Characteristics and evaluation of the effectiveness of monitoring and control measures for the first 69 Patients with COVID-19 from 18 January 2020 to 2 March in Wuxi, China

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Research

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Abstract

Background: The novel coronavirus disease 2019(COVID-19) outbreak and has caused has caused 82,830 confirmed cases and 4,633 deaths in China by 26 April 2020. We analyzed data on 69 infections in Wuxi to describe the epidemiologic characteristics and evaluate the control measures.

Methods: The demographic characteristics, exposure history, and illness timelines of COVID-19 cases in Wuxi were collected.

Results: Among the 69 positive infections with COVID-19, mild and normal types accounted for 75.36% (52/69), adolescents and children are mainly mild and asymptomatic. The basic reproductive number was estimated to be 1.12 (95% CI, 0.71 to 1.69). The mean incubation period was estimated to be 4.77 days (95% CI, 3.61 to 5.94), with a mean serial interval of 6.31 days (95%CI, 5.12 to 7.50). We also found that age (RR=1.57, 95%CI: 1.11-2.21) and fever (RR=4.09, 95%CI: 1.10-15.19) were risk factors for COVID-19 disease severity.

Conclusions: The incidence of COVID-19 in Wuxi has turned into a lower level, suggesting that the early prevention and control measures have achieved effectiveness. The community transmission can be effectively prevented through isolation and virus detection of all the people who were exposed together and close contact with the infected people. Aging and fever are risk factors for clinical outcome, which might be useful for preventing severe transition.

Introduction

The Corona Virus Disease 2019 (COVID-19) was first reported in December 2019 in Wuhan, China, and now has spread globally, resulting in more than 2.7 million confirmed COVID-19 cases worldwide by April 26, 2020 [1]. The Chinese government revised the law provisions concerning infectious diseases to add the COVID-19 on January 20 and closed the city of Wuhan on January 23. Simultaneously, containment measures, including solation and quarantine of patients, active monitoring of contacts, border controls, and community education and precautions, were performed in Wuxi to minimize the disease spread. The epidemic situation of Wuxi decreased significantly through such a series of measures after a longest incubation period. We have known that COVID-19 is transmitted by respiratory droplets and close contacts [2–4], but the indirect contact transmission route is not clear. Our current understanding of the incubation period for COVID-19 is also limited. Therefore, we aim to analyze the characteristics of the disease and dynamically assess the infectivity of the COVID-19 virus in Wuxi, and as well as the effectiveness of prevention and control measures.

Materials And Methods

Sources of data

According to the updated version (version5) of COVID-19 prevention and control program published by China's National Health Commission, when a medical institution finds a suspected case, a confirmed case or an asymptomatic infected person of COVID-19, it should immediately report the case directly in China Information System for Disease Control and Prevention. Then medical institutions timely revised the information of case classification and clinical severity according to laboratory test results, disease progression.

Once a suspected case was identified and reported, the joint field epidemiology team comprising members from Wuxi Center for Disease Control and Prevention (Wuxi CDC) together with prefecture CDCs would be informed to initiate detailed field investigations and collect respiratory specimens for centralized testing at the laboratory of Wuxi CDC. A joint team conducted detailed field investigations for all suspected and confirmed COVID-19 cases in 24 hours.

Epidemiologic data were collected through interviews and field reports. Data were collected onto standardized forms through interviews of infected persons, relatives, close contacts, and health care workers. Investigators interviewed each patient with infection and their relatives, where necessary, to determine exposure histories during the 2 weeks before the illness onset, including the dates, times, frequency, and patterns of exposures to Wuhan and surrounding areas and any fever or respiratory symptoms from Wuhan and surrounding areas. All epidemiologic information collected during field investigations, including exposure history, timelines of events, and close contact identification.

Related definitions

The case definitions according to the updated version (version 7) of COVID-19 diagnosis and treatment program published by China's National Health Commission. (1) A suspected COVID-19 case was defined as a pneumonia that either fulfilled all the following three criteria -fever, with or without recorded temperature; radiographic evidence of pneumonia; low or normal white-cell count or low lymphocyte count, following standard clinical guidelines or fulfilled the above mentioned two criteria and had an epidemiologic history. The epidemiologic four criteria were the following: a travel or residence history to Wuhan and surrounding areas or other communities with reported cases within 14 days before illness onset; a history of exposure to COVID-19 infection; direct contact with patients from Wuhan and surrounding areas who had fever or respiratory symptoms. (2) A confirmed case was defined as a case with respiratory specimens that tested positive for the COVID-19 virus by at least one of the following three methods: isolation of COVID-19 virus or at least two positive results by real-time reverse-transcription–polymerase chain-reaction (RT-PCR) assay for COVID-19 virus or a genetic sequence that matches COVID-19 virus. (3) Asymptomatic infection was referred to those who had no clinical symptoms, respiratory tract and other specimens positive in the detection of COVID-19 virus. It was mainly found by means of cluster epidemic investigation and infection source tracking investigation. Cluster outbreak referred to the detection of 2 or more confirmed cases or asymptomatic infection within 14 days in a small area (such as a family, a construction site, a unit, etc.), and the possibility of human-to-human transmission caused by close contact, or the possibility of infection caused by joint exposure.

Close contacts referred to persons who had not effective protection and had close contact (within 1 meter) with suspected and confirmed cases from 2 days before symptom onset or 2 days before sampling of samples of asymptomatic infected persons. Close contacts of the cases were monitored in intensive

isolation for 14 days, and nasopharyngeal swabs and serum samples were collected for testing on the first day of observation and on the day before the released or when any symptoms of discomfort not limited to the respiratory system. At the same time, we also performed CT tests on close contacts.

Clinical subtypes included asymptomatic infection, mild-type (clinical symptoms are mild and no pneumonia on imaging), normal-type (with fever, respiratory tract and other symptoms, imaging evidence of pneumonia), severe-type (ie, dyspnea, respiratory frequency 30/min, blood oxygen saturation 93%, partial pressure of arterial oxygen to fraction of inspired oxygen ratio <300, and/or lung infiltrates >50% within 24 to 48 hours) and critical-type (ie, respiratory failure, septic shock, and/or multiple organ dysfunction or failure).

Laboratory testing

The medical institution that accepts and treats the case should collect relevant clinical specimens in time, including upper respiratory tract specimens (e.g. nasopharyngeal swabs, pharyngeal swabs, etc.), lower respiratory tract specimens (e.g. deep cough sputum, alveolar lavage fluid, bronchial lavage fluid, respiratory tract aspiration, etc.), fecal/anal swabs, anticoagulant and serum specimens, etc. The samples were sent to the virus laboratory of Wuxi CDC for testing as soon as possible. The positive results were reviewed by Jiangsu provincial CDC.

MagNa Pure 96 DNA and Viral NA Small Volume Kit (Roche) was used to extract viral nucleic acid. The real-time fluorescent quantitative reverse transcription polymerase chain reaction (Real time RT-PCR method, Real time PCR instrument, Light Cycler 480) was applied to identifythe virus. The Novel Coronavirus was detected using the 2019 Novel Coronav sen University.

Statistical analysis

The epidemic curve was constructed by date of illness onset, and key dates relating to epidemic identification and control measures were overlaid to aid interpretation. Case characteristics were described, including demographic characteristics, exposures. The incubation period distribution (i.e., the time delay from infection to illness onset) was estimated by fitting a log-normal distribution to data on exposure histories and onset dates in a subset of cases with detailed information available. Onset-first-medical visit and onset-to-admission distributions were estimated by fitting a Weibull distribution on the dates of illness onset, first medical visit, and hospital admission in a subset of cases with detailed information available. We fitted a gamma distribution to data from cluster investigations to estimate the serial interval distribution, defined as the delay between illness onset dates in successive cases in chains of transmission.

The basic reproductive number (R_0), which is defined as the expected number of additional cases that one case will generate, on average, over the course of its infectious period in an otherwise uninfected population. We used an informative prior distribution for the serial interval based on the serial interval of SARS with a mean of 8.4 and a standard deviation of 3.8. We use the Exponential Growth (EG) model to calculate R_0. Analyses of the incubation period, serial interval and R_0 were performed with the use of R software (R Foundation for Statistical Computing).

Results

General characteristics

We identified suspected patients through enhancing surveillance among the fever clinics and collected their nasopharyngeal swabs for testing the COVID-19 virus. From January 18 to March 2, a total of 9023 nasopharyngeal swabs from suspected patients were sent to Wuxi CDC laboratory, 26 (0.29%) patients were detected COVID-19 virus positive. While screening suspected patients, we also quarantined and tested close contacts of the confirmed cases. Through testing 1326 close contacts, we detected 43 (62.32%) positive infections. All the total of 69 confirmed COVID-19 virus infections were reported from Jan 18, 2020 to Mar 2, 2020 in Wuxi city.

The median age of the patients was 45 years (range from 7 to 86), and 50.72% patients (35/69) were male. The age group was mainly between 20 and 60 years old, accounting for 66.67% of the total cases. 4.35% cases were aged 9 years or younger, 10.14% were aged 10 to 19 years, and 10.14% were age 70 years or older.

Among the 69 infected patients, mild and normal types accounted for 75.36% (52/69) and asymptomatic infections accounted for 14.49% (10/69). 46 (66.67%) cases were imported cases, of which 24 cases were from Hubei and 22 cases from other regions outside Hubei. The general characteristics of imported cases and locally transmitted secondary cases were shown in Table 1.

Date of symptoms onset

The prevalence curve of 59 patients (except 10 cases of asymptomatic infection) was shown in Figure 1, which also showed the implementation time of several specific interventions. On January 23, Wuhan sealed the city, and on January 25, Wuxi responded with a first-level response. After a maximum incubation period, the number of cases decreased significantly. As of March 2, the onset of the last case was February 9.

From January 18 to March 2, most of our early cases returned to Wuxi from Wuhan before the city was closed. In the middle to late period, our city began to discover cases from other provinces outside Hubei and other areas in our province. Our first local imported case came back from Wuhan on January 15 (Wuhan closed on January 23), and it developed on January 18. Our last imported case came back from Anhui province and became ill on February 9 (Fig. 1).

Days from exposure to symptom onset, onset to first medical visit and diagnosis

We examined data on exposures among 46 confirmed cases who had the last exposure time, and we estimated the mean incubation period to be 4.77 days (95% confidence interval [CI],3.61 to 5.94); the 95th percentile of the distribution was 12 days, 95%CI (10.09, 13.91) (Fig. 2A). We obtained information on 8 clusters of cases, shown in Figure 3. On the basis of the dates of illness onset of 14 pairs of cases in these clusters, we estimated that the serial interval distribution had a mean (±SD) of 6.31(±3.88) days (95% CI, 5.12 to 7.50) (Fig. 2B). The duration from illness onset to first medical visit for 52 patients was estimated to have a mean of 3.47 days (95% CI, 2.68 to 4.26) (Fig. 2C). The mean duration from onset to hospital admission was estimated to be 4.43 days (95% CI, 3.45 to 5.40) among 51 cases with illness (Fig. 2D). Of the 69 infections, 12 had a unique history of exposure, and 3 were asymptomatic at discharge, so we analyzed 9 of them and estimated another mean incubation period of 8.59 days (95% confidence interval [CI], 7.56-9.62) (Fig. 2E).

Multi-factors analysis of cases clinical outcome

In the study of 59 symptomatic patients, the most common symptoms were fever (66.10 %), cough (dry cough or expectoration) (49.15%), fatigue (15.25 %), headache (13.56 %), muscle aches (11.86 %), sore throat (10.17 %), and diarrhea (6.78%). Thirty-six percent (21/59) of the patients had underlying diseases, including diabetes (9 patients), hypertension (11 patients), and cardiovascular disease (4 patients). We divided the infected patients into the non-pneumonia group (asymptomatic and mild) and the pneumonia group (common, severe and critical), and found that older people (RR=1.57, 95%CI: 1.11-2.21) and fever (RR=4.09, 95%CI: 1.10-15.19) were risk factors for disease severity (Fig. 3).

Discussion

The prevention and control strategy of “external defense input and internal non-proliferation” was adopted in Wuxi on 25 January 2020. Since Wuhan was closed on January 23, after a maximum incubation period of 14 days, the number of cases has decreased significantly, proving that the blockade of Wuhan was effective [1,2]. COVID-19 was susceptible to infection in all age groups, and we also found that most (80%) of the 10 cases under 20 years of age were mild and asymptomatic, whereas our critical cases were all over 60 years old [5]. Analysis of the risk factors of clinical outcomes of cases also confirmed that high age and fever were prone to cause pneumonia and severe illness.

Here we provided an initial assessment of the transmission dynamics of COVID-19 to prove the effectiveness of our prevention and control measures. In our study, the mean time of the serial interval distribution (6.31 day) were similar to 7.5 day [6]. The delays between the onset of illness and seeking medical attention were generally shorter than that of Wuhan, with 65% of patients seeking attention within 1 day after onset, and the delays to hospitalization were 50% of patients being hospitalized until at least day 3 of illness, which indicated that our measures of early detection of cases and asymptomatic infections through close screening are effective. A case enters the susceptible population. Under ideal conditions, the number of second-generation cases that can be infected is the reproduction number R_0. From January 18th to February 9th, the Exponential Growth (EG) value of R_0 value was 1.12, meaning that each patient could spread infection to 1.12 other people on average, which was lower than a set of previously published estimates, ranging from 2.2 (95% CI, 1.4 to 3.9) to 3.58 (95%CI: 2.89-4.39) [6-8]. In general, an epidemic will increase as long as R_0 is greater than 1, and control measures aim to reduce the reproductive number to less than 1. In our study, we calculated two incubation periods. The first infection used the last exposure date, and although the result of mean incubation period 4.77 days was similar to other studies of 5.2 days and 5.1 days [6,9], we thought it was underestimated. We also selected 9 patients infected after single exposure and calculated the mean incubation period to be significantly higher than that of the former, which might be more accurate. Since we had few cases, this result would provide a clue for future research.

In conclusion, our data of epidemiological dynamics supported the effectiveness of prevention and control measures. After epidemiological investigation, we isolated and tested all the people who were exposed together and close contact with the infected people, which can effectively prevent community transmission. Our study of family clusters provided further clues to the path of COVID-19 transmission, such as single-exposure meals in families, playing cards in confined spaces, and eating and living together in families. At the same time, we found that the third-generation cases had a higher proportion of mild or asymptomatic cases. To reduce panic and economic loss, and to manage and save the infected, much remains to be done. The goal is to break the transmission chain of COVID-19.

Conclusions

The COVID-19 epidemic in Wuxi city was mainly imported cases. The cases were mainly 20-60 years old, mostly mild and normal, and 14.49% of asymptomatic infections. We found that aging and fever of initial symptom are risk factors for severe clinical outcome. Our study of family clusters provided further clues of the risk factors for COVID-19 transmission. Our data of epidemiological dynamics also supported the effectiveness of prevention and control measures. Our two results of incubation period were useful for current proposals of the length of quarantine, although longer monitoring periods might be justified.

Declarations

Acknowledgements

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Authors’ contributions

PS and YMG analyzed the data and wrote the manuscript. YS, EPC and JL conducted field investigation and data collection. HC and YJC conducted data analysis. YX was in charge of lab testing. CS and BL were the project coordinator, responsible for the project design and implementation, and supervised all

aspects of fieldwork, laboratory activities and data analysis. All authors approved the final version of the paper. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials

All datasets used and analyzed during the study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Data collection and analysis of cases and close contacts were determined by the National Health Commission of the People's Republic of China to be part of a continuing public health outbreak investigation and were thus considered exempt from institutional review board approval.

Consent for publication
Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Abbreviations

COVID-19: The novel coronavirus disease 2019; RT-PCR: Real-time reverse-transcription–polymerase chain-reaction; CI: Confidence interval; RR: Relative risk; CDC: Center for disease control and prevention; R_0: The basic reproductive number; EG: The Exponential Growth model; SD: Standard deviation; SIR: The secondary infection rate

References

1. Munster VJ, Koopmans M, van Doremalen N, van Riel D, de Wit E. A Novel Coronavirus Emerging in China - Key Questions for Impact Assessment. The New England journal of medicine 2020;382(8):692-4.
2. Liu J, Liao X, Qian S, Yuan J, Wang F, Liu Y, et al. Community Transmission of Severe Acute Respiratory Syndrome Coronavirus 2, Shenzhen, China, 2020. Emerging infectious diseases 2020;26(6).
3. Chan JF, Yuan S, Kok KH, To KK, Chu H, Yang J, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. Lancet (London, England) 2020;395(10223):514-23.
4. Burke RM, Midgley CM, Dratch A, Fenstersheib M, Haupt T, Holshue M, et al. Active Monitoring of Persons Exposed to Patients with Confirmed COVID-19 - United States, January-February 2020. MMWR Morbidity and mortality weekly report 2020;69(9):245-6.
5. Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72314 Cases From the Chinese Center for Disease Control and Prevention. Jama 2020.
6. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia. The New England journal of medicine 2020; 382(13): 1199-1207.
7. Tang B, Wang X, Li Q, Bragazzi NL, Tang S, Xiao Y, et al. Estimation of the Transmission Risk of the 2019-nCoV and Its Implication for Public Health Interventions. Journal of clinical medicine 2020;9(2).
8. Zhao S, Lin Q, Ran J, Musa SS, Yang G, Wang W, et al. Preliminary estimation of the basic reproduction number of novel coronavirus (2019-nCoV) in China, from 2019 to 2020: A data-driven analysis in the early phase of the outbreak. International journal of infectious diseases: IJID: official publication of the International Society for Infectious Diseases 2020; 92: 214-7.
9. Lauer SA, Grantz KH, Bi Q, Jones FK, Zheng Q, Meredith HR, et al. The Incubation Period of Coronavirus Disease 2019 (COVID-19) From Publicly Reported Confirmed Cases: Estimation and Application. Annals of internal medicine 2020.

Tables

Table 1. Characteristics of the patients with COVID-19 in Wuxi, China

General characteristics	Total cases n (%)	Imported cases n (%)	Secondary cases n (%)
Total	69	46	23
Sex			
Male	35(50.72%)	26(56.52%)	9(39.13%)
Female	34(49.28%)	20(43.48%)	14(60.87%)
Age group(year)			
0-	3(4.35%)	1(2.17%)	2(8.70%)
10-	7(10.14%)	7(15.22%)	0(0)
20-	9(13.04%)	8(17.39%)	1(4.35%)
30-	10(14.49%)	7(15.22%)	3(13.04%)
40-	10(14.49%)	7(15.22%)	3(13.04%)
50-	16(23.19%)	8(17.39%)	8(34.78%)
60-	7(10.14%)	4(8.70%)	3(13.04%)
70-	5(7.25%)	3(6.52%)	2(8.70%)
≥80	2(2.90%)	1(2.17%)	1(4.35%)
Exposure history			
Travel or residence history in Hubei	24(34.78%)	24(52.17%)	-
Travel or residence history in other regions except Hubei	22(31.88%)	22(47.83%)	-
Contact with other people with a history of travelling or residence history in Hubei or other regions	14(20.29%)	-	14(60.87%)
History of exposure to locally confirmed cases or asymptomatic infections	9(13.04%)	-	9(39.13%)
Underlying diseases			
Yes	27(39.13%)	15(32.61%)	12(52.17%)
No	42(60.87%)	31(67.39%)	11(47.83%)
Clinical severity*			
Asymptomatic	10(14.49%)	4(8.70%)	6(26.10%)
Mild	17(24.64%)	10(21.74%)	7(30.43%)
Normal	35(50.72%)	26(56.50%)	9(39.10%)
Severe	5(7.25%)	4(8.70%)	1(4.35%)
Critical	2(2.90%)	2(4.35%)	0(0)

*Patients were classified by their most severe status as of March 2, 2020. There may be cases where the composition ratio is not 1 due to rounding.

Table 2. Risk factors analysis of clinical outcome of the 59 infected patients

Factors	B	S.E.	Wald	df	Sig	Exp(B)	95%C.I. for Exp(B)	
							Lower	Upper
Sex	0.02	0.65	0.01	1	0.98	1.02	0.29	3.60
Age	0.45	0.17	6.62	1	0.01	1.57	1.11	2.21
Fever	1.41	0.67	4.44	1	0.04	4.09	1.10	15.19

Figures

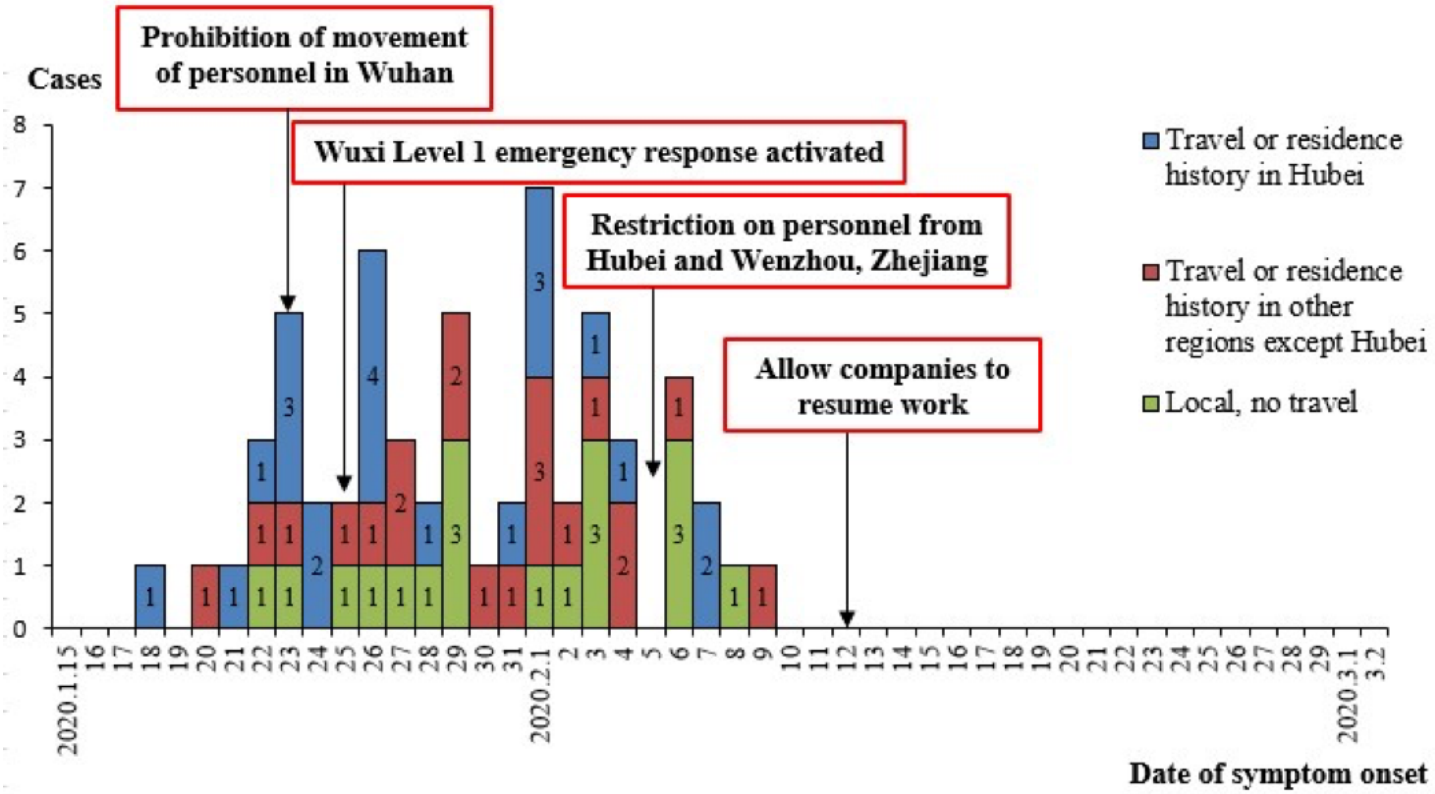


Figure 1

Onset of illness among the cases of COVID-19 in Wuxi, China

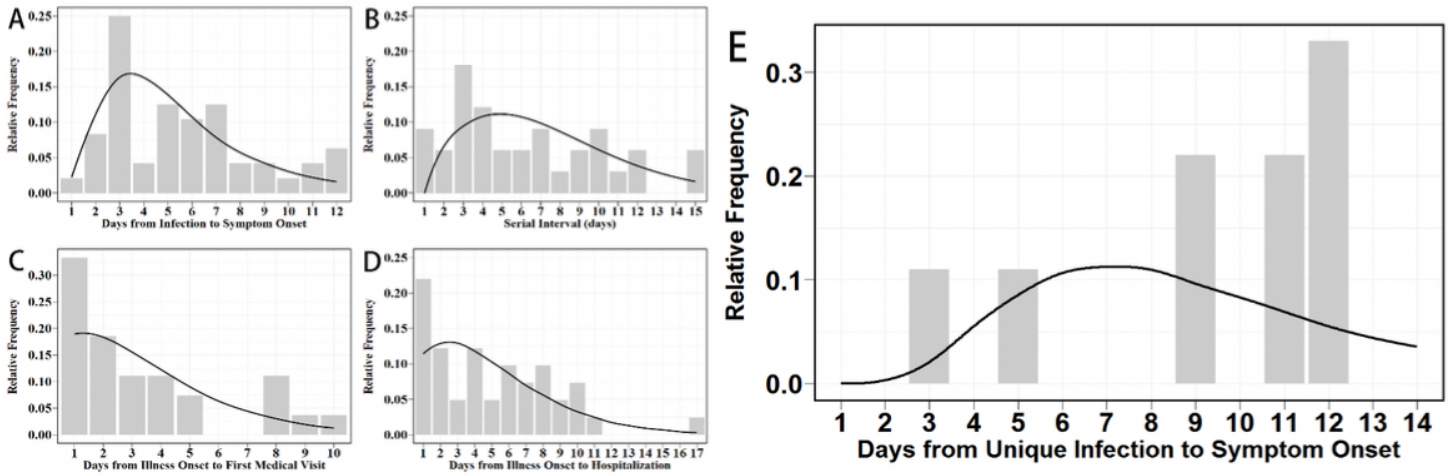
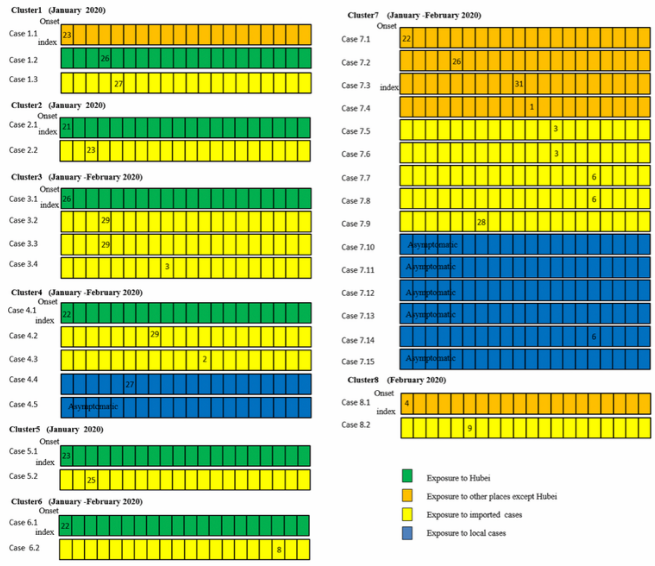


Figure 2

Key time-to-event distributions The estimated incubation period distribution (i.e., the time from infection to illness onset, the time infection defined as the latest exposure to epidemic areas or infectious persons) was shown in Panel A. The estimated serial interval distribution (i.e., the time from illness onset in successive cases in a transmission chain) was shown in Panel B. The estimated distribution of times from illness onset to first medical visit was shown in Panel C. The estimated distribution of times from illness onset to hospital admission was shown in Panel D. The estimated incubation period distribution (i.e., the time from unique infection to illness onset, the unique infection defined as once exposure to infectious persons) was shown in Panel E.



Data from the 8 Clusters Used in the Estimation of Serial Interval

Case	Serial Interval (days)
1.3	4
2.2	2
3.2	3
3.3	3
3.4	8
4.2	7
4.3	11
5.2	2
6.2	17
7.5	3
7.6	3
7.7	6
7.8	6
8.2	5

Figure 3

Detailed information on exposures and dates of illness onset in 8 clusters including 35 cases Numbers in boxes were calendar dates in January and February 2020. Data from the 14 secondary cases (patients who had clear exposure to only one index case and had no other potential source of infection) were used to estimate the serial interval distribution.