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Abstract

Background: to analyze the epidemic situation of COVID-19 in northeast China, Liaoning and Jilin. To study the prevalence of COVID-19 virus in areas other than Hubei province and understand the spread of COVID-19 in Liaoning and Jilin provinces by means of communication network. More in-depth understanding of COVID-19 epidemic, and put forward effective prevention and control recommendations.

Methods: We collected the demographic characteristics, exposure history and course of action of patients with laboratory-confirmed infection with COVID-19 published by Liaoning Provincial Health Commission and Jilin Provincial Health Commission as of February 15, 2020. We describe the demographic characteristics, case characteristics, spatial distribution characteristics and related interpersonal network of these patients. To analyze the transmission of COVID-19 in two provinces.

Results: By February 15, 2020, the cumulative number of infected people in Liaoning province is 119. The largest number is 27(22.7%) in Shenyang and the smallest in Fushun, with no reported cases of infection. Among them, 55(46.2%) have a history of sojourning in Hubei province. The mainly clinical symptoms of the infected patients are fever, and 67(56.3%) of them developed fever at the time of diagnosis. Cough, sneezing and other respiratory symptoms are less. The cumulative number of infected people in Jilin province is 89, with the highest number in Changchun city at 39(43.8%) and the lowest in Baishan city, with no reported infections. 21(23.6%) people with a history of sojourning in Hubei province. Most of those infected in the two provinces are related to Hubei province, and most of those infected in the second generation or more are infected by close contact with relatives.

Conclusion: The COVID-19 outbreaks in Liaoning and Jilin provinces are gradually stabilizing, but have not yet reached the time required to lower the prevention and control level. The fatality rate of the two provinces is relatively low. There is no evidence of super-spreader in either province.

Keyword: COVID-19, Northeast China, Epidemiological survey, Transmission network

Background

In December 2019, a case of pneumonia caused by new coronavirus (COVID-19) infection emerged in Wuhan, Hubei province, China [1-4]. According to the World Health Organization (WHO), a total of 50,580 people have been diagnosed with the virus, with 1,524 deaths. Most of the deaths have been in Wuhan, Hubei province. The number of migrants across Hubei has surged as the country's Spring Festival travel rush peaks. This has allowed a large number of people who have not yet developed symptoms to spread globally, starting in Wuhan, Hubei province [5,6]. Liaoning and Jilin, two major provinces in northeast China, raised their public health preparedness to the highest level on Jan. 25 and 26, respectively, after the outbreak. Therefore, the situation of the two provinces has certain reference value in the global scope.

Methods

Data source

According to The *New Coronavirus Pneumonia Prevention and Control Plan Issued (4th edition)* by the National Health Commission of China, nasopharyngeal swabs from patients were collected by medical institutions and sent to the local center for disease control for laboratory examination. A laboratory-confirmed case of COVID-19 infection was reported by the local centers for disease control within two hours. The local Center for disease control (CDC) conducts an epidemiological survey of the patient within 24 hours. The survey included the patient's travel within the first 14 days of onset and close contacts. The data in this study is from the information of COVID-19 infection published by the Health Commission of Liaoning province and Jilin province. Because the two provinces have different policies on data disclosure, there are some differences in the comprehensiveness of patient information. Data on infected patients in Jilin province only collected basic information about the patients and their relationships with other patients.

Case definition

According to the standard of The *New Coronavirus Pneumonia Prevention and Control Plan Issued (4th 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.

Suspected case definition

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 person within 14 days prior to onset of illness;
3. Patients 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.

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.

Will conform to any one of the epidemiological histories and to any two of the clinical manifestations. If there is no obvious history of epidemiology, the patients meeting the three clinical manifestations can be identified as suspected cases.

Confirmed case:

Real time reverse transcriptase polymerase chain assay (rRT-PCR) is used to detect the nucleic acid of COVID-19 virus in respiratory or blood samples.

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

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

Results

General demographic description

The average age of patients diagnosed in Liaoning province is 45.5 years, with a median age of 45 years. The oldest is an 85-year-old male from Huludao. The youngest, aged 4, is a female returning to Liaoning province from Wuhan.

The average age of patients diagnosed in Jilin province is 43.5 years, with a median age of 42 years. The oldest is an 88-year-old man from Changchun. The youngest 8 years old is a girl from Liaoyuan.

Analysis of time and space

Overview of COVID-19 infection in Liaoning province.

Since the first case of a 33-year-old male from Wuhan was confirmed on January 22, 2020, a total of 119 patients with COVID-19 have been confirmed in Liaoning province (as of February 15, 2020). The peak occurred on January 31 when a total of 15 people were diagnosed with COVID-19. After that day, the number of new cases in Liaoning province gradually decline and stabilize.

Overview of COVID-19 infection in Jilin province.

Since the first case of a 41-year-old female patient imported from Wuhan was confirmed on January 22, 2020, a total of 89 cases of COVID-19 infection have been confirmed in Jilin province (as of February 15, 2020). The peak occurred on February 4 when a total of 12 people were diagnosed with COVID-19. After that day, the number of new cases in Jilin province gradually declined and stabilized, with only one abnormal increase, nine, on Feb. 8. Since it takes 1-2 days to carry out inspection and compound, the sudden increase on February 8th is the reason for the backlog of samples in the previous days.

After February 15, 2020, the number of newly diagnosed patients in the two provinces was zero for several consecutive days.

According to the regional distribution of the patients in Liaoning province, the largest

number of infected patients in Shenyang and Dalian are 27 and 18, respectively. Less distributed cities including Benxi, Anshan, Tieling, the number of patients are 3 to 4. No cases have been reported in Fushun. The regional distribution of patients in Jilin province is more concentrated than that in Liaoning province, and the geographical distribution shows more obvious aggregation. As can be seen from figure 4, the population of Changchun and Siping is obviously larger than that of other prefectures.

Age distribution and sex ratio

In the age distribution we can see that patients in the two provinces are concentrated between 20 and 69 years old. The proportion of this group of patients in the total number of confirmed cases is 84.1 percent in Liaoning province and 83.1 percent in Jilin province.

The proportion of cases in the elderly group over 60 years old was 21.8% in Liaoning province and 13.4% in Jilin province.

Clinical features of infected person

Fever (56.3%) and cough (16.8%) are the most common symptoms among the 119 infected patients diagnosed in Liaoning province, and the proportion of fever and cough at the time of diagnosis is lower than that in Wuhan [7,8]. Therefore, if only body temperature and cough are selected as the screening criteria for infected patients, it is more likely to be missed. A very small percentage of these patients reported diarrhea and vomiting (6.7%), suggesting that clinical patients with gastrointestinal disease need to be more cautious than ever. Notably, 31 of these confirmed cases are asymptomatic. These patients did not show significant symptoms when they were diagnosed as infected. This has led to missed cases during screening. One of the 119 confirmed cases was died, with a crude fatality rate of 0.84%. The death occurred on February 12 in an 87-year-old man in Huludao. Prior to infection with COVID-19, the patient had bilateral femoral head necrosis, coronary heart disease and chronic obstructive pulmonary diseases.

History of sojourning in Hubei province

Among the confirmed patients, 55(46.2%) from Liaoning province and 21 (23.6%) from Jilin province had been to Hubei province within 14 days before the onset of disease. None of the patients had been exposed to Huanan seafood market before arriving in Liaoning province and Jilin province.

Propagation network analysis

By analyzing the travel schedule of the patients 14 days before diagnosis published by the Health Committee of the two provinces and the interpersonal relationship between the patients, the communication relationship between the patients is sorted out. Build the propagation network using Gephi0.9.2.

Since this outbreak first occurred in Hubei province, we defined patients from Hubei province as first-generation cases.

In terms of transmission route, most of the first confirmed positive cases of COVID-19 virus infection in Liaoning province are close contacts of the confirmed patients, and most of the infected are relatives. But the investigation found that some of those infected are from unknown sources, including two taxi drivers. These infected people had no recent history of living in other cities, but all had experienced access to densely populated public Spaces. The investigation found that the confirmed cases did not wear protective equipment when entering populated public places. In comparison, the communication relationship in Jilin province is more complicated.

The chain of transmission of COVID-19 infected people in Jilin province is significantly longer. Therefore, it is speculated that there are fourth - generation infected people among the COVID-19 infected people in Jilin province. And there is a high probability that there are more than four generations of infected people. At the same time, the communication relationship of Jilin province showed more obvious aggregation than that of Liaoning province. Seven of the patients attended the mass and two of those patients directly infected five. Since the number of imported cases in central Hubei province is less than that in Liaoning province, the total number of

infected people is less than that in Liaoning province.

From the perspective of transmission mode, all the patients are transmitted by close contact, except for patients 40th and 41st in Liaoning province and 83rd and 79th in Jilin province, which were probably infected by unidentified infected people in public places. Most of the cases in the two provinces are spread within families. In Liaoning, 32 people (26.9%) are infected by family members, while in Jilin, 41 people (53.9%) are infected by family members.

It is worth noting that the presence of these patients with unknown source of infection proves that the transmission of the virus is very strong. The presence of a large number of infections with unknown generations suggests that the COVID-19 virus is capable of continuing human-to-human transmission.

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 two infected people from the city of Wuhan on January 23 and 25 and provided them with medical care. Because two patients hid their Wuhan residency histories from their doctors, the doctor treated two patients without adequate protection and contracted the virus.

Discussion

Here we report the symptoms and interpersonal relationships of 208 laboratory-confirmed patients with COVID-19 infection.

The COVID-19 outbreak began in Wuhan, Hubei province, in central China, which is directly linked to six major provinces. Wuhan is the most important transportation hub in Hubei province, which plays an important role in China's transportation. As the traditional Chinese Spring Festival approaches, the number of migrants in Wuhan has increased sharply since the Spring Festival travel rush in December. 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[9]. Subsequently, other cities in Hubei also gradually implemented traffic control measures to varying degrees. Figures from the two provinces also show that the rise in new diagnoses has been halted in both provinces since around February 4th. According to the results, the traffic control measures implemented in Hubei province have played a positive role in the prevention and control of the epidemic in the two northeastern provinces. Subsequently, the two provinces introduced their own traffic control measures and postponed the resumption of non-essential work units and the opening of schools. These measures have effectively curbed the spread of the disease in the province.

From the regional distribution of COVID-19 infections, the number of infected people in Changchun, Shenyang, Dalian and Siping is significantly higher than that in other cities. The main reasons are as follows: first, the population of Shenyang and Dalian is much higher than that of other cities in Liaoning province. According to the 2018 population statistics of Liaoning province, the populations of Shenyang and Dalian are 7.489 million, 7.394 million and 5.801 million, respectively. Anshan, the most populous of the other cities, has a population of 3.5 million. Secondly, the population flow of the two places is obviously larger than that of other cities in Liaoning province. Changchun, Shenyang and Dalian are the major transportation hubs and the most economically developed areas in their respective provinces. The three cities are home to a large number of returnees and migrants as they approach the traditional Chinese New Year. As a result, the number of imported cases is higher than that of other cities in the two provinces. In addition, these three cities have better medical conditions than other cities. Therefore, it is easier to find infected patients in the process of patient admission and testing. By contrast, Siping, as the third largest city in Jilin province, has a smaller floating population than Changchun, but it does not have the infrastructure and medical level of Changchun. It is difficult to identify and treat infected people in time. Therefore, it is more difficult to prevent and control the epidemic in Siping.

From the perspective of clinical symptoms, most of these patients had different degrees of relevant clinical symptoms at the initial stage of diagnosis. Fever is the most common clinical manifestation. So using a high body temperature as a standard for community screening is still a relatively reliable screening at the moment, even though it may miss a lot of people who are not symptomatic. It is therefore recommended that in persons with a highly suspicious epidemiological history, continuous observation and management are required after the monitoring temperature has not developed fever. Of those diagnosed, six had diarrhea that had no apparent cause. Since the receptor used by the COVID-19 virus 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 [10]. So the COVID-19 virus has the ability to replicate massively in the digestive system. The first American case of COVID-19 infection, published in the New England journal of medicine, was found to have the nucleic acid sequence of COVID-19 in the stool [11]. Subsequently, Nanshan Zhong's team successfully isolated live viruses from the feces of patients infected with COVID-19 virus on February 13, indicating that there may be a path of fecal-oral transmission of COVID-19 virus [12,13]. Therefore, hospitals should be more careful in handling patients' feces to prevent potential fecal-oral transmission. In the course of the investigation, the confirmed cases in Liaoning province have included many asymptomatic patients 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 [14]. *The New Coronavirus Pneumonia Prevention and Control Plan Issued (4th edition)* by the National Health Commission of China clearly states that the management and identification of asymptomatic or preclinical infections should be strengthened.

One 87-year-old man died in Liaoning province, out of 119 people infected with the COVID-19 virus. The patient had severe underlying disease prior to infection with COVID-19. This is the only death from COVID-19 in Liaoning province, which is

similar to that in other Chinese provinces (except Hubei) [15]. Looking at other studies, it is not difficult to find that people infected with serious underlying diseases are more likely to die. Therefore, timely treatment should be given to patients with underlying diseases that co-infect 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 four patients who may have been infected in public places and one health care worker, all the infected persons are related to the infected persons. On the whole, interpersonal transmission of COVID-19 is still limited to human-to-human transmission. During the Chinese New Year, the National Health Commission of China urged people throughout the country to reduce the need to go out, suggesting that measures to stop gatherings of all sizes have a very positive effect on the control of the epidemic. According to the transmission chain of the two provinces, although there is a phenomenon of family aggregation in the spread of the virus, the transmission degree of the virus in the family is relatively limited. There have been no cases of a single infected person infecting large numbers of family members or close contacts, and most transmission has been limited to one generation of infected people, with a few developing two generations of infected people. There are also cases in two provinces where large Numbers of imported cases have failed to spread the virus. From the form of communication network, there is no evidence of super spreaders in Liaoning and Jilin provinces. This fully proves that the health departments of the two provinces have made rapid and effective efforts to prevent and control the epidemic.

Limitations

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

Abbreviations

WHO: World Health Organization; **COVID-19:** Corona Virus Disease 2019; **CDC:**
Center for disease control

Declarations

Ethics approval and consent to participate

The National Health Commission of the People's Republic of China has determined that data collection and analysis of cases and close contacts are part of ongoing investigations into public health outbreaks and are therefore exempt from the approval requirements of the agency review committee.

Source of map

The map is our own. No copyright issues.

Consent for publication

All authors agree to publish.

Availability of data and material

The data used in this study are all public data. Contact the author if necessary.

Competing interests

The author declared no competing interests.

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Authors' contributions

T.F. was responsible for the design of the study and the analysis of the data, while S.H., S.M. and Y.W. were responsible for the collection of data and related materials. Other authors were involved in the writing and polishing of the article.

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Figures

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

Figure 2

the number of daily confirmed cases and the cumulative confirmed cases in Jilin province

Figure 3

distribution of confirmed patients in Liaoning province. 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

distribution of patients in Jilin province. 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 5

Age distribution in the two provinces

Figure 6

Relationship of transmission among confirmed infected persons in Liaoning province. The arrow line represents an infected person 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.

Figure 7

Relationship of transmission among confirmed infected persons in Jilin province. The arrow line represents an infected person 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

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