Transmission and epidemiological characteristics of Novel Coronavirus (2019-nCoV)-Infected Pneumonia (NCIP): preliminary evidence obtained in comparison with 2003-SARS

Rongqiang Zhang[1] Hui Liu[1], Fengying Li[2], Bei Zhang[1], Qiling Liu[1], Xiangwen Li[1*], Limei Luo[3#]

1: School of Public Health, Shaanxi University of Chinese Medicine, Xianyang 712046, P. R. China.

2: Centers for Disease Control and Prevention of Xianyang, 712046, P. R. China.

3: Shangdong Provincial Maternity and Childcare Hospital, Jinan, China

*** Corresponding author:**

Xiangwen Li

School of Public Health, Shaanxi University of Chinese Medicine, Xianyang 712046, P. R. China. Tel: 86-029-38185219; Fax: +86-029-38185219

Co- corresponding author

E-mail address: Zhangrqxianyang@163.com

Running title: Epidemiological characteristics of 2019-nCoV

Fund Project: Research Project from Health Commission of Shaanxi Provincial Government (2018A017), Research Project from Education Department of Shaanxi Provincial Government (19JS015), Subject Innovation Team of Shaanxi University of Chinese Medicine (132041933).

Word count: 3000 words

[Abstract] Objectives Latest epidemic information of Novel Coronavirus (2019-nCoV)-Infected Pneumonia (NCIP) was collected and a detailed statistical analysis was carried out to make comparison with 2003-SARS in order to provide scientific reference for the prevention and control of 2019-nCoV. **Methods** The

information of NCIP and 2003-SARS from websites of NHCPRC and the World Health Organization was collected, and then the transmission dynamics of the two kinds of infectious diseases were analyzed. The information of 287 confirmed NCIP patients obtained from the website of health committees of 16 provinces. A descriptive epidemiological analysis method was employed to carefully analyze the epidemic characteristics. Subsequently, the NCIP epidemic data in Wuhan and other inland regions of China was analyzed separately and compared. A multivariate function model was constructed based on the confirmed NCIP case data. **Results** The growth rate of new cases and deaths of NCIP were significantly faster than those of 2003-SARS. The number of confirmed cases in Wuhan and other inland areas both showed increasing trends. 287 confirmed NCIP cases aged 9 months to 90 years and the average age was (42.38 ± 15.97) years. The gender ratio (M: F) was 1.35: 1. The numbers of NCIP patients in Wuhan and other inland areas were in line with Y=0.7209 x^3-11.97x^2+59.129x (R^2=0.9858) and Y=2.2169 x^3-39.74x^2+158.88x (R^2=0.9357) , respectively, with good fitting effects judging by their R^2 values. **Conclusions** The fatality rate of NCIP is lower than that of 2003-SARS and the cure rate is higher. The age of NCIP patients is mainly concentrated in the 30-50 years old (68.29%). The harm of the first-generation NCIP patients is indeed higher than that of secondary cases.

[Key words] Transmission, epidemiological characteristics, 2019-nCoV, SARS

On December 8th, 2019, the National Health Commission of the People's Republic of China (NHCPRC) of the People's Republic of China received a case report of an unexplained pneumonia patient. Subsequently, NHCPRC appointed an expert group to arrive in Wuhan to guide the epidemic management. On January 7, the pathogen of this unexplained infected pneumonia was identified as a novel coronavirus (2019-nCoV)[1]. On January 28th, 2020, a total of 5,974 cases of 2019-nCoV patients were diagnosed and reported in 31 provinces (autonomous regions, municipalities)[2]. At the same time, China's Hong Kong Special

Administrative Region, Taiwan, Macau and Japan, the United States, Vietnam, Singapore, Nepal, France, Canada, South Korea, Thailand, Malaysia, etc, all have 2019-nCoV reports. The rapid spread of 2019-nCoV has brought a huge impact on the health of Chinese residents, economic development, and even social stability.

Within the last week, Chinese governments had taken a series of comprehensive measures to prevent and control the Novel Coronavirus (2019-nCoV)-Infected Pneumonia(NCIP), such as closing the traffic of Wuhan to minimize the spread of confirmed cases, medical staff across the country and around the world to assist Wuhan. Scientists have also actively researched and explored the etiology, genomics, transmission dynamic of 2019-nCoV and made due contributions to the prevention and control of the spread of 2019-nCoV infection. However, from the perspective of the epidemic of NCIP, its number of confirmed cases is still increasing rapidly, and the number of deaths has also increased significantly. Actively exploring and studying the transmission characteristics and epidemiological characteristics of NCIP will greatly help to curb its spread. It has been reported that the epidemiological and clinical characteristics of NCIP show some similarities to Severe Acute Respiratory Syndrome in 2003 (2003-SARS)[3-4]. Whether the effective control of 2003-SARS can provide direction for the prevention and control of NCIP, there is still no reported evidence. In the present study, we collected relevant latest epidemic data of NCIP and a detailed statistical analysis was carried out and the results were compared with 2003-SARS in order to explore and provide scientific reference for the prevention and control of NCIP.

Materials and Methods

Diagnosis and Definition of NCIP Patients

A confirmed NCIP patients was defined as a case with respiratory specimens that tested positive for the 2019-nCoV by at least one of the following three methods: isolation of 2019-nCoV or at least two positive results by real-time reverse-transcription–polymerase-chain-reaction (RT-PCR) assay for 2019-nCoV or a genetic sequence that matches 2019-nCoV[5].

Incidence Trends and Characteristics of NCIP

The information of NCIP cases from January 10th, 2020 to January 28th, 2020 and 2003-SARS cases from March 26th to May 26th, 2003 in China's inland regions (data from websites of NHCPRC and the World Health Organization) was collected and then the incidence trend and change characteristics of the both infectious diseases were analyzed to understand the transmission dynamics of the two kinds of infectious diseases.

Epidemiological Characteristics of NCIP

The information of NCIP patients reported in inland areas of China (Beijing, Shaanxi Province, Sichuan Province, etc.) was collected, including age, gender, and contact history (consist of having been to Hubei or living in Hubei, contacting confirmed cases, contacting people who were from Hubei and unclear). The data was collected from the website of the health and health committees of the above provinces. A descriptive epidemiological analysis method was employed to carefully analyze the epidemic characteristics of NCIP. However, only several provincial administrations released the baseline information of NCIP confirmed patients, so the number of confirmed cases with detailed baseline information was far less than the total. Finally, 287 NCIP confirmed patients from 16 provinces, whose baseline information was available, were included into our analysis.

Comparison of NCIP in Wuhan and Regions except Wuhan

2019-nCoV originated in Wuhan, China. In the early stage of NCIP outbreak, there may be cases of underreporting or concealment in Wuhan, which may make it difficult to objectively reflect the true epidemic characteristics of NCIP. Therefore, the NCIP epidemic data in Wuhan and other inland regions of China was analyzed separately and compared to obtain more objective NCIP epidemic knowledge.

Model Construction of NCIP Epidemic Data

In the present study, the number of confirmed cases of NCIP in Wuhan and other inland regions was used as the dependent variable *Y* and the time (date) was used as the independent variable *X*. A multivariate function model was constructed based on the confirmed cases of NCIP from January 10th to January 28th, 2020, aiming to explore the accurate epidemic trend of the NCIP cases.

$$Y= a\,x^{n} + b\,x^{n-1} + \ \ldots\ldots\ + c\,x + d$$

Results

Overall epidemic trends of NCIP

As of 24:00 on January 28, NHCPRC has received a total of 5,974 confirmed cases in 31 provinces (autonomous regions, municipalities), 1,239 cases of severe cases, 132 cases of deaths, and 103 cases of discharged patients. There were 9239 suspected cases. The overall incidence trends of NCIP and 2003-SARS were shown in Figure 1.

Epidemic trends and characteristics of NCIP and 2003-SARS

As shown in Figure 2, the growth rate of new cases and deaths of NCIP were significantly faster than those of 2003-SARS, while the number of cured patients was significantly less than that of 2003-SARS, suggesting that NCIP showed a faster transmission ability and could require longer treatment.

However, it was worth noting that on the 18th day after comprehensive case reporting (January 28th, 2020), the number of new NCIP cases began to decline, which may suggest that the comprehensive response measures adopted by the Chinese government began to take effect.

Trends in Confirmed Cases and Fatality Rate of NCIP of Wuhan and Regions except Wuhan of China's Inland

Both the numbers of confirmed cases in Wuhan and other inland areas showed increasing trends. From January 24th, 2020, the number of confirmed cases in areas other than Wuhan in inland China began to exceed Wuhan (Figure 3A); the fatality rate in Wuhan (1.52% -6.64%) was significantly higher than that of inland areas of China except for Wuhan (0% -2.64%) (Figure 3B).

Epidemiological Characteristics of NCIP

As of 17:00 on January 29th, 2020, the basic information of 287 confirmed NCIP cases (94 from Beijing, 27 from Tianjin, 47 from Sichuan, 18 from Yunnan, 5 from Guangxi, 4 from Jilin, 8 from Guizhou, 2 from Heilongjiang, 8 from Hunan, 1 from Chongqing, 3 from Liaoning, 1 from Inner Mongolia, 56 from Shaanxi, 3 from Gansu,

6 from Qinghai, and 4 from Xinjiang, Figure 4) was collected on the official websites of 16 provincial and municipal health committees. 287 confirmed NCIP cases were aged 9 months to 90 years and the average age was (42.38 ± 15.97) years; 287 confirmed NCIP cases included 165 males and 122 females, the gender ratio (M: F) was 1.35: 1 (Figure 5, Table 1).

In the 287 confirmed NCIP patients, 172 cases had a history of having been to Hubei or living in Hubei, 19 cases had a history of contacting confirmed cases, 8 patients had a history of contacting people who were from Hubei, and the contact history of the other patients were unclear (Figure 6).

Epidemic Models of NCIP Confirmed Cases

The result of model construction showed that in the future (about 5 days to 1 week), the numbers of NCIP confirmed cases in Wuhan and other inland areas might increase. If continue to develop according to the existing principles, their epidemic trends were in line with $Y=0.7209\ x^3-11.97x^2+59.129x$ ($R^2=0.9858$) and $Y=2.2169\ x^3-39.74x^2+158.88x$ ($R^2=0.9357$) , respectively, with good fitting effects judging by their R^2 values (Figure 7).

Discussion

In 2002, a case of SARS appeared in Guangdong Province, China, and then spread to Southeast Asia and all of the world [6]. The SARS outbreak comprehensively tested that the public health system of China was very vulnerable in front of the prevention and control of infectious diseases. Subsequently, the Chinese government implemented a series of reforms in the public health field, such as reorganization of the CDC, training public health professionals, and establishing the disease information system covering the whole country, the establishment of a complete reporting system for infectious diseases and an excellent mechanism for handling public health emergencies, etc. After a development for 17 years, a complete public health system has been established in China and great progress has been made in handling public health emergencies such as infectious disease epidemics.

After the outbreak of NCIP in 2020, the Chinese government adopted

comprehensive measures to handle its spread. The people from China and the world also provided generous assistance to Wuhan, including actively treating the confirmed patients, donated medical supplies such as masks, etc., which have been played important roles in effectively curbing the spread of NCIP. The main process of NCIP in China was shown in Figure 8. Meanwhile, governments across China were also actively adopting strict measures. The appropriate performance of the Chinese government and local governments at all levels to deal with NCIP was due to the experience accumulated in the SARS disposal process and the great development of public health system in the past 17 years.

The NCIP epidemic has brought a significant impact on the health and normal lives of the residents and the social and economic development of China. In addition, it was catching up with the Chinese Lunar New Year, and the above adverse effects are even more prominent. However, until now, the etiology, epidemiology, and pathogenesis of NCIP are unclear, which has made it difficult to effectively contain the epidemic. Under this background, the latest data of NCIP epidemic was collected to conduct a detailed analysis, and compared with the relevant characteristics of 2013-SARS. The aim of our present study is to make positive contributions to help contain the NCIP epidemic, prevent panic and anxiety to develop, and to restore China's normal social order as soon as possible.

Although many details such as the source of the virus and the ability to spread among people are still unknown, an increasing number of cases that have confirmed the human-to-human transmission of the virus. Studies have shown that the interpersonal transmission ability of NCIP corresponds to SARS, but its doubling time (6 to 7 days) is shorter than that of SARS (about 9 days) [1, 7], and the passage interval of NCIP is also relatively short. The second generation of NCIP cases unrelated to Wuhan has gradually appeared, which has also contributed to a sharp increase in short-term confirmed cases, resulting in a serious situation of NCIP prevention and control, and thus it is now very difficult to predict the epidemic trend.

Age and comorbidities (such as diabetes or heart disease) are independent predictors of poor SARS-CoV and MERS-CoV outcomes. The spread of SARS-CoV

and MERS-CoV occurred to a large extent through super-transmission events[6-7]. Currently, there are data suggesting that there may be super-transmission events in NCIP transmission, and the entire range of interpersonal transmission capabilities of NCIP remains unknown [8-9]. In addition to the fragility of medical institutions in the face of the new coronavirus epidemic, the risk of infection complications among hospital populations is also greatly increased [10-11]. What we need to do now is to continue to strengthen prevention and control measures, actively strengthen patient admission, diagnosis, and treatment.

Our results showed the following epidemiological characteristics related to NCIP:

1) The overall epidemic of NCIP is similar to that of 2003-SARS, but the total number of confirmed cases is higher than that of 2003-SARS. The fatality rate is significantly lower than that of 2003-SARS in the same period, and the cure rate is significantly higher than that of 2003-SARS, which suggests that the prognosis for NCIP is good.

2) The age of NCIP patients is mainly concentrated in the 30-50 years old (68.29%), and the male are more susceptible than the female (M: F 1.35: 1). This may be related to the fact that the adults at this age group are more active in social activities than other age groups.

3) The results showed that that the fatality rate of NCIP in Wuhan (1.52% -6.64%) was significantly higher than that in other regions (0%-2.64%). Most of the confirmed cases in Wuhan were the First-generation infections, and the other regions may exist more secondary cases. The information above provided evidence that the harm of the first-generation NCIP cases is significantly higher than that of secondary cases (including second- and third-generation cases).

Acknowledgments

The present study was funded by Research Project from Health Commission of Shaanxi Provincial Government (2018A017), Research Project from Education Department of Shaanxi Provincial Government (19JS015), Subject Innovation Team of Shaanxi University of Chinese Medicine (132041933).

Competing interests

The authors declare that they have no competing interests.

Author contributions

R. Z. and X. L. planned the study.

R. Z., H. L., F. L. B. Z., Q. L. and L. L. performed the data analysis, wrote and modified the manuscript.

R. Z. submitted the study.

Figure legends:

Figure 1. Epidemic trends of NCIP and 2003-SARS

Figure 2. Comparison of incidence characteristics between NCIP and 2003-SARS (Days for NCIP were January 10th from 28th, 2020; Days for 2003-SARS were March 26th from April 13th, 2003)

Figure 3. Comparison of trends in confirmed cases and fatality rate of NCIP between Wuhan and regions except Wuhan (not include the data of Hongkong, Macao, and Taiwan)

Figure 4. The source of 287 confirmed NCIP patients

Figure 5. Population pyramid plot of 287 confirmed NCIP patients

Figure 6. Contact history of 287 confirmed NCIP patients

Figure 7. Epidemic Models of NCIP confirmed cases

Figure 8. The main process of NCIP in China

Table legends:

Table 1. Characteristics of age distribution of 287 NCIP patients n(%)

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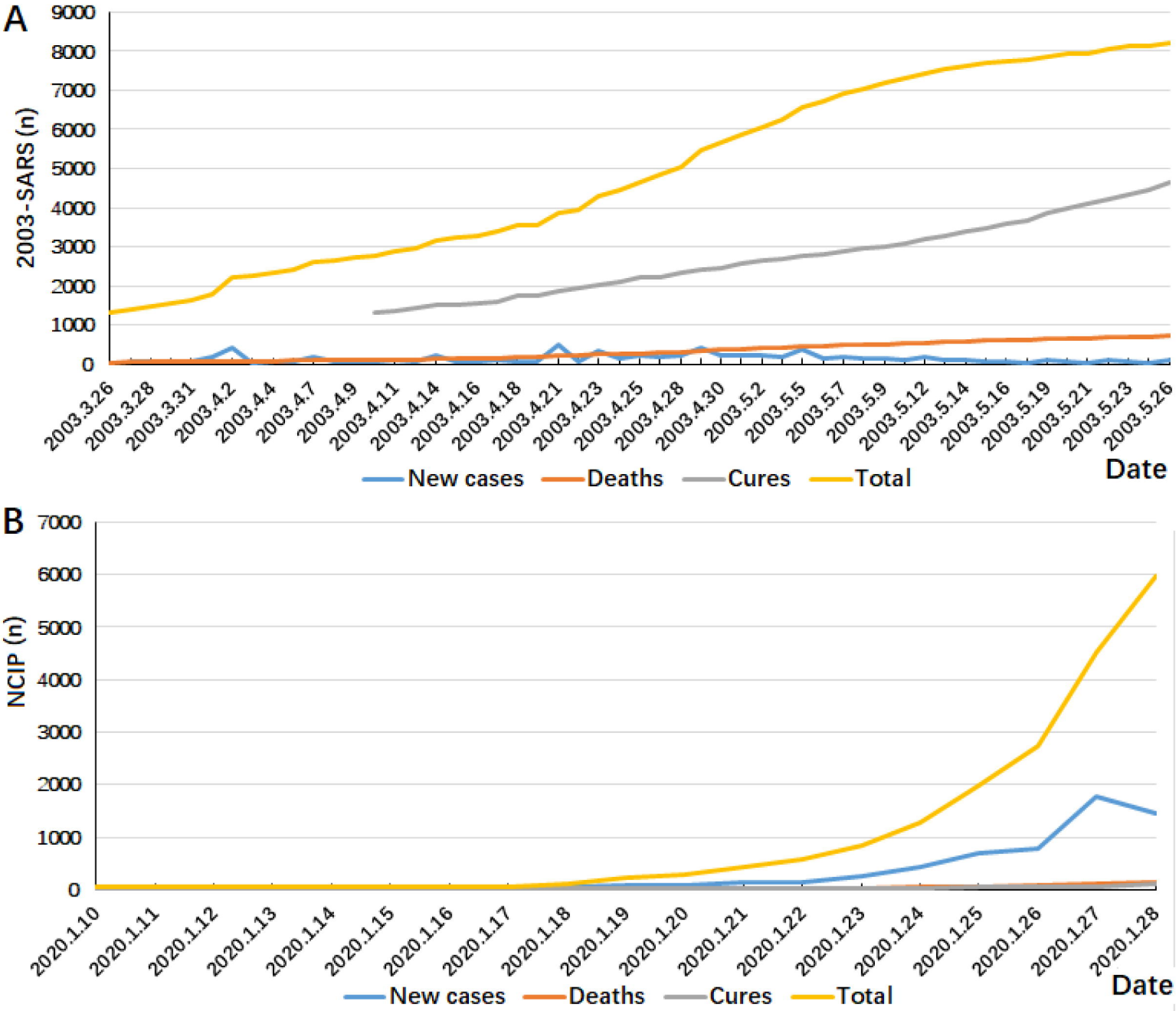
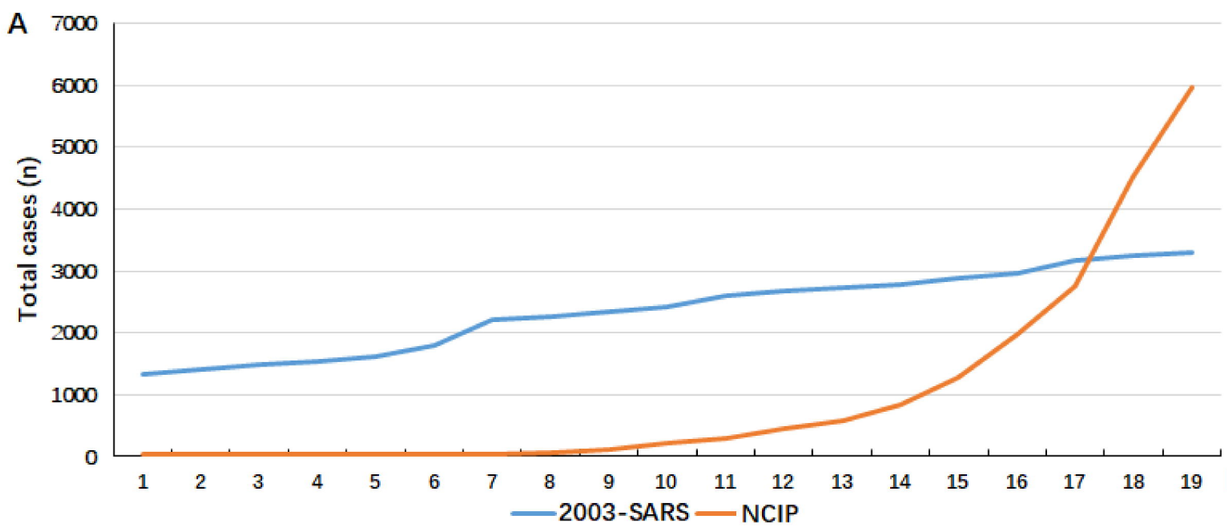
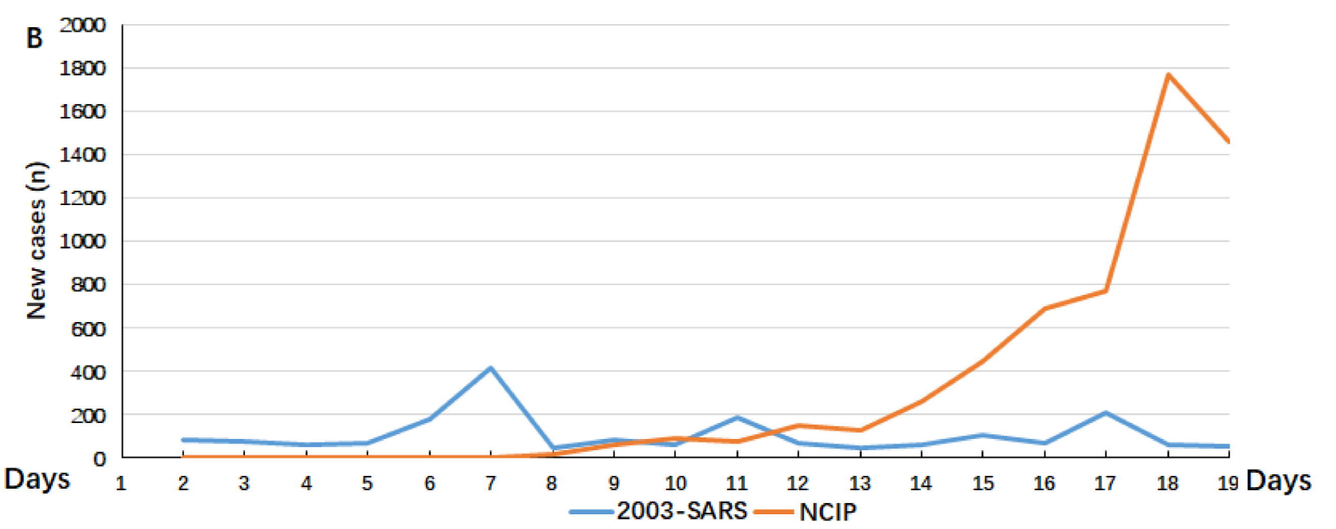
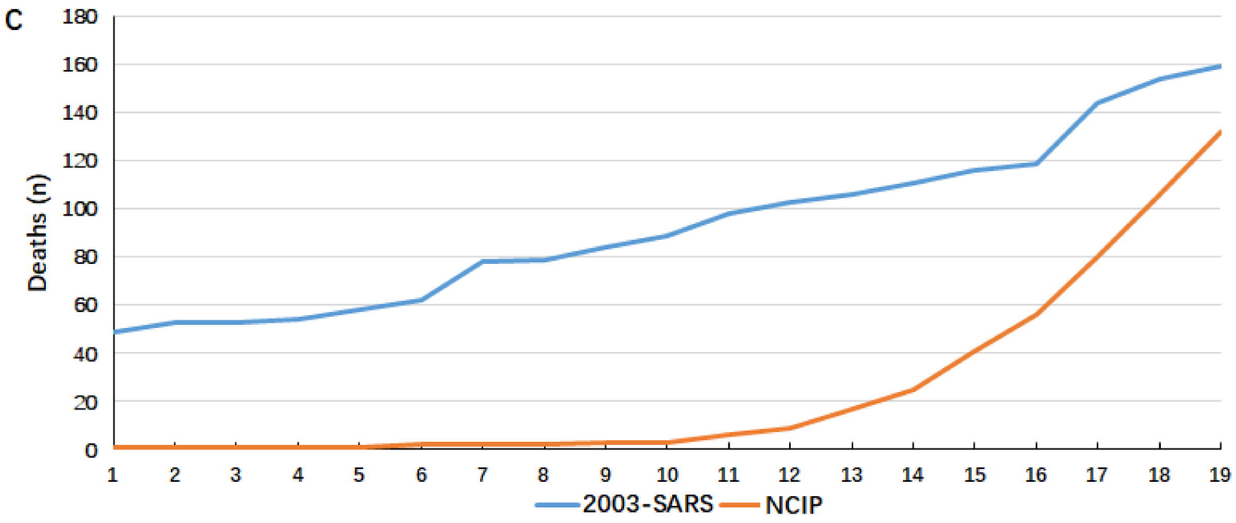
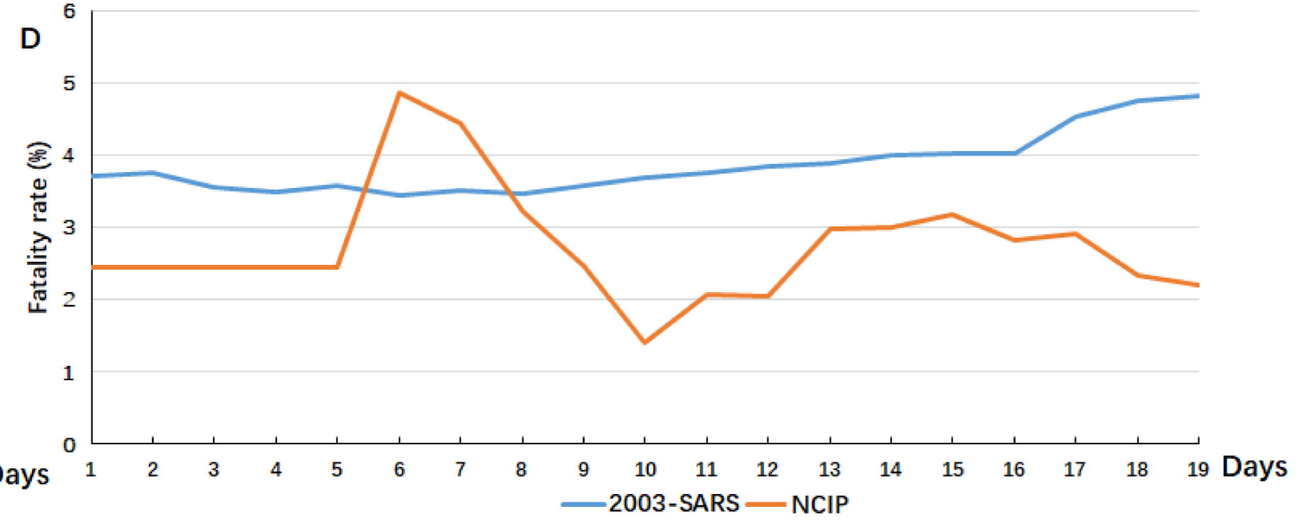
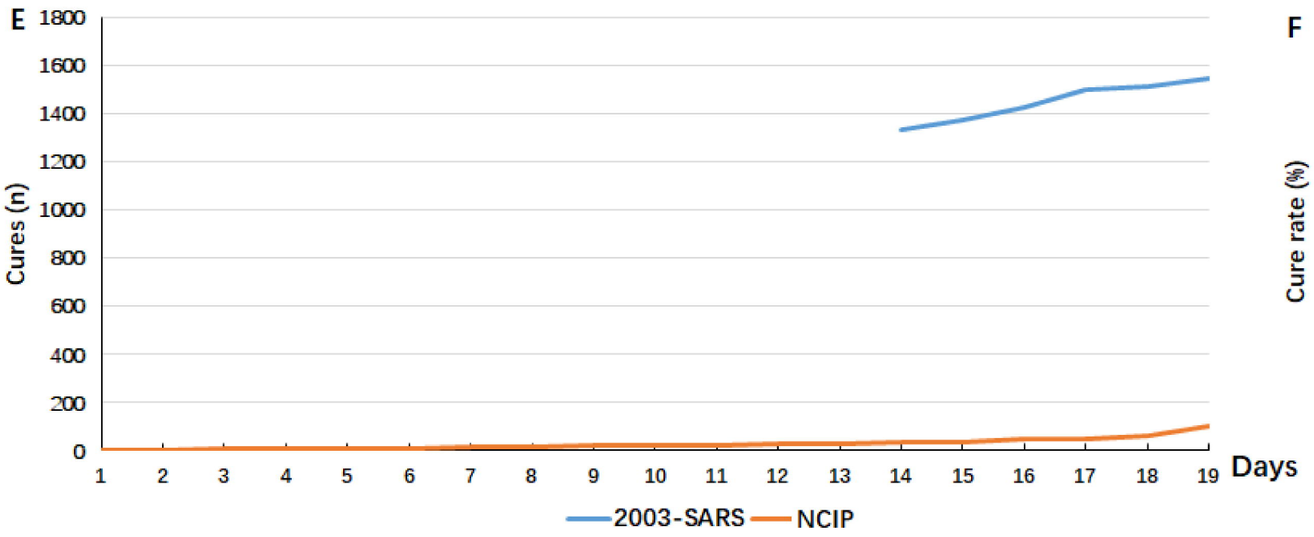

A
2003-SARS (n)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2003.3.26
2003.3.28
2003.3.31
2003.4.2
2003.4.4
2003.4.7
2003.4.9
2003.4.11
2003.4.14
2003.4.16
2003.4.18
2003.4.21
2003.4.23
2003.4.25
2003.4.28
2003.4.30
2003.5.2
2003.5.5
2003.5.7
2003.5.9
2003.5.12
2003.5.14
2003.5.16
2003.5.19
2003.5.21
2003.5.23
2003.5.26
Date
New cases
Deaths
Cures
Total
B
NCIP (n)
7000
6000
5000
4000
3000
2000
1000
0
2020.1.10
2020.1.11
2020.1.12
2020.1.13
2020.1.14
2020.1.15
2020.1.16
2020.1.17
2020.1.18
2020.1.19
2020.1.20
2020.1.21
2020.1.22
2020.1.23
2020.1.24
2020.1.25
2020.1.26
2020.1.27
2020.1.28
Date
New cases
Deaths
Cures
Total

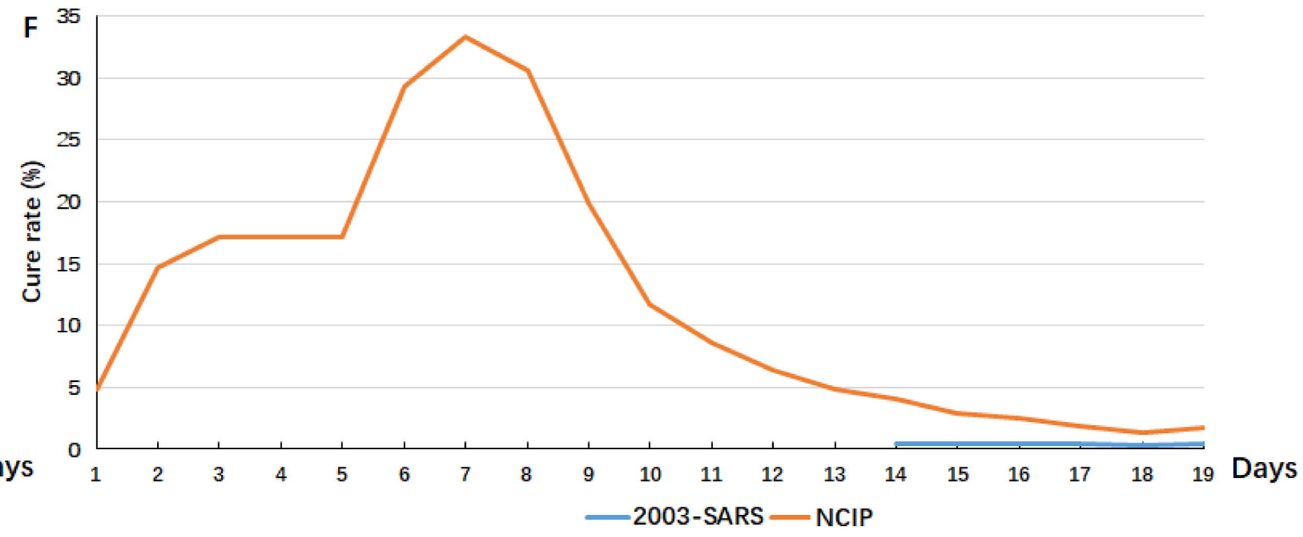

A
Total cases (n)
7000
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Days
2003-SARS
NCIP

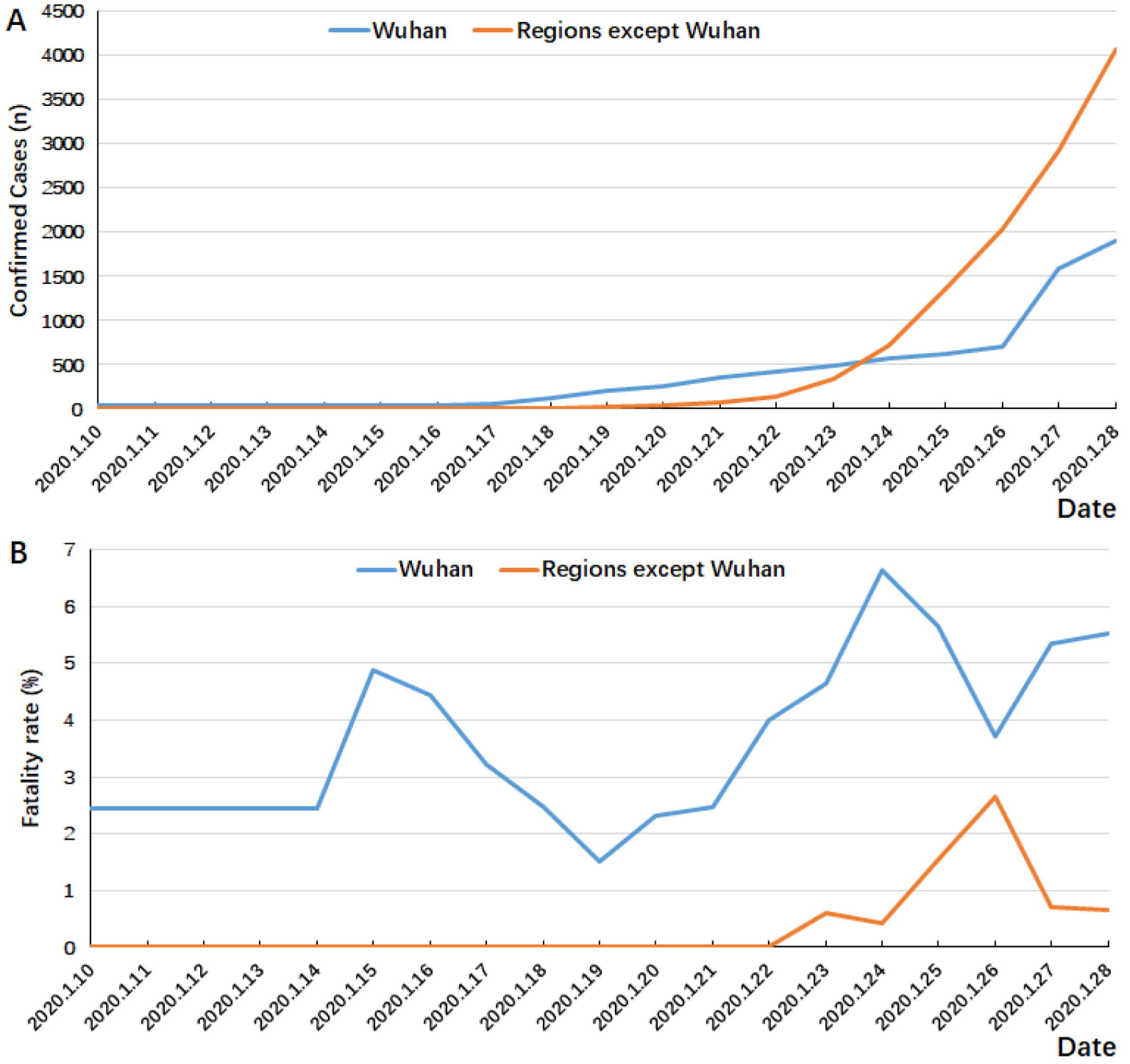

B
New cases (n)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Days
2003-SARS
NCIP

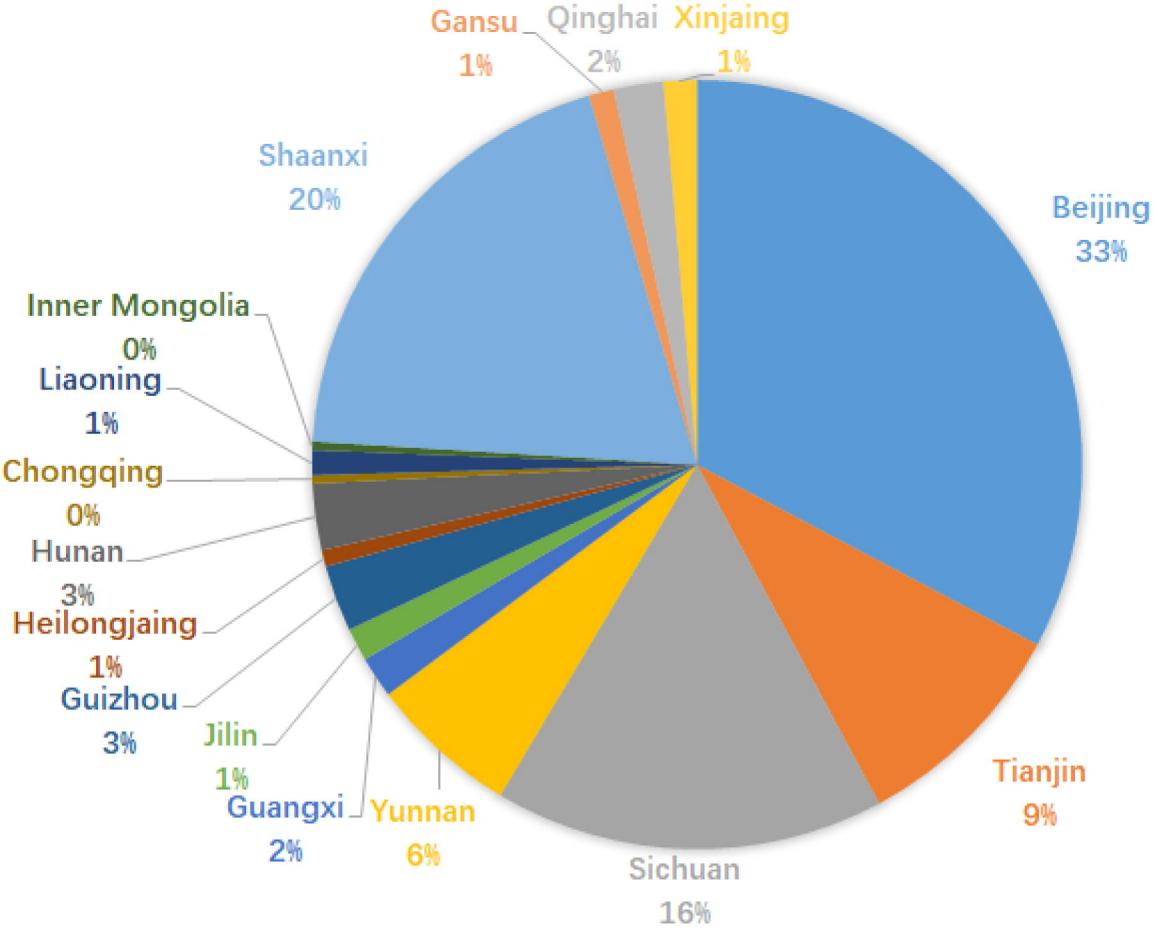

C
Deaths (n)
180
160
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Days
2003-SARS
NCIP

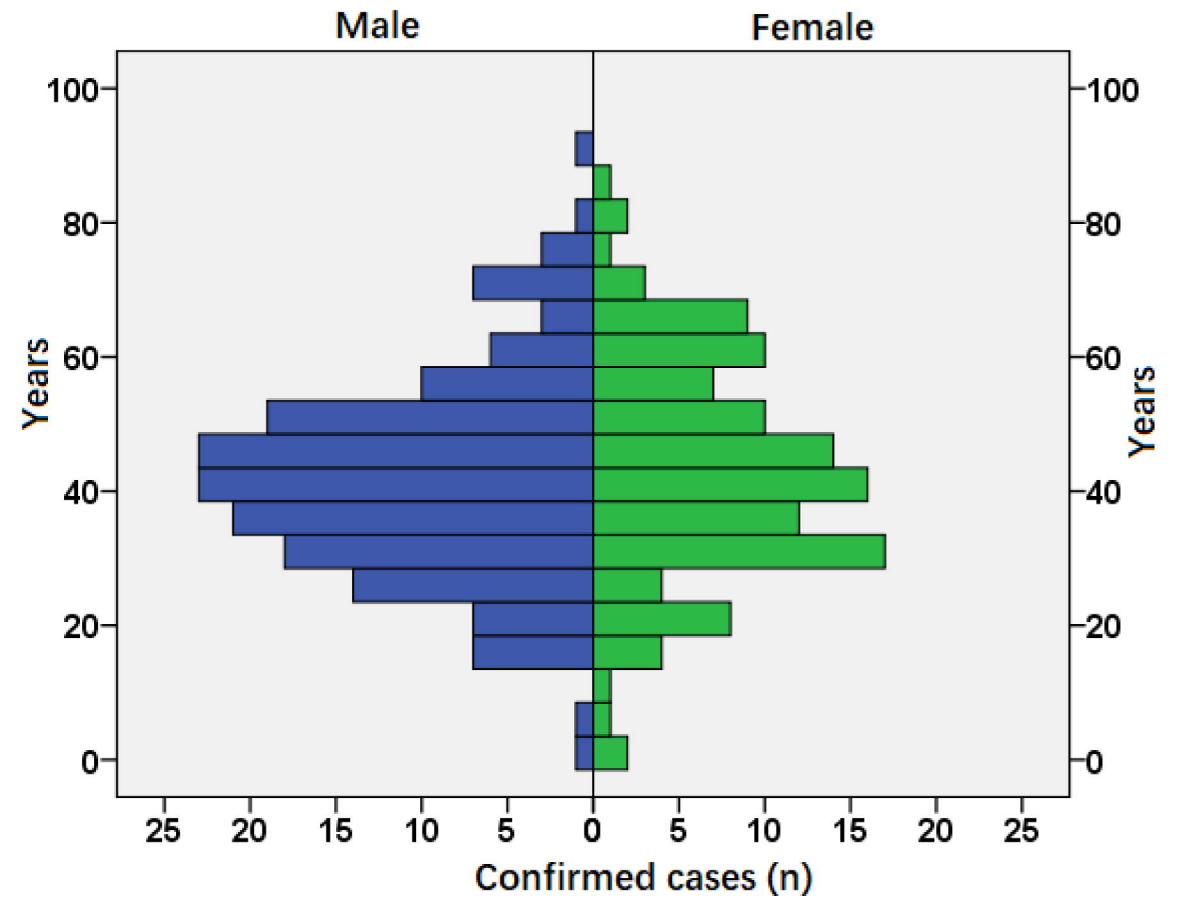

D
Fatality rate (%)
6
5
4
3
2
1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Days
2003-SARS
NCIP

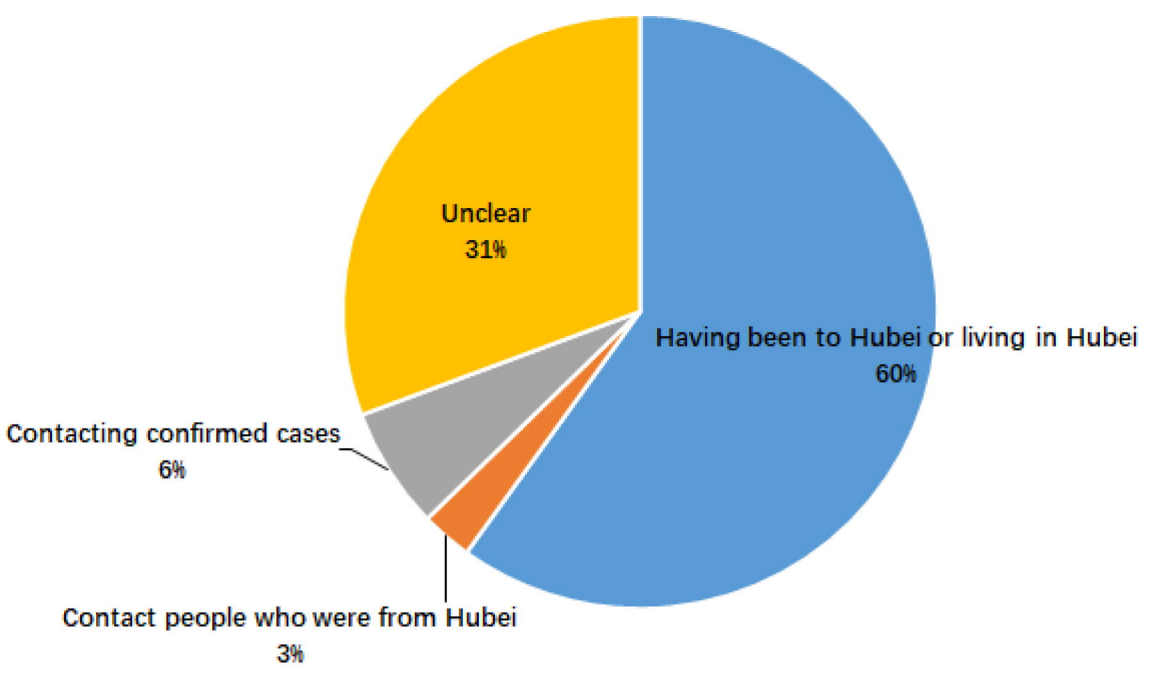

E
Cures (n)
1800
1600
1400
1200
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Days
2003-SARS
NCIP

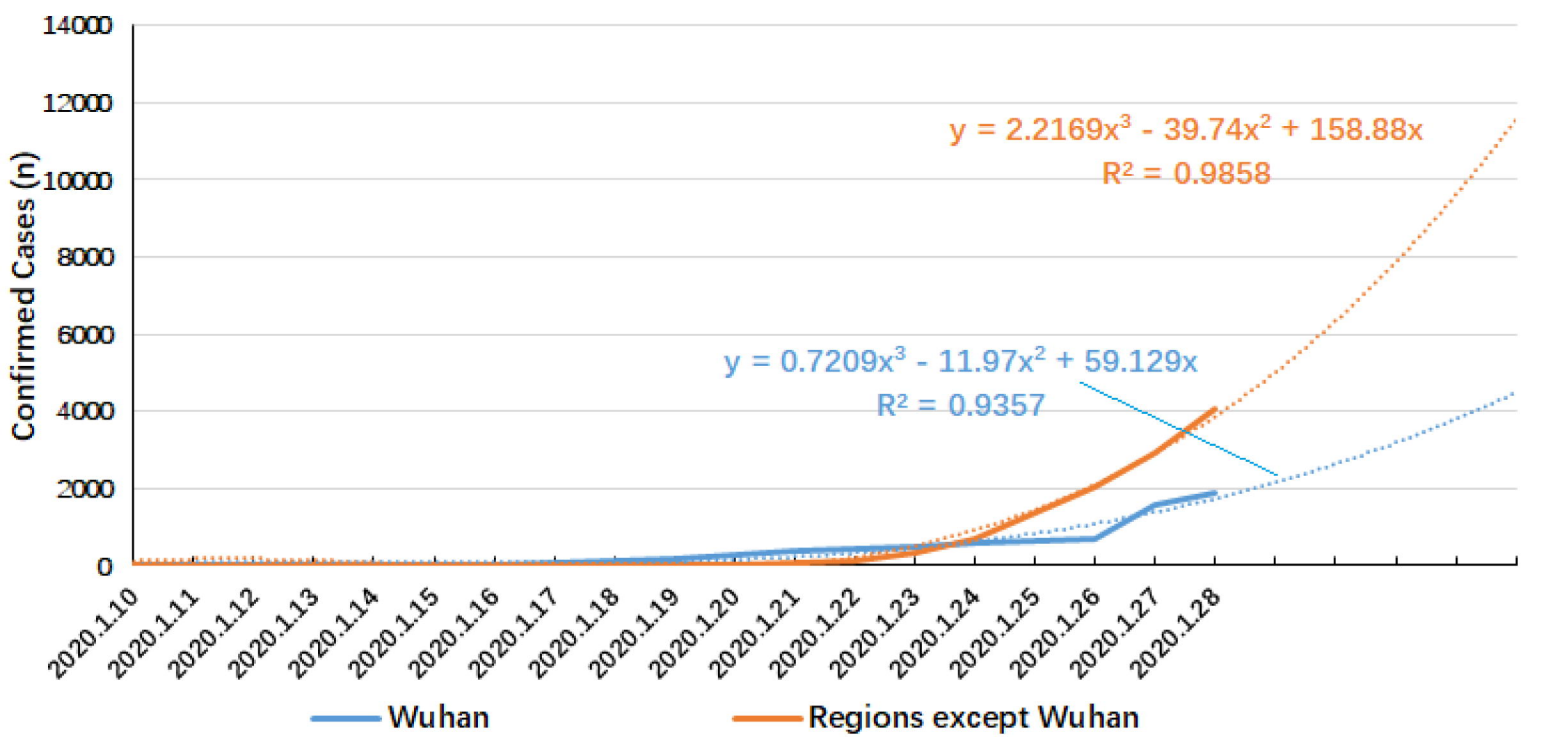

F
Cure rate (%)
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Days
2003-SARS
NCIP


A
Wuhan
Regions except Wuhan
Confirmed Cases (n)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2020.1.10
2020.1.11
2020.1.12
2020.1.13
2020.1.14
2020.1.15
2020.1.16
2020.1.17
2020.1.18
2020.1.19
2020.1.20
2020.1.21
2020.1.22
2020.1.23
2020.1.24
2020.1.25
2020.1.26
2020.1.27
2020.1.28
Date
B
Wuhan
Regions except Wuhan
Fatality rate (%)
7
6
5
4
3
2
1
0
2020.1.10
2020.1.11
2020.1.12
2020.1.13
2020.1.14
2020.1.15
2020.1.16
2020.1.17
2020.1.18
2020.1.19
2020.1.20
2020.1.21
2020.1.22
2020.1.23
2020.1.24
2020.1.25
2020.1.26
2020.1.27
2020.1.28
Date


Gansu
1%
Qinghai
2%
Xinjaing
1%
Shaanxi
20%
Beijing
33%
Inner Mongolia
0%
Liaoning
1%
Chongqing
0%
Hunan
3%
Heilongjaing
1%
Guizhou
3%
Jilin
1%
Guangxi
2%
Yunnan
6%
Tianjin
9%
Sichuan
16%


Male
Female
Years
Years
100
80
60
40
20
0
25
20
15
10
5
0
5
10
15
20
25
Confirmed cases (n)


Unclear
31%
Having been to Hubei or living in Hubei
60%
Contacting confirmed cases
6%
Contact people who were from Hubei
3%


14000
12000
10000
8000
6000
4000
2000
0
Confirmed Cases (n)
y = 2.2169x3 - 39.74x2 + 158.88x
R2 = 0.9858
y = 0.7209x3 - 11.97x2 + 59.129x
R2 = 0.9357
2020.1.10
2020.1.11
2020.1.12
2020.1.13
2020.1.14
2020.1.15
2020.1.16
2020.1.17
2020.1.18
2020.1.19
2020.1.20
2020.1.21
2020.1.22
2020.1.23
2020.1.24
2020.1.25
2020.1.26
2020.1.27
2020.1.28
Wuhan
Regions except Wuhan

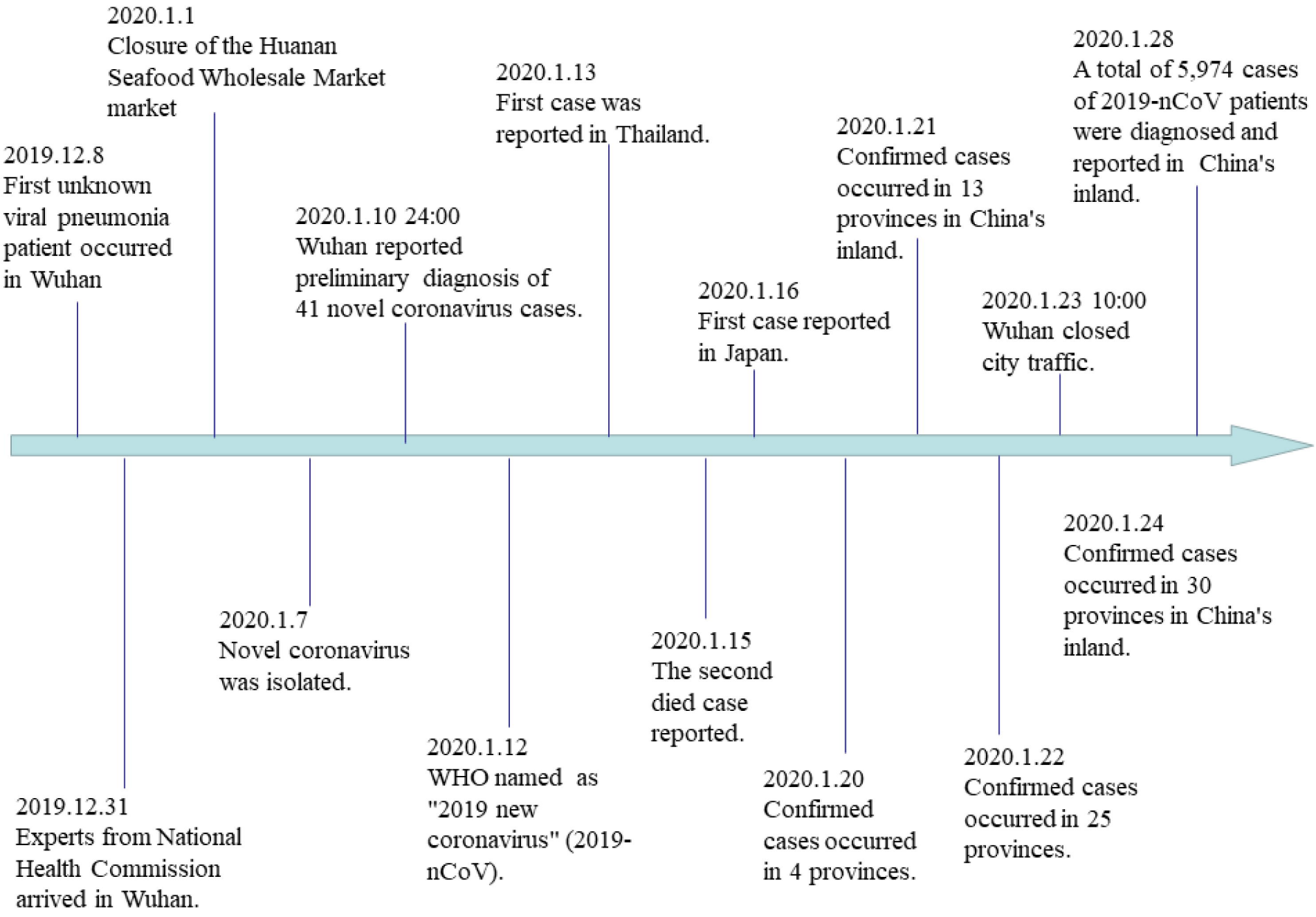

2019.12.8
First unknown viral pneumonia patient occurred in Wuhan
2020.1.1
Closure of the Huanan Seafood Wholesale Market market
2019.12.31
Experts from National Health Commission arrived in Wuhan.
2020.1.7
Novel coronavirus was isolated.
2020.1.10 24:00
Wuhan reported preliminary diagnosis of 41 novel coronavirus cases.
2020.1.12
WHO named as "2019 new coronavirus" (2019-nCoV).
2020.1.13
First case was reported in Thailand.
2020.1.15
The second died case reported.
2020.1.16
First case reported in Japan.
2020.1.20
Confirmed cases occurred in 4 provinces.
2020.1.21
Confirmed cases occurred in 13 provinces in China's inland.
2020.1.22
Confirmed cases occurred in 25 provinces.
2020.1.23 10:00
Wuhan closed city traffic.
2020.1.24
Confirmed cases occurred in 30 provinces in China's inland.
2020.1.28
A total of 5,974 cases of 2019-nCoV patients were diagnosed and reported in China's inland.

Table 1. Characteristics of age distribution of 287 2019-nCoV patients n(%)

Age group (Y)	Male	Female	Total
0-	2(33.33)	4(66.67)	6
10-	9(52.94)	8(47.06)	17
20-	22(68.75)	10(31.25)	32
30-	39(57.35)	29(42.65)	68
40-	52(63.41)	30(36.59)	82
50-	21(53.85)	18(46.15)	39
60-	10(37.04)	17(62.96)	27
70-	8(61.54)	5(38.46)	13
80-	1(50.00)	1(50.00)	2
90-	1(100.00)	0(0.00)	1