

## THE EPIDEMIOLOGICAL CHARACTERISTICS OF CLUSTERS OF NOVEL CORONAVIRUS PNEUMONIA IN CHENZHOU, CHINA

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### ABSTRACT

**Objective:** This study was designed to analyze the characteristics of the novel coronavirus disease 2019 (COVID-19) epidemic in seven clusters in the city of Chenzhou, China, to act as a reference for the prevention and control of the COVID-19 epidemic.

**Methods:** The data of confirmed COVID-19 cases reported between January 23 and February 24, 2020, were obtained from the Chenzhou infectious disease surveillance system. In line with the diagnostic criteria of the Novel Coronavirus Pneumonia Diagnosis and Treatment Plan (Sixth Edition, Trial Implementation), 33 patients in seven clusters were selected as the research subjects, and epidemiological data were collected for descriptive analysis.

**Results:** Between January 23 and February 24, 2020, 46 patients with COVID-19 were diagnosed in the city of Chenzhou, comprising 24 male patients and 22 female patients. The age of these patients ranged from seven months to 72 years old. The average age was  $35.88 \pm 17.98$  and included 13 individual patients and 33 patients in seven clusters. Six clusters were exposed to the virus in Wuhan (the Wuhan group), and the other cluster was exposed to it in Shenzhen (the Shenzhen group). In the Wuhan group, the disease was spread in clusters of one family. The incubation period was 1–9 days, and the average length of hospital stay was  $13.25 \pm 2.67$  days. Only close contacts were infected. In the Shenzhen group, three different families were infected in the same cluster. The incubation period was 11–14 days, the time of positive-to-negative conversion in the nucleic acid test was longer, and the average hospitalization time was  $17.33 \pm 5.87$  days. Contacts who were not in close contact were infected.

**Conclusion:** Patients are infectious in the incubation period, and asymptomatic patients are also infectious. The infectivity of the Shenzhen group was stronger than that of the Wuhan group. In the Shenzhen group, the time of positive-to-negative conversion of COVID-19 nucleic acid was longer, and the length of hospital stay was longer.

**Keywords:** novel coronavirus 2019, COVID-19, novel coronavirus (SARS-CoV-2), clustered patients, incubation period, epidemiological characteristics .

DOI: 10.19193/0393-6384\_2021\_4\_341

Received October 15, 2020; Accepted March 20, 2021

### Introduction

In December 2019, an outbreak of unexplained pneumonia began in Wuhan, Hubei Province. The epidemic gradually spread to non-Wuhan areas in Hubei Province and then all over the country, and eventually it spread abroad. On January 7, 2020, the pathogenic coronavirus was first isolated from

respiratory specimens of patients in China. The coronavirus was named as a "novel coronavirus"<sup>(1)</sup> to distinguish it from other coronaviruses. On February 8, 2020, the National Health Commission of the People's Republic of China temporarily identified the new pneumonia induced by coronavirus disease 2019 (COVID-19) as novel coronavirus pneumonia (NCP)<sup>(2)</sup>. On February 11, 2020, the International

Committee on Taxonomy of Viruses (ICTV) officially named it as severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2)<sup>(3)</sup>.

Patients infected with this virus did not all present with pneumonia, and mild cases were asymptomatic, but severe or critical cases sometimes had multiple organ failure. Because of this, the World Health Organization (WHO) named the disease caused by this virus "coronavirus disease 2019" (COVID-19)<sup>(4)</sup>. Since the epidemic was serious, the National Health Commission of the People's Republic of China issued a notice on January 20, 2020, to incorporate NCP into the class B infectious diseases stipulated in the Infectious Disease Prevention Act of the People's Republic of China and took preventive and management measures for class A infectious diseases<sup>(5)</sup>. After an imported case of NCP from Wuhan was reported in Chenzhou, 46 more cases of NCP were admitted between January 21, 2020, and February 20, 2020, including 39 confirmed cases and seven asymptomatic cases. Of these 46 cases, 13 instances were individual cases, and the remaining 33 cases were from seven clusters. The epidemiological characteristics of the cases in the seven clusters are analyzed in this study.

### ***Subjects and methods***

#### ***Subjects***

Patients with COVID-19 reported by the infectious disease surveillance system in Chenzhou between January 21, 2020, and February 20, 2020 were included as the study subjects. A total of 46 patients who tested positive in pharynx swab nucleic acid tests were enrolled, including seven asymptomatic cases, 37 mild cases, and two severe cases. The diagnosis was based on the Novel Coronavirus Pneumonia Diagnosis and Treatment Plan (Sixth Edition, Trial Implementation)<sup>(5)</sup> issued by the National Health Commission of the People's Republic of China. The study was conducted in accordance with the Declaration of Helsinki (as was revised in 2013). The study was approved by the Ethics Committee of the First People's Hospital of Chenzhou, and informed consent was obtained from all the patients.

#### ***Methods***

According to hospital reports, staff from the Center for Disease Control and Prevention at the county, city, and district levels immediately went to the patient's residence to carry out an investigation,

which involved asking questions, filling out forms, observing, and monitoring. This was done to inform medical staff of the current medical history, exposure history, lifestyle, and contact history of each patient. In accordance with the "Law of the People's Republic of China on the Prevention and Control of Infectious Diseases," and following the principle of territorial management, before a confirmed diagnosis, patients were placed in designated medical institutions for further diagnosis and treatment, and people who had had contact with these patients were put into isolation and kept under medical observation.

In this study, statistical analysis was carried out on the original data of the epidemiological investigation. The history of exposure was classified as follows: those cases related to Wuhan or the epidemic areas around Wuhan were defined as Wuhan exposure; those related to non-Hubei Province were defined as local exposure, such as Shenzhen exposure; and those infected in Chenzhou were defined as Chenzhou exposure. Close contacts were those who ate or lived in the same room or shared a bed with the infected people from the epidemic area. Non-close contacts were those who had had a ride in the same train, bus, or car, or who had had a face-to-face conversation or meeting with the infected person, or participated in some public activity at the same time.

### **Results**

#### ***General information***

As of February 20, 2020, a total of 46 COVID-19 positive cases had been treated in the city of Chenzhou, including seven asymptomatic cases, 37 mild cases, and two severe cases. These included 24 male patients and 22 female patients. The patients' ages ranged from seven months to 72 years, and the average age was  $36.7 \pm 18.4$ . Two patients had a previous medical condition: one patient had liver cirrhosis, and the other had chronic bronchitis.

#### ***Cluster data***

There were 13 single patients and 33 patients from seven clusters. The clusters were named groups A-G. The number of infected cases in each instance was as follows: Group A had seven patients from the Liao family; Group B had five patients from the Xie family; Group C had four patients from the He family; Group D had four patients from the Deng family; Group E had two patients from the Cao family; Group F had two patients from the Deng

family; and Group G had nine patients from the Long, Zhang, and Cao families.

**Epidemiological data**

The cluster cases in Groups A-F were classified as the Wuhan exposure group, and the cluster case in Group G was classified as the Shenzhen exposure group. In the Wuhan group, each cluster consisted of one family. The exposure history of the first infected person was clear, the exposure was in Wuhan or its surrounding cities (e.g. Jingzhou), the infected people in the family were all in close contact, and there were only second-generation cases of infection. None of the non-close contacts were infected (see Table 1).

Groups	The number of infected cases	The first exposure site and number of cases	The second exposure site and number of cases	Contact mode	Frequency of contact	Number of close contacts	Number of non close contacts
A	7	Wuhan, 5	Suxian, 2	(1)(2)(3)(4)	(1)	10	4
B	5	Wuhan, 3	Anren, 2	(1)(2)(3)(4)	(1)	6	13
C	4	Wuhan, 1	Zixing, 3	(1)(2)(3)	(1)	8	29
D	4	Wuhan, 3	Yongxing, 1	(1)(2)(3)(4)	(1)	6	9
E	2	Wuhan, 2	Yizhang, 0	(1)(2)(3)(4)	(1)	8	28
F	2	Wuhan, 0	Suxian, 2	(1)(2)(3)(4)	(1)	6	28

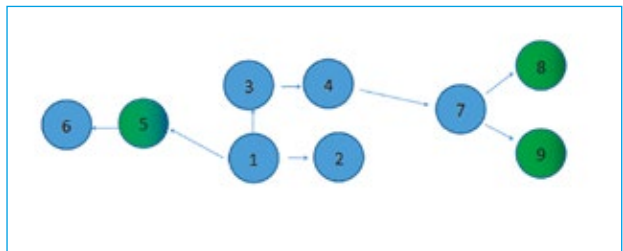
**Table 1:** Epidemiological data of the Wuhan group.  
 Note: Contact modes: (1) Eat together, (2) live together, (3) live in the same room, and (4) have the same bed; frequency of contact: (1) frequent, (2) general, (3) occasional.

In the Shenzhen group, the first infected person may have been either one of a young couple. After infecting their parents, they infected the Zhang and Cao families. In other words, three families were involved, there was a fourth or fifth generation of infection, and the total number of infected cases was nine (see Figure 1).

**Epidemiological association**

In the Wuhan group, five people in group A (Mr. Liao and his son, daughter-in-law, and two grandchildren) had lived in Wuhan for a long time. Mr. Liao usually did the shopping. He had a fever and cough in Wuhan on January 9, 2020, and was diagnosed with an upper respiratory tract infection at that time. Later, the family drove to Chenzhou and stayed with five family members (his wife, eldest son and partner, and two grandchildren). Among the ten people in the family, seven went on to develop the disease. In Group B, Mr. and Mrs. Xie lived together in Wuhan. They took the train to Chenzhou and stayed with their parents. Mr. Xie's father developed the disease first, then his wife and mother developed the disease. In Group C, Mr. He went from Wuhan to Zixing in Chenzhou, and went to eat in various places, causing his mother, sister, and nephew to be

infected one after the other. In Group D, Mrs. Deng went back to Chenzhou in Yongxing County, with her daughter, son-in-law, and nephew from Jingzhou City, Hubei Province. Another male friend first developed symptoms after staying at her home for one night.



**Figure 1:** The epidemiological history of the Shenzhen group is as follows:

Notes: (1) Mr. Long is the No.1 infected person in this clustered epidemic, (5), (8) and (9) are asymptomatic.  
 (1) Mr. Long (42 years) and (2) his wife (38 years) lived in a subway entrance community in Luohu District, Mr. Long infected (2); (1) When (1) Mr. Long and (2) returned to Yongxing, Chenzhou City and lived with (3) and (4), their parents, caused infection of (3) and (4), (3) Mr. Long's father (63 years) is a severe patient. (1) Mr. Long had dinner with his friend (5) Mr. Zhang, (5) Mr. Zhang was infected but asymptomatic, was an asymptomatic case, and infected (6) his father. (4) Mr. Long's mother (64 years) met and chatted with (7) Cao at the vegetable market, (7) Cao was infected, (7) Cao (female, 51 years) lives with the eldest daughter-in-law (25 years) and the youngest son (18 years), and then infected them, however, (9) was an asymptomatic case. Mr. Long and Cao live in a community, 50 meters apart. Long, Cao, and Zhang live within 500 meters.

Later, Mrs. Deng, her daughter, and nephew all developed the disease. In Group E, Mr. Cao and his wife traveled from Wuhan to Yizhang, in Chenzhou, and developed the disease one after the other, but no one else in the family became infected. In Group F, Mr. and Mrs. Deng lived in Suxian in Chenzhou. Their daughter and son-in-law attended a banquet in Xiantao, Hubei Province, from January 21 to 23. They shuttled between Wuhan and Xiantao picking up relatives. On January 23, Mr. Deng went to Chenzhou to stay with family members. However, his daughter and son-in-law had no symptoms, and their nucleic acid test was negative. In Group G, the cluster of patients was exposed to COVID-19 in Shenzhen. The situation was more complex, involving three families, and a total of nine people were infected. Mr. and Mrs. Long lived near a subway entrance in Luohu District, Shenzhen. According to the investigation, there were eight confirmed cases of COVID-19 in the communities near the subway, but no exact source of infection was found. Mr. Long's parents became ill after they returned to Chenzhou. Mr. Long and a friend, Mr.

Zhang, had dinner together, but Mr. Zhang did not present with symptoms (Mr. Zhang was positive for COVID-19 antibodies twice). However, it is possible that Mr. Zhang infected his father as the latter was diagnosed with the disease on February 7. Mr. Long's mother and her neighbor Mr. Cao met in the vegetable market, but they did not have close contact. After becoming infected, Mr. Cao transmitted the disease to his eldest daughter-in-law and youngest son, but, since his youngest son was asymptomatic, he was classified as belonging to the asymptomatic infection group.

**Clinical characteristics**

Among the 33 patients from the clusters, the clinical characteristics were a cough (20 patients), fever (18 patients), and fatigue (six patients), while nasal obstruction, a sore throat, and a runny nose were rare. The incubation period of the Wuhan group was 1-9 days, and the incubation period in the Shenzhen group was 11-14 days (see Table 2).

Groups	Gender	Age (years)	Incubation period (d)	Time of onset (Month, Day)	Clinical symptoms	Clinical classification	Length of hospital stay (d)
A.1	Male	59	—	1.18	Fever, Cough, Fatigue	General	10
A.2	Female	32	—	1.23	Fever, Cough	General	14
A.3	Male	33	—	1.27	Fever, Dizziness, Lower limb aching pain	General	15
A.4	Male	38	6	1.29	Nasal congestion, Runny nose	General	14
A.5	Male	7M	—	1.28	Cough	General	10
A.6	Female	60	7	1.30	Fever, Cough,	General	14
A.7	Male	4	—	2.4	Cough	General	19
B.1	Male	30	—	1.28	Cough	General	12
B.2	Female	27	—	2.1	Cough	General	12
B.3	Male	56	1	1.25	Fever, Cough	General	21
B.4	Female	2	—	2.1	Cough	General	13
B.5	Female	52	3	2.3	Fever, Nasal congestion, Fatigue	General	13
C.1	Male	42	—	2.3	Fever	General	11
C.2	Female	71	4	2.4	Fever, Cough	Severe	15
C.3	Female	46	8	2.1	Fever, Sore throat	General	13
C.4	Male	15	9	2.3	Fever, Fatigue	General	12
D.1	Female	51	—	1.28	Fever, Cough	General	11
D.2	Female	20	—	—	Asymptomatic	—	14
D.3	Male	2	—	—	Asymptomatic	—	12
D.4	Male	46	3	1.25	Fever, Cough,	General	12
E.1	Male	50	—	1.23	Dry cough, Fatigue	General	16
E.2	Female	49	—	1.28	Fever, Dry cough	General	10
E.1	Male	56	3	1.26	Fever, Cough, Abdominal distention	General	14
E.2	Female	49	5	1.29	Cough, Fever	General	11
F.1	Male	41	—	2.7	Cough, Fatigue	General	21
F.2	Female	38	—	2.2	Fever, Fatigue	General	20
E3	Male	62	14	2.1	Fever, Cough, Expectoration	Severe	26
F.4	Female	63	12	1.31	Cough	General	22
F5	Male	28	—	—	Asymptomatic	—	21
F.6	Male	56	—	2.7	Fever, Headache, Cough	General	13
7.7	Female	51	11	2.12	Cough	General	13
7.8	Female	25	—	—	Asymptomatic	—	10
7.9	Male	18	—	—	Asymptomatic	—	10

**Table 2:** Clinical characteristics of 33 clustered patients. Note: The grouping "A.1" indicates the possible patient number 1 in the first (group A) aggregated case, "B.2" indicates the patient number 2 in the second (group B) aggregated case, and so on. "-" indicates unclear.

**Discussion**

In December 2019, an unexplained pneumonia broke out in Wuhan, Hubei Province<sup>(6-8)</sup>. The disease spread rapidly because of close contact between people, and it presented in clusters involving

families, communities, or even those who had traveled in the same vehicles<sup>(9,10)</sup>.

Hunan and Hubei are separated by a lake, and people from the two places travel frequently. As the Spring Festival approached, many people went to Chenzhou from Wuhan or other parts of Hubei province. Hunan is a big labor export province, and before the Spring Festival, a large number of migrant workers returned home from Guangzhou and Shenzhen in Guangdong province. On January 21, 2020, the first suspected case of what became known as COVID-19 was admitted to hospital and diagnosed two days later (Ms. Deng, a 23-year-old female with a Wuhan epidemiological history). By February 20, 2020, 46 positive COVID-19 cases had been diagnosed. Among these patients, 13 were single cases, who all had a clear epidemiological history within the previous 14 days of either working or studying in Wuhan, or traveling or staying there for a short time. The other 33 patients were from nine families in total, and there were two or more cases in each family. According to the definition of a clustered epidemic situation for "Diagnosis and Treatment Plan for Novel Coronavirus Pneumonia (Sixth Edition, Trial Implementation)" issued by the National Health Protection Committee, these cases are categorized as a disease cluster.

**Epidemiological characteristics**

In the Wuhan group, in Group A, five people from the Liao family traveled to Chenzhou from Wuhan at the same time (Mr. and Mrs. Liao, his parents and their 4-year-old-son). Mr. Liao's father often went to the farmers' market to buy vegetables. While he was in Wuhan, he had had a fever and cough, and a local upper respiratory tract infection was initially considered. It was not possible to calculate the incubation period of the five members of the family. For example, although the four-year-old son had the same degree of contact with other people in the family, he was the last to develop the disease. When they were in Chenzhou, the family stayed with the eldest brother's family of four. However, due to different degrees of contact, only Mr. Liao's mother and elder brother were infected and his sister-in-law and two nephews were not. In Group B, Mr. Xie and his wife returned home from Wuhan together. The earliest symptom occurred in Mr. Xie's father. The incubation period was one day, as was the incubation period of his mother. So "Patient No. 1" in the cluster, in this instance Mr. Xie, developed symptoms only after his parents had developed the disease. In Group

C, Mr. He worked in Wuhan. After returning home, he visited many relatives and friends and infected his mother, sister, and nephew, with whom he had close contact. The incubation period was four days, eight days, and nine days, respectively. In Group D, Mrs. Deng engaged in domestic work in Jingzhou, Hubei Province. She returned to Yongxing, Chenzhou, together with her daughter, son-in-law, and nephew. Her boyfriend was infected after staying at her home for one night, and in his case the incubation period was three days. The throat swabs of her daughter and nephew were positive for COVID-19 nucleic acid, but they were asymptomatic, so they belonged to the asymptomatic infection group. Group E was a couple called Mr. and Mrs. Cao who lived in Wuhan, where they became infected. They visited Yizhang, Chenzhou, and although they had eight close contacts and 28 non-close contacts, none of them became infected. In Group F, the infected cases were a couple, Mr. and Mrs. Deng. Their daughter and son-in-law went to a big party in Xiantao, in Hubei province, and returned to Chenzhou with two boxes of local products of special purchases for the Spring Festival and gifts from the party, after which Mr. and Mrs. Deng became ill. However, the daughter and son-in-law had no symptoms, and their nucleic acid tests were negative. The reason for this may be that the special purchases were contaminated with COVID-19 from the epidemic area and Mr. and Mrs. Deng were infected via the "object-human" route. In previous literature, only "person-person" communication has been reported<sup>(11-14)</sup>, with the main routes of transmission being respiratory droplets, aerosols, and direct body contact. Fecal-oral transmission, mother-to-child transmission, and blood transmission still need to be confirmed<sup>(15-17)</sup>.

Recently, the infection was found to be transmitted to people through a cold seafood chain, confirming that COVID-19 can be spread by contact with a surface or object that has the COVID-19 virus on it (18-19). COVID-19 may also be spread through non-cold food chains in the winter, and it would appear that the couple in Group F were infected by contact with special purchases for the Spring Festival. The cluster in Group G (the Shenzhen group) involved three families: the Longs, the Zhangs, and the Caos. "Patient No. 1" in this instance was probably Mr. Long. He and his wife lived near the subway entrance in Shenzhen. According to the investigation, there were eight COVID-19 cases confirmed in communities near the subway. So, Mr. Long must have been exposed in Shenzhen and

then infected his wife. When Mr. Long went home, he infected his father, the incubation period for his infection being 14 days. Mr. Long also had dinner with and infected his friend Mr. Zhang, but he was asymptomatic. Although his nucleic acid test result was negative, he was positive for the anti-COVID-19 antibody IgM, and, in turn, he infected his father. This chain of infection indicates that asymptomatic infections can be contagious. Mr. Long's mother and her neighbor Mr. Cao met in the vegetable market, which may have led to Mr. Cao's infection. He then infected his eldest daughter-in-law and his youngest son. Thus, it can be seen that if Mr. Long was the first generation infected, he eventually caused a fourth or fifth generation of infection.

In the patients in these seven clusters, the source characteristics of "first infection" were obvious in the Wuhan group. The infection came from Wuhan or the surrounding areas of Wuhan and spread in only one family. All the infections were caused by close contact, and the non-close contacts were not infected. However, not all close family member contacts became infected. For example, in Group A, the elder sister-in-law and two nephews were not infected despite being in the same environment, and, in Group C, Mr. He's wife and daughter were not infected. On the other hand, the symptoms of the "first infected" patients appeared later than those with secondary infections. For example, in Groups A, B, C, and D, family members with secondary infections presented with symptoms before the person who had infected them. This indicates that cases can be infectious during the incubation period and when they are asymptomatic. However, there was only one second generation infection in the infectious group, and there were no other family members with secondary infections. The seventh instance (Group G, the Shenzhen group) was highly infectious and infected three families. It would therefore seem that non-close contact can also cause infection since, for example, Mr. Long and his friend Mr. Zhang only ate together once, and Mr. Long's mother and her neighbor Mr. Cao only met in the vegetable market once.

### *Clinical signs*

Of the 33 infected patients, 26 had obvious clinical symptoms. The main manifestations were the onset of fever (18 patients), which generally lasted for 3-5 days, and, in the later stages, the main symptom was a cough (20 patients), which was normally a dry one. Six patients had fatigue, and only

one patient had a sore throat and nasal congestion. In four families in the Wuhan group, the first patient with respiratory symptoms was not the so-called Patient No. 1, but the oldest infected person in the family. Therefore, it is speculated that patients in the pre-symptom period (i.e. the incubation period) are also infectious. As there are no obvious symptoms in the incubation period, the illness is hidden, and so it is not easy to ensure vigilance and self-protection in other parties. This may be one of the reasons why COVID-19 spread so easily.

### *Length of hospital stay*

In the Wuhan group, the length of hospital stay was  $13.25 \pm 2.67$  days. In Group G, the nucleic acid positive-to-negative conversion time was longer, and the average time of positive-to-negative conversion was  $19.4 \pm 3.7$  days. Therefore, the length of hospital stay was longer. The average length of hospital stay was  $17.33 \pm 5.87$  days. In particular, first- and second-generation patients, like Mr. Long and his parents, tested positive in nucleic acid tests for a long time, and the length of their hospital stay was as long as 20-26 days.

The following conclusions can be drawn from the findings of this study of seven clusters of COVID-19 patients. Patients are infectious in the incubation period, and asymptomatic infections are infectious. The disease that originated in the Wuhan area was not infectious without close contact, but the disease originating in Shenzhen was highly infectious, and people became infected without close contact. While a fourth or fifth generation of patients can be infected, the incubation period for such cases is longer. In addition to respiratory droplets, aerosols, and close contact, the "object-human" route is a potential route of infection. Finally, it is likely that the differences between the epidemiological characteristics of COVID-19 from Shenzhen and from Wuhan are due to the variation in the virus or different strains, and this possibility requires further study.

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#### *Acknowledgements*

*We are particularly grateful to all the people who have given us help on our article.*

#### *Funding*

*This study was funded by the 2020 Chenzhou Key R&D Projects (No. ZDYF2020006) and the 2020 Chenzhou Technology Innovation Guide Special Project Technology Bureau Plan Project (No. ZDYF2020016). The funding body had no role in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.*

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