COVID-19: Epidemiology and Preventive Measures in Jiangsu Province, China

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Abstract

Background To discuss the epidemiological features of coronavirus disease 2019(COVID-19) and prevention measures in Jiangsu Province.

Methods Information on all novel coronavirus pneumonia confirmed cases in Jiangsu was collected from the official website of Jiangsu Commission of Health. All data are entered into Excel and Python3 for statistical analysis. Epidemiological characteristics of novel coronavirus pneumonia confirmed cases from January 10, 2020 to March 18th in Jiangsu province were retrospectively analyzed. Meanwhile, the preventive measures of Jiangsu Commission of Health and the people's Government of Jiangsu Province were also analyzed.

Results 631 COVID-19 cases were diagnosed in Jiangsu Province, covering 13 districts in Jiangsu. Before February 1, the confirmed cases were mainly imported cases, and after February 1, community transmission cases became main part of confirmed cases. There were more male patients than females, and most patients were in the group of 30-70 years old, 49 patients (7.8%) with mild symptom and 572 patients (90.6%) with common type accounted for the majority. The cumulative mortality rate was 0% and the cure rate was 100%. Reasonable treatment, timely and effective preventive measures were taken to effectively improve cure rate and to prevent the spread of the epidemic, all measures ensure the health and life safety of the people.

Conclusion The preventive measures in Jiangsu Province were timely and effective, the epidemic situation in Jiangsu Province had been well controlled and cured.

1. Background

Since December 2019, a cluster of cases of pneumonia of unknown cause was detected in Wuhan City, Hubei Province, China. A novel coronavirus had been identified in samples obtained from cases and that initial analysis of virus genetic sequences suggested that this was the cause of the outbreak. This virus is referred to as SARS-CoV-2, and the associated disease as COVID-19(Coronavirus Disease 2019). SARS-CoV-2 belongs to the coronavirus of the genus β, with an envelope, with round or oval virus particles, polymorphic, and the diameter is 60 – 40 nm. The continued human-to-human transmission of SARS-CoV-2 is reported, which can be spread through respiratory droplets and close contact, resulting in a rapid increase of confirmed cases nationwide and even worldwide [1]. On January 30, the epidemic was declared by WHO as ‘a Public Health Emergency of International Concern’. As of 10 April 2020, more than 1.56 million cases have been diagnosed globally, with over 95,000 fatalities. Investigating the epidemiological characteristics of COVID-19 is essential for formulating and implementing effective prevention and control strategies and measures. There are few studies on the epidemiology of novel coronary pneumonia in Jiangsu Province. This study analyzed the epidemiological characteristics of all COVID-19 cases occurring in Jiangsu province until March 18, 2020, in order to provide a basis for the prevention and control of COVID-19.

2. Methods

2.1 The data source The data source is based on the official data of Jiangsu Commission of Health (http://wjw.jiangsu.gov.cn), from which the confirmed cases and epidemics of COVID-19 cases were counted from January 23 to March 18, 2020. The diagnosis of patients with COVID-19, and the clinical classification of mild, common, severe and critical diseases, the cure standard and the isolation standard were all judged according to「Novel Coronary Virus Pneumonia Diagnosis and Treatment Program」(Trial Sixth Edition). The diagnosed date or confirmed date of COVID-19 patients in this study is defined as the day before the confirmed date of the official data of Jiangsu Commission of Health (http://wjw.jiangsu.gov.cn).

2.2 Methods Descriptive epidemiological studies were used to retrospectively analyze the data collected above, to describe the distributions, the source of case infection, and clinical outcomes. Curve fitting was introduced to establish a mathematical description of the disease data with time sequence based on Likely-Sigmoid function. By this means, the peaks and characteristic points of the curves for confirmed and cured cases number can be quantified by derivative which was used to describe the changes in the epidemic situation and the expected development of the epidemic situation.

2.3 Statistical analysis Data time sequence estimation adopts Sigmoid function fitting. Statistical processing was performed with SPSS20.0, GraphPad Prism6.0 and Matlab2017 were used for picture production, Python 3 was used for function fitting, and ArcGis10.6 was used for map production.

3. Result

3.1 Characteristics of COVID-19 cases

Until March 18, 2020, a total of 631 confirmed cases were reported, including 191 imported cases (30.27%), 440 second-generation or above transmission cases (69.73%). 240 of 631 cases were reported by age and gender according to available information (Table 1).

Table 1
Characteristics of COVID-19 cases in Jiangsu Province

Case characteristics	Confirmed cases (n(%))
Total	631(100)
Age group #	
0~	3(1.25)
10~	4(1.67)
20~	23(9.58)
30~	46(19.17)
40~	52(21.67)
50~	59(24.58)
60~	31(12.92)
70~	17(7.08)
≥ 80	5(2.08)
Gender group #	
male	131(54.58)
female	109(45.42)
Source	
Import	191(30.27)
second-generation or above transmission cases	440(69.73)
Severity	
Mild	49(7.77)
Common	572(90.65)
Severe	10(1.58)
Time	
Before 28-Jan	70(11.09)
From 29-Jan to 30-Jan	59(9.35)
From 31-Jan to 7-Feb	279(44.22)
From 8-Feb to 19-Feb	223(35.34)

Case characteristics	Confirmed cases (n(%))
#:Only 240 of total 631 cases were reported by age and gender	

3.2 Geographical distribution

On January 22, 2020, 5 newly diagnosed cases of COVID-19 were first confirmed by Jiangsu Commission of Health. All 5 patients had a history of travel in Hubei, in other words, were imported cases. Two of them were confirmed by Nanjing City, and one each was in Suzhou, Yangzhou, and Lianyungang (Fig. 1A). On January 26, an imported case was confirmed in Zhenjiang City for the first time. So far, 13 cities across the province had reported confirmed cases of COVID-19[2], with a total of 47 imported cases. Nanjing, Changzhou and Suzhou have more COVID-19 patients, compared with other cities (Fig. 1B). As of March 18, Jiangsu Province had a total of 631 cases of COVID-19 diagnosed, among which the top three cities for the number of confirmed cases were Nanjing (93 cases, 15%), Suzhou (87 cases, 14%), Xuzhou (79 cases, 12%) (Fig. 1C).

3.3 Time distribution

On January 22, Jiangsu Province confirmed 5 patients with novel coronary pneumonia, all of whom had a clear history of contact with Wuhan. On January 27, Jiangsu Commission of Health confirmed the first case of second-generation transmission of novel coronary pneumonia in the province. So far, COVID-19 had opened a community transmission model, which means imported cases and community transmission cases coexist. The peak period of the epidemic was from January 28 to February 8, and the number of new additions after February 8 showed a downward trend in volatility. The number of confirmed cases stopped increasing on February 19, with total 631 cases. Through a retrospective study of patients' epidemiologic history, imported cases were predominantly diagnosed before January 29, the percentage of daily imported cases accounted for more than 67% in daily total cases. Then the number of imported cases began declining and no imported cases were reported after February 3. From that time on the confirmed cases are all second-generation or above transmission cases in the province, which means, the onset was typically caused by SARS-CoV-2 after contacting with confirmed cases in the gathering place (Fig. 2).

Until March 18, Jiangsu had a total of 631 confirmed COVID-19 patients, 631 cured, 49 mild patients (7.8%), 572 common patients (90.6%), and 10 severe and critically ill patients (1.6%). From February 18 to March 18, there were no newly confirmed cases in Jiangsu Province, and on March 13 the confirmed cases in Jiangsu Province were all cured. The cumulative number of severe patients in Jiangsu was 10, and gradually changed to mild or common patients after February 21. The cumulative case fatality rate in Jiangsu Province was 0% (Fig. 3).

It was a common analysis method in other papers to directly select the characteristic date as the inflection point of the epidemic from the cumulative number of confirmed or cured cases sequence over time. This kind of method used empirical judgment for several consecutive days with high values without mathematical description, and cannot explain the fluctuation of data after the inflection point date.

Therefore, a certain degree of smooth curve fitting from mathematical point of view was necessary, which could remove the influence of data noise, and removed the overfitting description, and fund the characteristics of the data trend.

Further analysis based on data driven methodology of cases was carried out. The changing trend of both cumulative confirmed and cured cases number time sequence indicated a smooth slow-fast-slow growth pattern, which has a well-matched property with the classic *Sigmoid* function from the perspective of graphics features. Therefore, this study attempted to fit the cumulative confirmed cases number time sequence and the cured cases number time sequence with the scaled Sigmoid (Likely-Sigmoid) function to get the closed form math expression respectively. Python module scipy and its optimize. Curve fit tool was utilized in this paper. The cumulative number of confirmed patients was fitted to: f(x) = 633/ (1 + e^(-0.259(x-15.5))), (R-square: 0.9979, RMSE: 10.347); the cumulative number of cured patients was fitted to: f(x) = 629/(1 + e^(-0.196(x-31.2))), (R-square: 0.9983, RMSE:10.422). These high R-squares showed excellent performance of Likely-Sigmoid function to fit the cases number time sequence. Therefore, it was chosen in this study to calculate the first and second order derivatives in order to estimate the key points of the epidemic.

For the functional model of the cumulative number of confirmed cases, the extreme point of the first order derivative of the fitted curve corresponded to the point with the largest growth rate of confirmation. From this point, the epidemic could be divided into two stages. The first was the acceleration growth stage, while the second was the deceleration growth stage. The date corresponding to the extreme point of the first derivative could be regarded as the turning point, after which the cases growth changed from acceleration to deceleration. Also, the point could be called inflection point of the epidemic. The first derivative of the cumulative confirmed number of Likely-Sigmoid models in Jiangsu Province had an extreme point on February 4, indicating that February 4 is the peak day for newly confirmed cases (Fig. 4B). The inflection point indicated that the growth rate of the cumulative number of confirmations after February 4 had slowed down, means the emergence of the inflection point. As a comparison, the epidemic inflection point of the whole China (except Hubei Province) appeared on February 3, which showed epidemic trend of COVID-19 in Jiangsu province was consistent with the national (Fig. 4A).

For the functional model of the cumulative number of cured patients (Fig. 4C-D), there were two extreme points of the second derivative of the fitted curve, corresponding to the epidemic can be divided into three periods, respectively corresponding to the growth rate acceleration ‘increase-decrease-increase’ mode, that is, the acceleration of cumulative number of cured patients would increase first, then decrease, then increase. That corresponds to the cases number growth speed would increase slowly first, then fast and then slowly, that formed a ‘low speed- high speed- low speed’ pattern. The characteristic points of the growth acceleration of the cured patients’ number were on February 12 and February 26, respectively. After February 12, the number of cured patients increased significantly and the growth acceleration was significantly higher than before. After February 26, the growth acceleration of the cured patients number slowed down.

3.4 Population Distribution

Since the demographic sociological information of cases was not a project that must be announced by the Commission of Health, the basic information of some cases was missing. The distribution of 240 diagnosed patients with complete data in 7 cities (Taizhou, Yangzhou, Xuzhou, Nantong, Suzhou, Zhenjiang, and Nanjing) was analyzed. Of the 240 confirmed cases, 131 were male (54.58%) and 109 were female (45.42%). The gander ratio of male to female was 1.20: 1, which meant more male infected than female. Of the 240 confirmed cases, 7 cases were younger than the 20-year-old (2.92%), 23 cases were among 20–30 years old (9.58%), and 5 cases were old than the 80-year-old (2.08%). The number of confirmed cases in 30–80 years old is the largest, 205 cases, accounting for 85.41% of the total number, which was roughly similar to the overall situation in China (30–80 years old group accounted for 86.6%) [3]. The median age of diagnosed cases was 47.035(± 1.162) years for males and 47.633(± 16.763) years for females. The youngest patient was a 10-month-old male child in Nanjing, and the oldest patient was a 91-year-old male patient in Huaian city.

3.5 Transmission route

Based on complete epidemic history data of confirmed cases in Jiangsu Province, transmission routes of COVID-19 were classified into four types. Type one was for imported cases who had a clear contact history in Hubei, and then were confirmed a few days after isolation (Fig. 6. patient 1, 2), with or without second-generation transmission. Type two was for clustering cases in a family, in which situation, family members were transmitted by other infected family members (Fig. 6. patient 3, 4). Type three was entertainment aggregation transmission, in which situation, patients were infected by person who carried the virus through close contact in congregation or party (Fig. 6. patient 5, 6). The last type was unconscious contact transmission (Fig. 6. patient 7, 8), in which situation, patients were infected by unconscious contact with confirmed COVID-19 patients, such as staying in the same train cabin with infector. The second-generation infected patients under the three modes may again generated three-generation or more-generation infected cases through the above three transmission routes, forming a complete route of transmission.

4. Discussion

In terms of geographical distribution, until March 18, the cumulative number of confirmed patients in Nanjing, Xuzhou, and Suzhou ranked the top three in the province. According to the transportation network map of Jiangsu Province (Fig. 1D), Nanjing and Xuzhou are the largest road and railway transportation hub in Jiangsu province, and Suzhou has extremely convenient railway and road traffic with Shanghai, the international transportation hub. The above data suggested that the convenience of transportation of the region was relative to the number of imported cases. The epidemic prevention work at airports, stations, and railways would have the top priority. The timely first-level response of Jiangsu Province greatly reduced the input of imported cases.

In terms of time distribution, for the ‘low-speed growth-high-speed growth-low-speed growth’ model shown by the cumulative diagnosis curve, the inflection points of the growth rate of the cumulative number of

cured persons were on February 12 and February 26, respectively(Fig. 4D). After February 12, the number of cured people increased significantly and the growth rate was significantly improved. The continuous increase in the cumulative number of confirmed cases was a possible acceleration factor. Another possible reason is due to optimized treatment plan recommended by < Novel Coronavirus Infected Pneumonia Diagnosis and Treatment Program (Trial Version 5) > on February 8[4]. After February 26, the growth rate of the number of cured patients slowed down was possibly due to the discharge of mild patients and common patients from the existing patients, the structure of the patients changed, and the proportion of severe patients increased. The severe and critically patients' discharged was considered as the use of chloroquine phosphate and other drugs, which was suggested in < Trial Seventh Edition> [5–6]. Lung transplantation and the application of artificial cardiopulmonary circulation were also considered had the contribution for the discharged of severe patients [7]. Meanwhile, Jiangsu Province completed 100% patient cure, which may due to the traditional Chinese medicine widely used and timely consultation taken by provincial expert team—89% patients were treated by integrated Chinese and western medicine and 100% patients were diagnosed by professional expert team in Nanjing [2].

The Sigmoid function was also used to fit the cumulative number of cured cases in Hubei and Beijing respectively as a supplement and comparative study [8]. It was found that the increase in the number of cured people in Hubei and Beijing also showed a slow-fast situation, and the first inflection point of their growth rate was around February 21, when was about 2 weeks after the plan 'upgrade the dosage of ribavirin to Adults 500 mg/time, 2 to 3 times a day intravenously' (Fig. 7). Therefore, this study speculated that high-dose application of ribavirin has a positive effect on the treatment of novel coronary pneumonia, and patients with novel coronary pneumonia could obtain benefice from it after 1–2 weeks of comprehensive treatment including high-dose ribavirin. Since this study did not collect detailed clinical features and treatment options for each case, this inference still needed to be confirmed by further studies. The first inflection point about Hubei and Beijing appeared 5 days behind Jiangsu. The proportion of severe patients was higher [3, 8, 9], the total number of diagnosed patients was larger, and the medical resources were tight, etc, all of above were considered as possible factors.

There were still some limitations in this study. Because the epidemic data were collected from the official websites of the National Commission of Health and Jiangsu Commission of Health, the information provided was limited, since we were not able to get the information of the specific onset time, exposure history, and past history of each case, clinical manifestations, diagnosis and treatment plans, treatment effects and personal basic conditions, etc., we failed to do a more in-depth study on the population distribution, susceptibility factors and so on. At the same time, all the treatment methods and epidemic prevention measures in this study came from the official website of the People's Government of Jiangsu Province and the National Novel Coronavirus Pneumonia Medical Treatment Expert Group, which may be some bias. Furthermore, in the context of the international outbreak of novel pneumonia, until March 18, 2020, Jiangsu Province had reported none new case in the province for 27 consecutive days, and no new imported cases have been found. It can be considered that the epidemic in this province was close to

disappearing. However, the epidemic prevention work still needed to be highly valued, guarded against the importation of foreign cases.

In the early stage of the outbreak of Novel Coronary Pneumonia, the People's Government of Jiangsu Province successively initiated the first-level response to public health emergencies according to the < Emergency Response Plan for Public Health Emergencies in Jiangsu Province > on January 24. It also highlighted the focus of work to strictly preventing imported epidemics, including strictly managing the agricultural market, doing a good job in the ventilation, disinfection, temperature detection, and health quarantine of personnel-intensive places such as airports, stations, and docks, and public transportation. The hospital strengthened emergency protocols, and medical personnel improved their own safety protection to effectively ensure early detection, early reporting, early diagnosis, early isolation, and centralized treatment measures. It was forbidden to assemble, and it was necessary to close large entertainment venues, continue to track close contacts, etc., cut off the chain of communication in time, and require residents to reduce going out and wear masks in public places (Fig. 8). At the same time, on January 27, the Jiangsu Health Committee issued a document, proposing 'strengthen epidemic surveillance and implement a reporting system. standardize medical treatment and ensure patient safety [10]. manage in accordance with laws and regulations to prevent the spread of the epidemic; promptly disclose information and strengthen propaganda and guidance. Actively strive for support and strengthen logistics support.' and further eight specific requirements. All of above affirmed the timeliness of the previous epidemic prevention work, and made a more detailed system of arranging epidemic prevention work from the aspects of mission, monitoring, treatment, logistics, etc.at the same time.

In addition, the Jiangsu Provincial Government and the Jiangsu Health Committee attached great importance to possible imported cases. On March 5th and 26th, they issued a document to emphasize the procedures for handling the epidemic situation after travelers arriving in Nanjing. Work links such as screening of fevered passengers, determination of close contacts, retention of fevered passengers, etc., make clear requirements for the entire work flow of fever passengers for inspection and medical treatment [2]. At the same time, high attention was paid to the safety issues in the work of returning to work.

5. Conclusion

In conclusion, the analysis of the epidemiological characteristics of novel coronary pneumonia reported by Jiangsu Province as of March 18, 2020, and the analysis of the prevention and control measures during the epidemic can lead to the following conclusions: timely, reasonable and effective epidemic prevention measures, constantly updated treatment methods, rich medical and health resources are indispensable parts of the success of this Jiangsu epidemic prevention work.

Abbreviations

SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2; COVID-19: Coronavirus disease 2019; WHO: World Health Organization.

Declarations

Availability of data and materials

Supplementary data and codes were uploaded in Github

The URL is as following: https://github.com/liujs1/Jiangsu_COVID19

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Authors' Contributions

YC, JL and CY contributed to study design, introducing function fitting methods, mathematical calculation, data analysis and processing, figures plotting, literature search and paper writing. AZ, ZA contributed to article quality supervision and overall control.

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Ethics declarations

Ethics approval and consent to participate

All data in this article comes from the official report of the Health Commission, and no privacy and ethics issues are involved.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Due to technical limitations, table 1 is only available as a download in the Supplemental Files section.