID-19 had “pandemic” characteristics. According to the WHO, as of May 29, a total of 5,701,337 people worldwide had been confirmed infected with COVID-19 and 357,688 cases had died. Worldwide, research in virology, epidemiology, clinical therapy, and mathematics have been largely uploaded to prepublication platforms or published in academic journals.<sup>[7-9]</sup> The COVID-19 pandemic is caused by human-to-human transmission, particularly through close contact with people and respiratory droplets from coughing or sneezing of infected cases.<sup>[10]</sup> At the same time, a study showed that this novel Coronavirus has the characteristic of transmission between families, hospitals, and even cities. Therefore, people should be alert at the early stage of epidemic.<sup>[11]</sup> Some studies show that large numbers of asymptomatic infected cases spread throughout China before strict containment measures were put in place, which seems to facilitate the rapid spread of the virus among people.<sup>[12]</sup> To prevent the transmission of COVID-19 from person to person, infection control measures should be implemented.<sup>[13]</sup> Epidemiological investigation and genomic data monitoring have a positive impact on reducing the transmission of COVID-19.<sup>[14]</sup> The results of Jia et al<sup>[15]</sup> suggest that high relative humidity is also a positive factor for the COVID-19 control. Xia et al<sup>[16]</sup> suggest that EK1C4 may contribute to the prevention and treatment of the current epidemic of COVID-19 and other emerging COVID-19. As outbreaks develop and populations migrate from country to country, the control of imported cases becomes more important. Liaoning and Jilin are two important provinces in northeast China, they improved their public health preparedness to the highest level on January 25 and 26 after the outbreak. Our study shows the response to COVID-19 in Liaoning and Jilin provinces from January to May. Between January and March, large numbers of COVID-19 infections from other provinces entered the 2 provinces. The situation is very similar to many countries in the world. Therefore, the study of the epidemic characteristics and control experience of COVID-19 in these 2 provinces can have certain reference value for controlling the spread of COVID-19 on a global scale.

## 2. Methods

### 2.1. Data source

According to the New Coronavirus Pneumonia Prevention and Control Plan Issued (7th edition) by the National Health Commission of China, nasopharyngeal swabs from cases were collected by medical institutions and sent to the local center for disease control (CDC) for laboratory examination. A laboratory-confirmed case of COVID-19 infection was reported by the local centers for disease control within 2 hours. The local CDC

conducts an epidemiological survey of the case within 24 hours. The survey includes the case's travel within the first 14 days of onset and close contacts. The data in this study are from the information of COVID-19 infection published by the Health Commission of Liaoning province and Jilin province. Because the 2 provinces have different policies on information disclosure, there are some differences in the comprehensiveness of case information. Information on infected cases in Jilin province is only basic demographic information about the cases and their relationships with other cases.

### 2.2. Case definition

According to the standard of the New Coronavirus Pneumonia Prevention and Control Plan Issued (7th edition) by the general office of the National Health Commission, the definition of COVID-19 infection in other provinces except Hubei was made. The definition is divided into suspected case definition criteria and confirmed case definition criteria.

### 2.3. Suspected case definition

#### 2.3.1. Epidemiological history.

1. Travel history or residence history of Wuhan and its surrounding areas within 14 days before the onset of the disease, or other communities with cases report;
2. A history of contact with a confirmed infected cases within 14 days prior to onset of illness;
3. Cases with fever or respiratory symptoms from Wuhan and surrounding areas or from communities where cases have been reported were exposed within 14 days prior to the onset of the disease.

#### 2.3.2. Clinical manifestation.

1. Clinical manifestations include fever or respiratory symptoms;
2. Imaging features of pneumonia;
3. The total number of white blood cells is normal or decreased or the lymphocyte count is decreased.

A case with any epidemiological history and 2 clinical manifestations may be considered a suspected case. If there is no obvious history of epidemiology, the cases fitting the 3 clinical manifestations can be identified as suspected cases.

**2.3.3. Confirmed case.** Real time reverse transcriptase polymerase chain assay (rRT-PCR) is used to detect the nucleic acid of SARS-CoV-2 in respiratory or blood samples.

Viral gene sequencing of respiratory or blood samples is highly homologous to the known COVID-19.

Any one of these conditions is considered a confirmed case of COVID-19 infection.

### 2.4. Statistical analysis

Continuous variables were expressed as median (IQR) and categorical variables were expressed as number (%). Linear regression was used to analyze the relationship between the economic status of the 2 provinces on the number of confirmed COVID-19 diagnoses. Histogram was used to show the transmission routes of infected cases. Transmission networks were used to analyze the transmission relationships between infected cases.

Statistical analyses were done using the SPSS software, version 22.0. Gephi 0.9.2 was used to perform the transmission network analysis.

### 3. Results

#### 3.1. Basic statistical characteristics

**3.1.1. General demographic description.** The average age of cases diagnosed in Liaoning province is 46.9 years, with a median age of 45 years. The oldest case is an 85-year-old man from Huludao. The youngest case is a 4-year-old girl.

The average age of cases diagnosed in Jilin province is 45.5 years, with a median age of 44 years. The oldest is an 88-year-old man in Changchun. The youngest 8 years old is a girl in Liaoyuan. The details are shown in Table 1.

**3.1.2. Analysis of time and space.** As of May 3, Liaoning and Jilin provinces have confirmed and reported a total of 218 local COVID-19 infections. Since the first case of a 33-year-old man from Wuhan was confirmed on January 22, 2020, a total of 125 COVID-19 infections have been confirmed in Liaoning province (as of May 3, 2020). From February 15 to May 3, only a small amount of confirmed cases appeared sporadically. The peak occurred on January 31 when 15 people had been diagnosed with COVID-19. Liaoning province has reported only sporadic new locally confirmed cases since February 16. Shown in Fig. 1.

Since the first case of a 41-year-old woman case from Wuhan was confirmed on January 22, 2020, a total of 93 COVID-19 infections have been confirmed in Jilin province (as of February 23, 2020). The peak occurred on February 4 when a total of 12 people had been diagnosed with COVID-19 infection. There have been no new confirmed local cases in Jilin province since February 24.

The COVID-19 epidemic situation in both provinces was stabilized around mid-February, and both provinces downgraded their respective epidemic situation risk ratings on February 26.

After they downgraded their respective outbreak risk ratings, it has been no significant rebound in the number of local cases in the 2 provinces. Both provinces have achieved effective control of local cases.

According to the regional distribution of the cases in Liaoning province, the largest number of cases in Shenyang (27 cases) and Dalian (19 cases). Less distributed cities including Benxi, Anshan, Tieling, the number of cases were 3 to 4. The distribution is shown in Fig. 2. The regional distribution of cases in Jilin province is more concentrated than that in Liaoning province. The geographical distribution shows more obvious aggregation. As can be seen from Fig. 3, the number of cases of Changchun (45 cases) and Siping (19 cases) is obviously larger than other cities.

**3.1.3. Age distribution.** In the age distribution we can see that cases in the 2 provinces are concentrated between 20 and 69 years old. These cases account for >80% in both provinces (Liaoning 88.4%, Jilin 86.7%). The proportion of cases in the elderly group over 60 years old was 21.5% in Liaoning province and 17.8% in Jilin province. Shown in Fig. 4.

**3.1.4. Clinical features of infected cases.** Fever (55.2%) and cough (16.8%) are the most common symptoms among the 125 cases diagnosed in Liaoning province, and the proportion of fever and cough at the time of diagnosis is lower than that in Wuhan (fever 98%, cough 76%).<sup>[17,18]</sup> Therefore, if only body temperature and cough are selected as the screening criteria for confirmed case, it is more likely to be missed. A very small percentage of these cases reported diarrhea and vomiting (6.4%), suggesting that clinical cases with gastrointestinal disease need to be more cautious than ever. It's worth stating that 33 of these confirmed cases were asymptomatic. These cases did not show significant symptoms when they were diagnosed as infected. This has led to missed cases during screening.

Two deaths by COVID-19 have been reported in Liaoning province and 1 in Jilin province, with a crude mortality rate of 1.37%. All the dead were over 70 years old with serious underlying diseases. The details are shown in Table 2.

The incubation of confirmed cases in 2 provinces was used as the exposure time, and the incubation period was used as the length of clinical manifestations. The incubation period of 65 of these cases was determined through a rigorous epidemiological investigation. The average is 10 days, with a maximum of 23 days and a minimum of 4 days. The average incubation period was longer than that reported in Wuhan.

**3.1.5. History of sojourning in Hubei province.** Among the confirmed cases, 55 (46.2%) from Liaoning province and 21 (23.6%) from Jilin province had been to Hubei province within 14 days before the diagnosis. None of the cases had been exposed to Huanan seafood market before arriving in Liaoning province and Jilin province.

**3.1.6. Health care worker infection.** The case of a primary health care worker in Chaoyang, Liaoning, was confirmed on January 31. The doctor had close contact with 2 infected cases from the city of Wuhan on January 23 and 25 and provided them with medical care. Because 2 cases hid their History of sojourning in Wuhan from their doctors, the doctor treated 2 cases without adequate protection and contracted the virus. No health care workers have been infected in Jilin province. There were no clusters of hospital-acquired infections in either province.

**Table 1**  
Basic information of confirmed cases in Liaoning and Jilin province.

Liaoning	Patients (n=125)
Age, y	
Mean	46.9
Range	4–85
Median age	45
Gender	
Male	69 (55.2%)
Female	56 (44.8%)
History of sojourning in Hubei province	
Yes	55 (44%)
No	70 (56%)
Jilin	Patients (n=93)
Age, y	
Mean	44.5
Range	8–88
Median age	44
Gender	
Male	55 (59.1%)
Female	39 (41.9%)
History of sojourning in Hubei province	
Yes	21 (22.6%)
No	72 (77.4%)

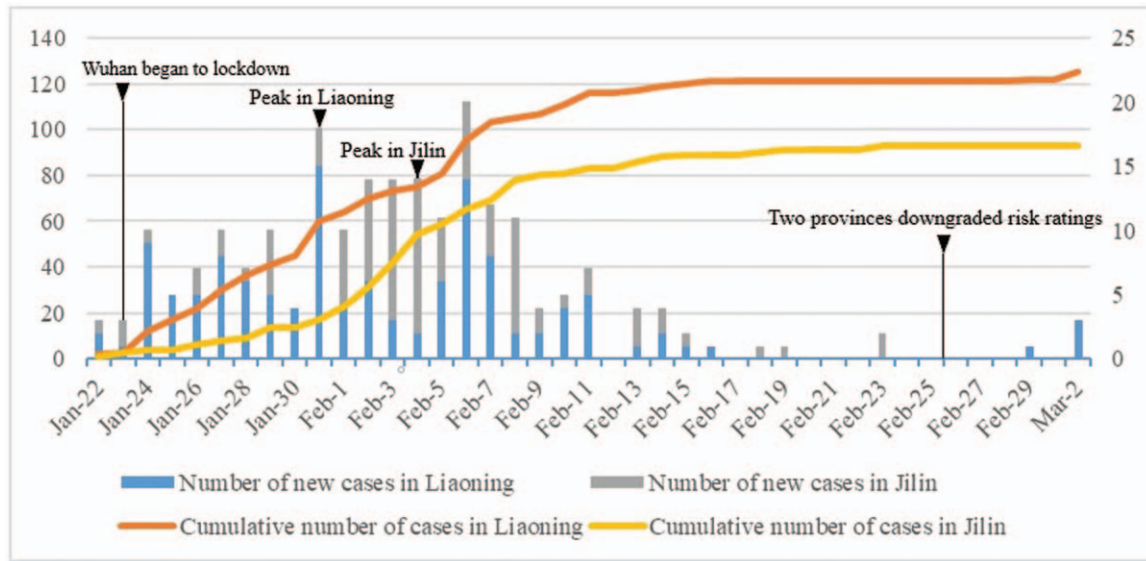


Figure 1. The number of daily diagnosed cases and the cumulative diagnosed cases in Jilin and Liaoning province.

3.2. Basic information of the 2 provinces

According to the statistics of Jilin and Liaoning provinces in 2019, the GDP and population of the 2 provinces are taken as the basic information of the 2 provinces. The GDP level of different regions can be a good measure of local health care level and

epidemic prevention spending. The respective provinces are shown in Table 3.

The number of confirmed cases was positively correlated with GDP ( $r=0.828, P<.001$ ) and the number of resident population ( $r=0.795, P<.001$ ) in the region. This indicates that the GDP

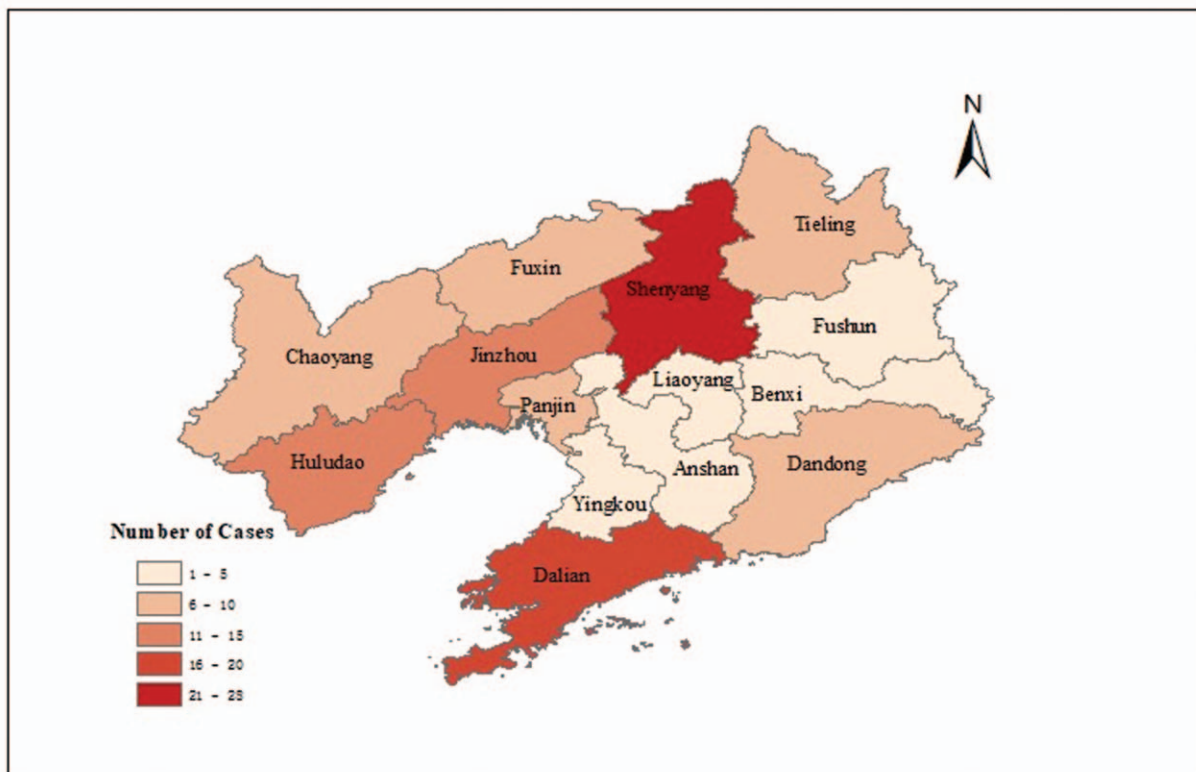


Figure 2. Distribution of confirmed cases in Liaoning province.

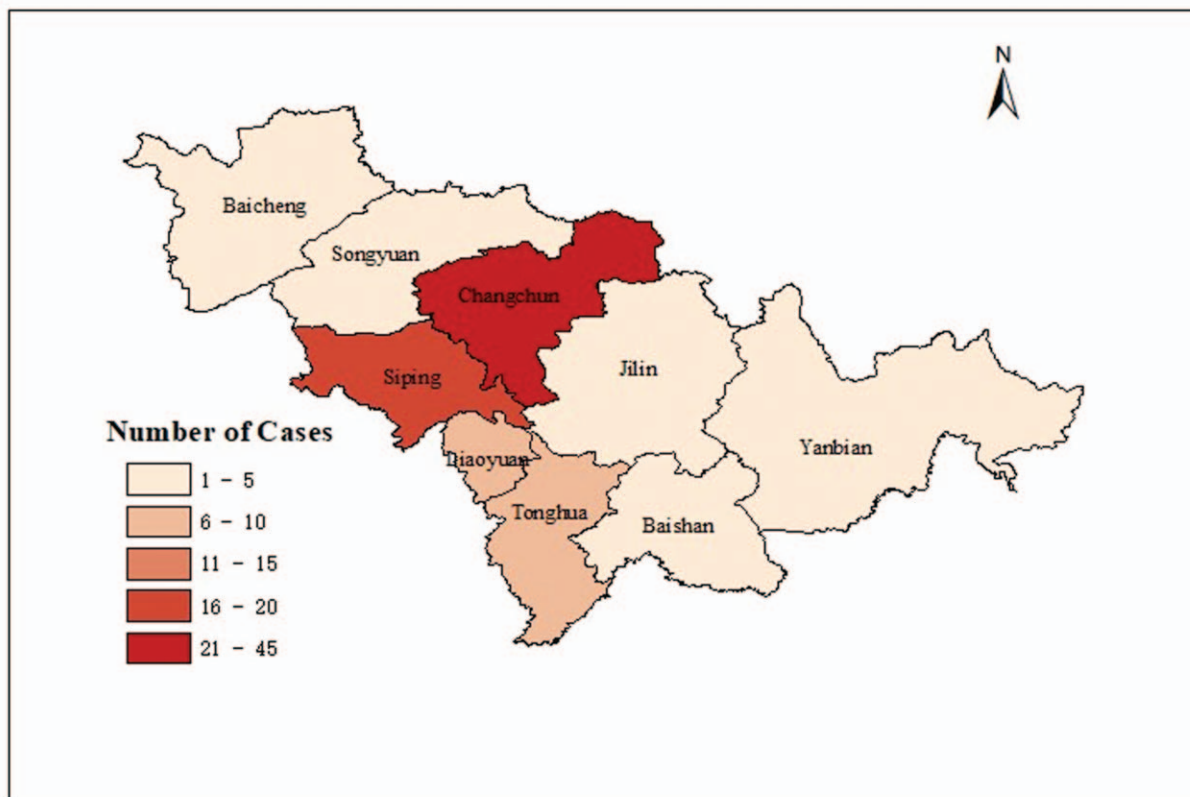


Figure 3. Distribution of cases in Jilin province.

level and population of the region are significantly correlated with the number of confirmed cases in the region. Regions with high levels of GDP also have more confirmed cases.

Linear regression analysis was conducted on 2019 GDP and permanent population of Jilin and Liaoning provinces respec-

tively, and the results were shown in table (Table 4). The model showed that both GDP ( $\beta \pm SE = 0.044 \pm 0.007$ ,  $P < .001$ ) and resident population ( $\beta \pm SE = 0.004 \pm 0.001$ ,  $P < .001$ ) were significantly correlated with the number of confirmed cases. This indicates that the higher the economic level of the city and

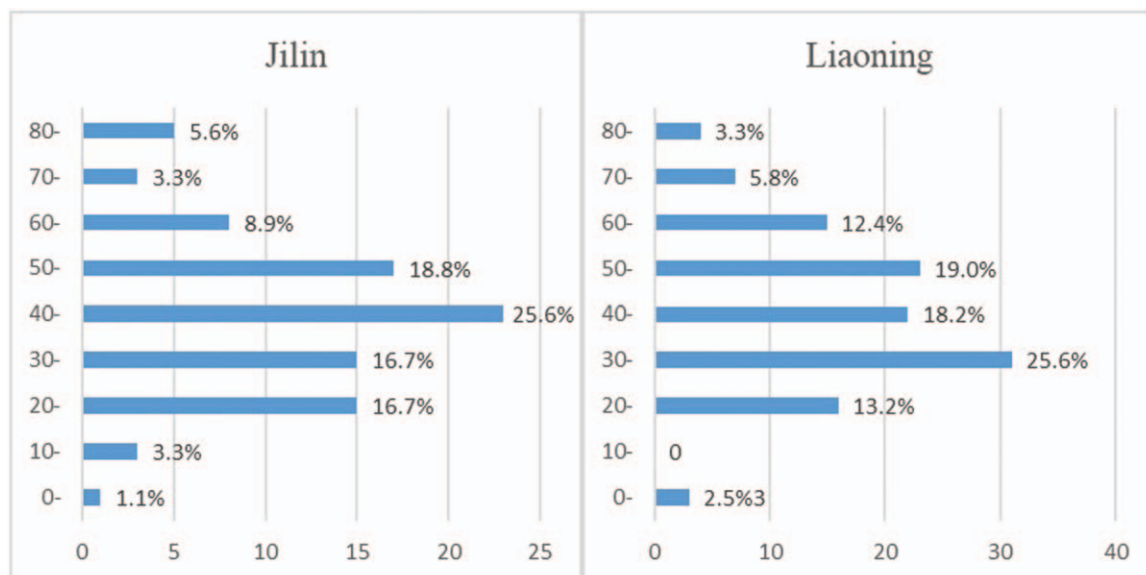


Figure 4. Age distribution of cases in the 2 provinces.

**Table 2****Clinical features of infected patients in Liaoning province.**

Clinical symptoms at the time of diagnosis	Patients (n=125)
Fever	69 (55.2%)
Cough	21 (16.8)
Muscle soreness or fatigue	11 (8.8%)
Diarrhea and vomiting	8 (6.4%)
Asymptomatic	33 (26.4%)

**Table 3****The economic and population size of each city in Liaoning and Jilin Province.**

City	GDP in 2019	Population	Cases
Changchun	7668.5	767	45
Jilin	1316.6	441	5
Siping	796.2	338	18
Liaoyuan	621.6	117	9
Tonghua	725.8	232	7
Baishan	661.71	129	4
Songyuan	729.78	288	2
Baicheng	606.51	203	1
Yanbian	723.37	227	2
Dalian	7001.7	699.1	19
Shenyang	6470.3	737	28
Anshan	1745.3	359	4
Yingkou	1328.2	243.8	1
Panjin	1280.9	143.1	10
Jinzhou	1073	305.6	12
Fushun	874.1	206.2	1
Dandong	768	239.5	10
Benxi	781.1	169.7	3
Liaoyang	831	183.7	3
Chaoyang	843.1	293.6	6
Huludao	807.1	254.2	12
Tieling	640	265	7
Fuxin	488.1	176.2	9

the larger the population, the higher number of COVID-19 cases will be detected.

### 3.3. Analysis of transmission network

The travel schedule of cases and interpersonal relationships published by the Health Committee of the 2 provinces were used to build transmission networks. We built the transmission network by using Gephi0.9.2.

**Table 4****The impact of population and economy on COVID-19 patients in Liaoning and Jilin Provinces.**

Predictors	$\beta$	SE	P	r
N=23				
Intercept	-3827	2.578	.153	
Population	0.044	0.007	<.001	0.795
Intercept	2.974	1.819	.117	
GDP	0.004	0.001	<.001	0.828

COVID-19=corona virus disease 2019.

Since this outbreak first occurred in Hubei province, we defined cases from Hubei province as first-generation cases. In terms of transmission route, most of the first confirmed positive cases of COVID-19 infection in Liaoning province are close contacts of the confirmed cases, and most of the infected are relatives. In comparison, the communication relationship in Jilin province is more complicated.

The chain of transmission of COVID-19 infected cases in Jilin province is significantly longer. At the same time, the communication relationship of Jilin province showed more obvious aggregation than Liaoning province. Seven of the cases attended the mass and two of those cases directly infected five. Liaoning province has more imported cases than Jilin province. The largest number of infections in the chain was 5.

After rigorous epidemiological investigation, all the secondary infected cases in the 2 provinces who could identify the source of infection were infected after close contact with imported cases. A taxi driver in Liaoning province (No. 40 cases in Liaoning province) may have served COVID-19 infected cases. Other cases with unknown sources of infection had a history of public exposure and were not wearing personal protective equipment. Most of the cases in the 2 provinces are spread within families. In Liaoning, 43 people (34.4%) are infected by family members, while in Jilin, 42 people (53.9%) are infected by family members.

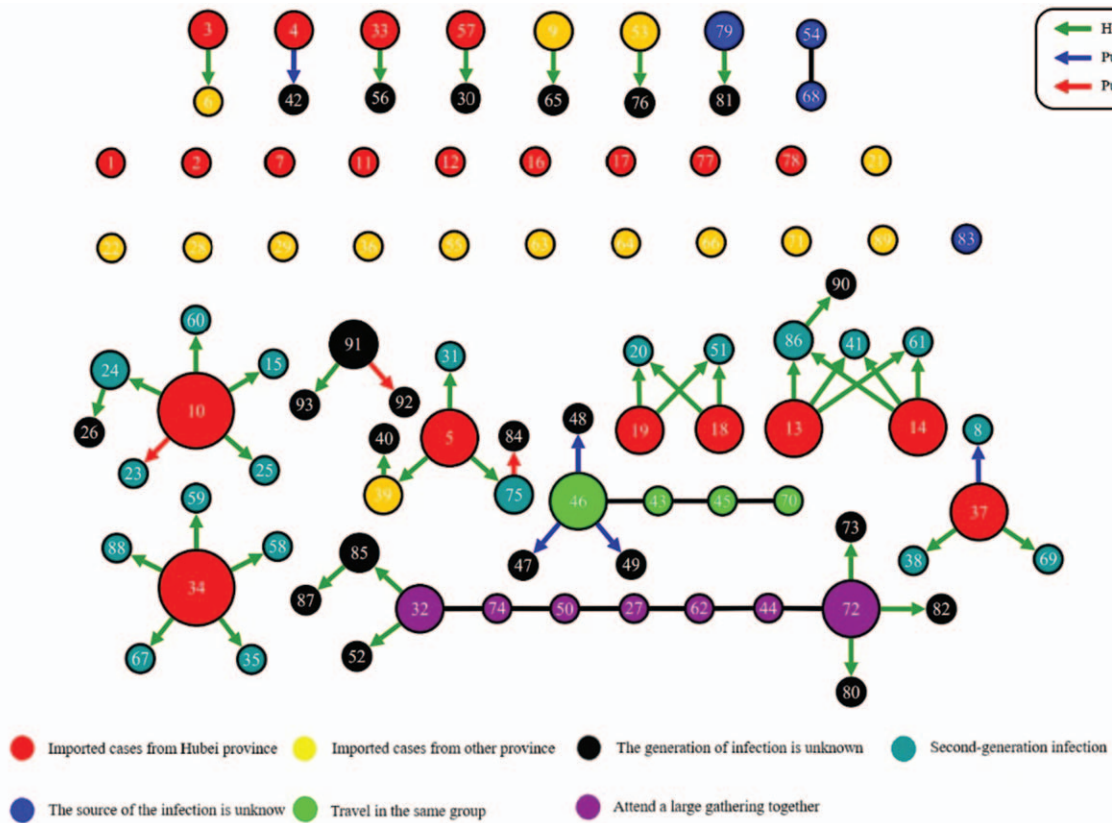
The longest infections chain in Jilin province involved a cluster of people spread by a business meeting (No. 27, No. 32, No. 44, No. 50, No. 52, No. 62, No. 72, No. 73, No. 74, No. 80, No. 82, No. 85, No. 87). This infections chain involved 13 infected people over a period of 12 days. The longest infections chain lasted 20 days with No. 5, No. 75, No. 84 cases. The largest chain of infections in Liaoning province was a cluster spread caused by family gatherings. This infections chain involved 5 infected cases over a period of 8 days. The longest chain was made up of No. 28, No. 30, and No. 33 cases over 10 days. In terms of the length of the infection chain, the length of the infection chain in Jilin province was significantly longer than that in Liaoning province, and the number of individual cluster infections was also significantly larger than that in Liaoning province. The relationship between infectious agents in Liaoning province was relatively dispersed. From the perspective of infection control effect, the epidemic prevention and control effect of Liaoning province is better than that of Jilin province. The transmission networks of the 2 provinces are shown in Figs. 5 and 6.

### 3.4. Analysis of transmission routes

Based on the information obtained from the epidemiological investigation and the relationship between the infected cases, we analyzed the possible transmission routes of the infected cases. We classified these transmission routes into 5 categories (Table 5). Among the common transmission routes in the 2 provinces, home infection was the most common transmission routes among local cases, while public place infection was the most common transmission routes among imported cases ( $\chi^2=90.613$ ,  $P<.001$ ). The transmission routes are shown in Fig. 7.

### 3.5. Analysis of asymptomatic infected cases

During the investigation, we identified 16 cases who had no history of sojourning and were not associated with any known sources of COVID-19. Excluding the absence of information on case travel due to incomplete investigation reports, we



**Figure 5.** Relationship of transmission among confirmed infected cases in Jilin province. The arrow line represents an infected case with a transmissive relationship. The nodes connected by the arrowless wires indicate that they belong to the same family or participate in the same activity together.

hypothesize that the source of infection in these cases was an unidentified asymptomatic infected cases. We assume that each case was transmitted through an unidentified asymptomatic infected case of at least 16 cases.<sup>[19]</sup> The ratio of unidentified asymptomatic infections to all cases was estimated under the above assumptions at 7.3%, higher than the 5.0% reported by Beijing. In reality, the ratio may be higher than 7.3%.<sup>[20]</sup>

#### 4. Discussion

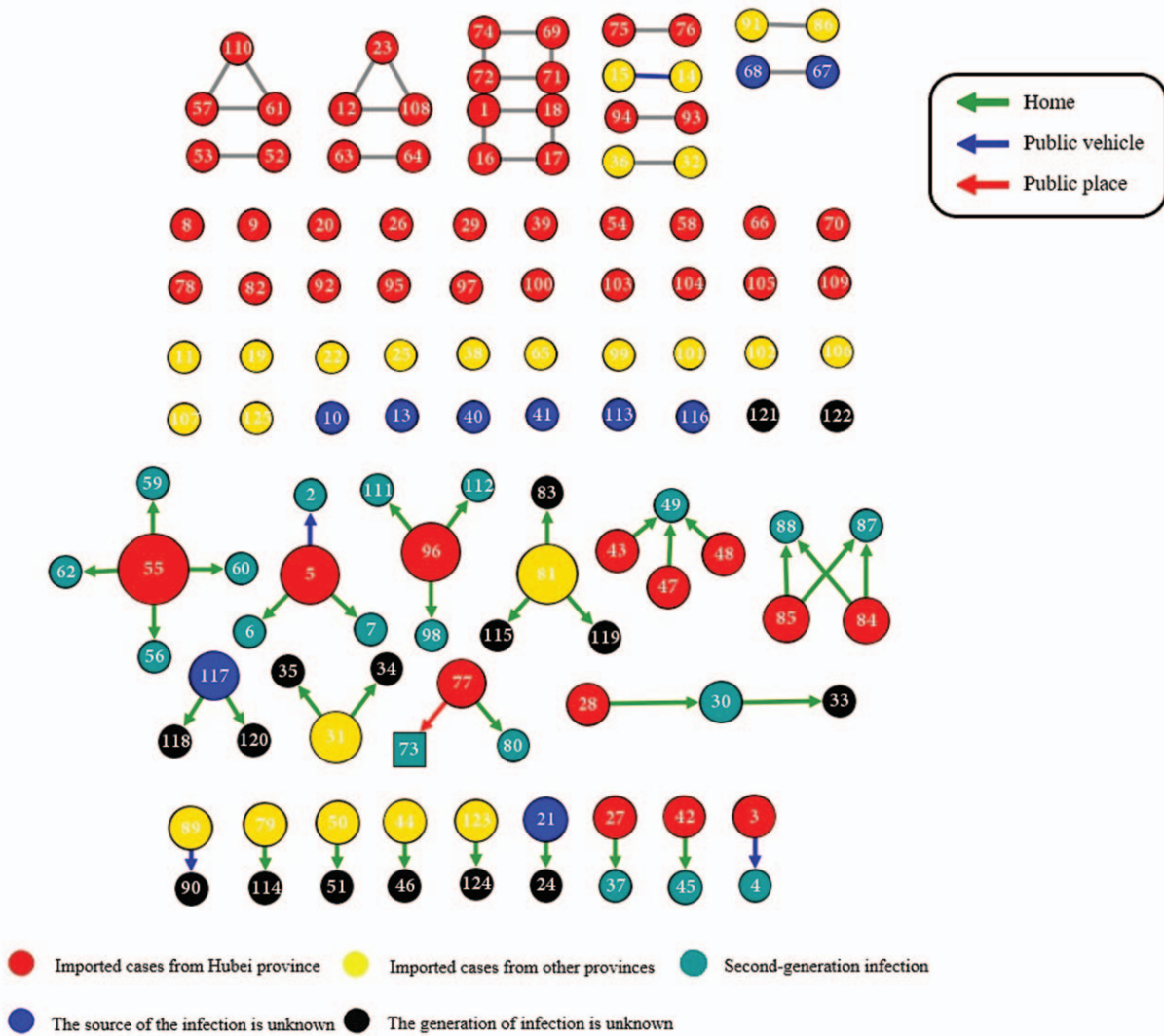
Here we analyzed the symptoms and interpersonal relationships of 218 laboratory-confirmed COVID-19 infection.

The COVID-19 outbreak began in Wuhan. As Hubei province is an important transportation hub in China, a large number of COVID-19 infections spread across the country through the developed transportation system. Although the WHO has not yet recommended any international travel restrictions, the city of Wuhan was under traffic control on January 23 in an effort to contain the spread of the outbreak.<sup>[21]</sup> Since the epidemic situation began during the traditional Spring Festival travel rush in China, a large number of COVID-19 infections spread to various parts of China. Those infected with COVID-19 imported from other provinces became the initial source of the virus in both provinces.

The 2 provinces promptly took preventive measures after the first confirmed case was reported in January. These measures mainly include the prohibition of large gatherings; the closure of large numbers of non-essential public facilities; citizens must

wear masks when entering public places; temperature monitoring devices are installed at all intersections; all aliens shall be quarantined for 14 days and tested for viral nucleic acid; disinfect public places several times a day; call on people to reduce their outings and gatherings; centralized isolation and treatment of cases who have been confirmed to be infected and isolation from other healthy persons; comprehensive tracing and medical observation of healthy persons who may be in contact with known infected cases. The enforcement of these measures has greatly reduced the contact between infected cases and healthy persons and greatly improved the ability to detect infected cases. Unfortunately, these measures have taken a heavy toll on the economies of both provinces.

From the perspective of population situation and GDP level, the number of confirmed COVID-19 cases in the 2 provinces showed a positive correlation with these 2 indicators. On the one hand, regions with a large population and a high level of GDP also have a relatively large number of migrant population.<sup>[22]</sup> This is an important source of imported cases. On the other hand, regions with a high level of GDP have a relatively high level of medical care. Therefore, these areas will have a higher ability to detect COVID-19 infection. Economic factors have also affected the effectiveness of COVID-19 prevention and control in both provinces.<sup>[23]</sup> Regions with a higher GDP level will invest more in epidemic prevention and control, and the prevention and control effect will be better. Liaoning province has better control effect on imported cases than Jilin province. This suggests that the relatively backward areas should be taken seriously. However,



**Figure 6.** Relationship of transmission among confirmed infected cases in Liaoning province. The arrow line represents an infected case with a transmissible relationship. The nodes connected by the arrowless wires indicate that they belong to the same family or participate in the same activity together.

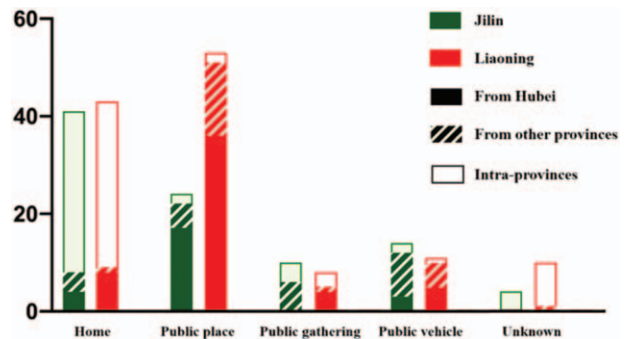
from the perspective of the time development of the epidemic network in Jilin province, the scale of the epidemic situation did not expand again in the later period through effective prevention and control policies.

Nosocomial infections were reported in both provinces (Liaoning No. 73 and Jilin No. 91). Nosocomial infections in Liaoning province did not develop successors, while those in Jilin province spread the disease to only 2 family members. The results

of nosocomial infection control in the 2 provinces were satisfactory.

From the perspective of clinical symptoms, most of these cases had different degrees of relevant clinical symptoms at the initial stage of diagnosis. Fever is the most common clinical manifesta-

Table 5	
Categories of infection location by the contact activities involved.	
Categories	Infection locations
Home	Within the family or in a relative's home
Public gathering	A large party held in a hotel or auditorium.
Public place	Shopping malls, hotels, hospitals, workplaces, and recreational facilities.
Public vehicle	Train, plane, taxi, bus, and other public transport.
Unknown	The location of the infection could not be identified.



**Figure 7.** Patterns of infection in cases in Jilin and Liaoning provinces.



tion. So using a high body temperature as a standard for community screening is still a relatively reliable screening at the moment. Of those diagnosed, 6 had diarrhea that had no apparent cause. Since the receptor used by the SARS-CoV-2 is the angiotensin-converting enzyme 2 (ACE2). This receptor is not only widely distributed in the respiratory tract, but also highly expressed in the kidney, liver, and digestive tract.<sup>[24–25]</sup> So the SARS-CoV-2 has the ability to replicate massively in the digestive system. In earlier studies, many teams found SARS-CoV-2 in feces of cases.<sup>[26]</sup> Hospitals should be more careful in handling cases' feces to prevent potential fecal-oral transmission. In the course of the investigation, the confirmed cases in Liaoning province have included many asymptomatic cases who did not show significant clinical symptoms when they were laboratory confirmed to be infected. Studies have shown that asymptomatic or preclinical infections can be highly contagious, so the potential for transmission cannot be ignored.<sup>[27]</sup> The New Coronavirus Pneumonia Prevention and Control Plan Issued (7th edition) by the National Health Commission of China clearly states that the identification of asymptomatic or preclinical infections should be strengthened.

The cases had severe underlying disease prior to infection with COVID-19. There are the 2 death from COVID-19 in Liaoning province and 1 death in Jilin province, which is similar to that in other Chinese provinces (except Hubei).<sup>[27]</sup> Looking at other studies, it is not difficult to find that cases infected with serious underlying diseases are more likely to die. So, timely treatment should be given to cases with underlying diseases that coinfect COVID-19, and priority should be given to those susceptible before infection occurs.

The vast majority of those infected in transmission relationships are relatives. With the exception of 4 cases who may have been infected in public places and 1 health care worker, all the infected cases are related to the infected cases. Most chains of transmission are limited to 1 generation, and a few develop to 2 generation of infections. There are also cases in 2 provinces where large numbers of imported cases have failed to spread the virus. From the form of transmission network, there is no evidence of super spreaders in Liaoning and Jilin provinces. The chain of transmission of COVID-19 infections in Jilin province is longer than that in Liaoning province and contains more people. From this perspective, the prevention and control effect of COVID-19 in Jilin province in the early stage was worse than that in Liaoning province. In terms of the time span of the 2 provinces, it also took about 25 days for the 2 provinces to control the local epidemic and restore social order. It shows that the performance of Jilin province in the middle and late stage of prevention and control work has made up for some losses in the early stage. There was no rebound in the number of infected people for a long time. This fully proves that the health departments of the 2 provinces have made rapid and effective efforts to prevent and control the epidemic situation. All in all, the spread of COVID-19 in the 2 provinces is limited due to timely and effective prevention and control policies.

## 5. Conclusion

The large number of clustered sexual infections indicated that COVID-19 has a strong transmission ability.

However, the epidemic situation caused by SRAS-CoV-2 infection can be completely controlled with effective human intervention. There was a positive correlation between the

population and the number of confirmed cases. The majority of local cases in both provinces were imported from other provinces, but the imported cases did not cause significant transmission in either province.

Local cases were mainly infected in their home and imported cases were mainly infected in public places. The explanation is that, there are asymptomatic cases of COVID-19 which have not been identified in the population, according to our research, the rate is not high.

Both provinces not showed significant rebound after the reduction of the risk level, which further proves the effectiveness of the epidemic management measures in the 2 provinces in the early stage.

To contain COVID-19, we believe that screening and identification of COVID-19 infections should be strengthened. Meanwhile, strict control measures need to be implemented and normalized. Although the implementation of these policies may bring huge economic losses, it is necessary to curb the spread of the epidemic in the world. In order to prevent a rebound in the number of infected people, prevention and control measures should be made a regular policy.

### 5.1. Limitations

Due to the limited degree of details of the public data, the specific clinical treatment process and treatment effect of cases in the 2 provinces cannot be described in detail.

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### Author contributions

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### Correction

Zhang Yulong has been moved to the position of second author in the author list and the affiliation, Department of Clinical Laboratory, Inner Mongolia Xingan League People's Hospital, The Inner Mongolian Autonomous Region, has been added for them.

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