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Epidemiological Characteristics and Incubation Period of 7015 Confirmed Cases With Coronavirus Disease 2019 Outside Hubei Province in China

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Background. Disease caused by SARS-CoV-2 broke out in Wuhan in December 2019. We utilized confirmed cases outside Hubei Province to analyze epidemiologic characteristics and evaluate the effect of traffic restrictions implemented in Hubei beginning on 23 January 2020.

Methods. Information on 7015 confirmed cases from 19 January to 8 February 2020 in all provinces outside Hubei was collected from the national and local health commissions in China. Incubation period and interval times were calculated using dates of the following events: contact with an infected person, onset, first visit, and diagnosis. We evaluated changes in incubation period and interval times.

Results. The average age of all cases was 44.24 years. The median incubation period was 5 days and extended from 2 days on 23 January to 15 days on 8 February. The proportion of imported cases decreased from 85.71% to 33.19% after 23 January. In addition, lengths of intervals between onset and diagnosis, onset and first visit, and first visit and diagnosis decreased over time.

Conclusions. Rapidly transmitting COVID-19 has a short incubation period. The onset mainly occurred among young to middle-aged adults. Traffic restrictions played an important role in the decreased number of imported cases outside Hubei.

Keywords. SARS-CoV-2; coronavirus disease 2019; incubation period.

In December 2019, a cluster of pneumonia cases caused by novel coronavirus (SARS-CoV-2) was identified in Wuhan of Hubei Province, China's central transportation hub [1]. The viral data were rapidly determined by high-throughput sequencing on 7 January and it was identified as having homology with human severe acute respiratory syndrome (SARS), a zoonosis originating from wild animals [2, 3]. Most reported initial pneumonia cases were geographically linked with the Huanan seafood market, which also sells wild animals in Wuhan [4].

To prevent widespread epidemic outbreaks, the government implemented isolation in Wuhan with traffic-blocking measures on 23 January 2020, and Hubei Province completed blocking traffic on 26 January [2, 5]. However, millions of people had left Wuhan before isolation due to the high mobility of the population during the Spring Festival (a traditional festival in China when families are reunited), which contributed to the spread of SARS-CoV-2. On 30 January 2020, the epidemic was listed as a Public Health Emergency of International Concern by the World Health Organization and was later officially named coronavirus disease 2019 (COVID-19) [6, 7]. As of 8 February 2020, a total of 27 100 cases were confirmed in Hubei Province and a total of 10 098 cases were confirmed in other parts of China [8, 9].

Human-to-human transmission has been confirmed in early epidemiological analyses of COVID-19 [5]. As SARS-CoV-2 could be transmitted via respiratory droplets and close contact [10], more evidence emerged to show positive polymerase chain reaction (PCR) detection of the virus in various clinical specimens, such as blood, sputum, feces, urine, and nasal samples [11, 12]. The detection of live virus in feces [12] implies the possibility of fecal-oral spread. In recent studies the basic reproduction number (R_0) was calculated to be from 2.20 to approximately 3.77, higher than those of SARS and Middle East respiratory syndrome (MERS) [5]. Due to the large number of cases of infection in Hubei Province, the details of the cases were not released and so we collected information on cases confirmed to be from outside of Hubei Province. In this study, our objectives were to analyze the epidemiological characteristics of confirmed cases and the length of the interval between contact with infected patients to the onset of symptoms and the diagnosis.

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METHOD

Study Population and Source of Data

This retrospective study included 7015 COVID-19 cases from 19 January to 8 February 2020 in all provinces of China outside Hubei Province. The information on all participants was collected from the website of the National Health Commission of the People's Republic of China (NHCPRC) and the health commission website of each province or city. Detailed data included age, sex, residence, history of contact with confirmed cases or persons from Hubei Province, travel history, initial symptoms, information on family clusters, and several crucial dates (such as the date of symptom onset, the date of first visit to a health care facility, the date of diagnosis, the date of hospitalization date, and the date of isolation). We indicated the number of cases used in analyses where part of the information was not available. A total of 3294 cases with detailed clinical information were included in the analyses of clinical symptoms and 2907 cases with contact history and date of onset or diagnosis were analyzed for the incubation period in this study. To compare the characteristics of confirmed cases with that of the domestic population, the latest demographic data (sex-, age-, and province-stratified population data) were obtained from the National Bureau of Statistics of China [13].

Diagnosis and Outcome of COVID-19

A confirmed case of COVID-19 was defined as a case with epidemiological exposure, clinical symptoms, and a positive result for nucleic acid detection in nasal and pharyngeal swab specimens by high-throughput sequencing or real-time reverse-transcriptase PCR (RT-PCR) assay according to the guidance from the NHCPRC [14, 15].

The outcome of disease (cure or death) was also collected. A cured case was defined as a case with body temperature that had returned to normal, markedly improved respiratory symptoms, significant inflammatory absorption shown in lung computed tomography, and 2 consecutive nucleic acid detections that were negative, according to the guidance from the NHCPRC [14, 15].

Definitions of Variates

An imported case was defined as one with exposure to pathogens in other cities, such as Wuhan or other cities in Hubei Province, including cases with a history of travel or residence in other cities or contact with a diagnosed person in other cities before the onset of symptoms. A nonimported case was defined as one with no travel history to other cities before onset and only local exposure to pathogens.

We extracted the last contact date to estimate the incubation period. Contact history information was collected through individual epidemiological questionnaire surveys by public health physicians. The questionnaire information included 4 types of contact: (1) contact with confirmed cases, (2) contact with suspicious cases or fever, (3) contact with people come from Hubei, and (4) travel or residence history in Hubei Province. By comparing the date of each type of contact, the last date of contact was extracted. If there was only one type of contact, this was taken to be the last contact date. The incubation period was defined as the time between the last contact date and the onset date. The onset date was defined as the first day when symptoms developed, such as fever and cough. In addition, to evaluate the relationship among exposure, onset, and diagnosis, we calculated several time intervals: (1) time interval between onset and diagnosis, (2) time interval between onset and first visit, (3) time interval between first visit and diagnosis, and (4) time interval between onset and the censored date (cure date, death date, or 8 February 2020).

Statistical Analysis

To study the distribution of COVID-19 cases, we presented the case number by sex, age, and province. Considering the variable distribution, age was presented as the mean and standard deviation, and the incubation period and time intervals listed above were presented as the median and interquartile range (IQR). The difference between imported cases and nonimported cases was tested using the t test or Wilcoxon rank-sum test. The χ^2 test was used to compare the numerical difference between imported cases and nonimported cases. All analyses were performed using R software (version 3.6.2) or Excel (Microsoft). A 2-sided $P < .05$ was considered statistically significant.

RESULTS

The characteristics of 7015 confirmed COVID-19 cases (3695 males, 54.12%) are shown in Table 1. Henan Province (1017) and Guangdong Province (852) reported more cases than other provinces (Supplementary Table 1). The average age for all cases was 44.24 years, with a range from 2 months to 97 years. Over 60% of confirmed cases were between 30 and 59 years old (21.81% 30–39 years old, 21.07% 40–49 years old, 19.24% 50–59 years old). By comparing with the age-specific proportion of the national population, we found the proportion of cases under 20 years old (20 826 per 10^6) was much lower than that of other age groups (56 189 per 10^6). Up to 61.50% (3802) of all cases were imported and 37.56% (1428) of them came directly from Wuhan (Table 2). The proportion of imported cases in adjacent provinces of Hubei was 55.77% (1411 cases) and in nonadjacent provinces was 65.47% (2391 cases).

As shown in Table 3, among 3294 confirmed cases (53.94% male) with an average age of 44.71 years, the most common symptoms were fever (83.00%) and cough (33.61%). Fatigue (9.96%) and pharyngalgia (6.68%) were common as well. A few cases also reported digestive tract symptoms such as diarrhea, nausea, or vomiting. Compared with 533 cured cases, 21 deaths occurred among patients who were much older (cured cases mean age, 39.9 years vs fatal cases, 71.9 years), and a much

Table 1. Epidemiological Characteristics of 7015 Cases With Confirmed COVID-19

Characteristics	Confirmed Cases (n, %)	Cured Cases (n, %)	Fatal Cases (n, %)	Domestic Population Distribution, %[a]
Sex				
Male	3695 (54.12)	272 (56.20)	12 (60.00)	51.13
Female	3132 (45.88)	212 (43.80)	8 (40.00)	48.87
Age, y				
< 20	640 (9.12)	98 (18.39)	1 (4.76)	21.95
20 to ≤29	831 (11.85)	86 (16.14)	0 (0.00)	14.07
30 to ≤39	1530 (21.81)	136(25.52)	2 (9.52)	15.29
40 to ≤49	1478 (21.07)	95 (17.82)	0 (0.00)	16.24
50 to ≤59	1350 (19.24)	68 (12.76)	3 (14.29)	14.56
60 to ≤69	787 (11.22)	37 (6.94)	2 (9.52)	10.73
≥70	399 (5.69)	13 (2.44)	13 (61.90)	7.15
Province[b]				
Adjacent provinces	2964 (42.25)	179 (33.58)	6 (28.57)	24.68
Nonadjacent provinces	4051 (57.75)	354 (66.42)	15 (71.43)	75.32

[a]Domestic population distribution data were extracted from China Statistical Yearbook 2019.

[b]Classified by adjacent of Hubei Province.

higher proportion of these deaths occurred among patients with other diseases (71.4% vs 0.9%).

We analyzed the variation in the age, sex, and proportion of imported cases by diagnosis date (Figure 1). The average age of the cases was 66 years on 19 January and 56.21 years on 20 January, and the average age gradually decreased to 43.73 years on 23 January. After 23 January, the average age for confirmed cases remained near 44.18 (SD 16.28) years. The proportion of imported cases gradually decreased with later dates of diagnosis, especially after 23 January. Before 23 January, the proportion of imported cases was approximately 85.71%–100%, and the proportion decreased to 33.19% on 8 February. We did not observe a difference in the age or sex distribution between cases from provinces adjacent to Hubei Province and those from other provinces with the time of diagnosis.

The median incubation period for the 2907 cases with contact history and date of onset or diagnosis was 5 days (IQR, 2–8) and the longest incubation period was 24 days for 1 case. The incubation period for more than 95% of the COVID-19 cases was less than 13 days. We did not observe a significant difference in incubation period among men (5 days; IQR, 2–8) and women (4 days; IQR, 2–8) ($P = .22$). The incubation period in imported cases was 5 days, while it was 4 days in nonimported cases, with no significant difference ($P = .23$). Interestingly, we observed that the median incubation period gradually extended over time (Figure 2 and Figure 3). We further analyzed the change in the incubation period between imported and nonimported cases (Figure 4). The extension of the incubation period was observed in imported cases but no significant change was observed among nonimported cases.

Table 2. Epidemiological Characteristics of Imported and Nonimported COVID-19 Cases

	All Confirmed Cases		Imported Cases		Nonimported Cases		
Characteristic	Value	No.[a]	Value	No.[a]	Value	No.[a]	*P* Value
Origin of cases, n		6182		3802		2380	
Male, n (%)	3695 (54.12)	6827	2155 (58.01)	3715	1119 (48.80)	2341	<.001[c]
Age, y, mean (SD)	44.24 (16.24)	6728	42.06 (15.22)	3703	47.37 (17.33)	2338	<.001[d]
Adjacent provinces, n (%)	2530 (40.93)	6182	1411 (37.11)	3802	1119 (47.02)	2380	<.000[c]
Wuhan permanent residents, n (%)	1428 (26.36)	5446	1417 (48.66)	2912	11 (0.47)	2352	<.001[c]
Time from onset to diagnosis, d, median (IQR)	4 (2–7)	5864	4 (2–7)	3250	5 (2–8)	1957	<.001[e]
Time from onset to first visit, d, median (IQR)	0 (0–3)	2723	0 (0–3)	1739	0 (0–3)	827	.484[e]
Time from first visit to diagnosis, d, median (IQR)	2 (1–4)	2714	2 (1–4)	1734	2 (1–4)	823	.054[e]
Time from onset to censored, d, median (IQR)[b]	12 (9–16)	5930	14 (10–17)	3276	7 (11–14)	1988	<.001[e]
Incubation period, d, median (IQR)	5 (2–8)	2907	5 (2–8)	2412	4 (1–8)	473	.225[e]

Abbreviation: IQR, interquartile range.

[a]The number of cases for each item is different due to lack of data.

[b]Censored time for cured cases is the date of cure, and fatal cases is the date of death.

[c]χ^2 test was used to compare distributions of category variables between the 2 groups.

[d]Student *t* test was used to compare means of the continuous variables between the 2 groups.

[e]Wilcox rank sum test was used to compare medians of the continuous variables between the 2 groups.

Table 3. Symptoms of 3294 Confirmed Cases, 292 Cured Cases, and 14 Fatal Cases With COVID-19

Symptoms	Confirmed Cases, n (%)	Cured Cases, n (%)	Fatal Cases, n (%)
Fever	2734 (83.00)	242 (82.88)	9 (64.29)
Cough	1107 (33.61)	149 (51.03)	7 (50.00)
Fatigue	328 (9.96)	51 (17.47)	0 (0.0)
Pharyngalgia	220 (6.68)	19 (6.51)	0 (0.0)
Expectoration	167 (5.07)	19 (6.51)	3 (21.43)
Chill	166 (5.04)	9 (3.08)	0 (0.0)
Myalgia	147 (4.46)	14 (4.79)	2 (14.29)
Headache	132 (4.01)	11 (3.77)	0 (0.0)
Rhinorrhea	80 (2.43)	10 (3.42)	0 (0.0)
Chest distress	74 (2.25)	7 (2.40)	4 (28.57)
Nasal congestion	68 (2.06)	6 (2.05)	0 (0.0)
Dizziness	62 (1.88)	8 (2.74)	0 (0.0)
Diarrhea	57 (1.73)	4 (1.37)	0 (0.0)
Shortness of breath	51 (1.55)	9 (3.08)	8 (57.14)
Nausea or vomiting	24 (0.73)	2 (0.68)	0 (0.0)
Anorexia	23 (0.70)	0 (0.0)	0 (0.0)
Abdominal pain	20 (0.61)	0 (0.0)	0 (0.0)
Chest pain	11 (0.33)	4 (1.37)	0 (0.0)

The median times from disease onset to diagnosis, disease onset to first visit, first visit to diagnosis, and disease onset to censoring were 4, 0, 2, and 12 days, respectively. We collect data in the early stages of the epidemic and therefore the outcome of many cases had not yet occurred. We used 8 February as censored time for confirmed cases, the time of cure for cured cases, and the time of death for fatal cases. The time between disease onset and diagnosis for imported cases (4 days; IQR, 2–7) was significantly shorter ($P < .01$) than for nonimported cases (5 days; IQR, 2–8) (Table 2). The median time from disease onset to diagnosis decreased to zero over the time of onset from 31 December 2019 to 7 February 2020 (Figure 3A). Similar trends were observed in the median time from onset to first visit (Figure 3C) and first visit to diagnosis

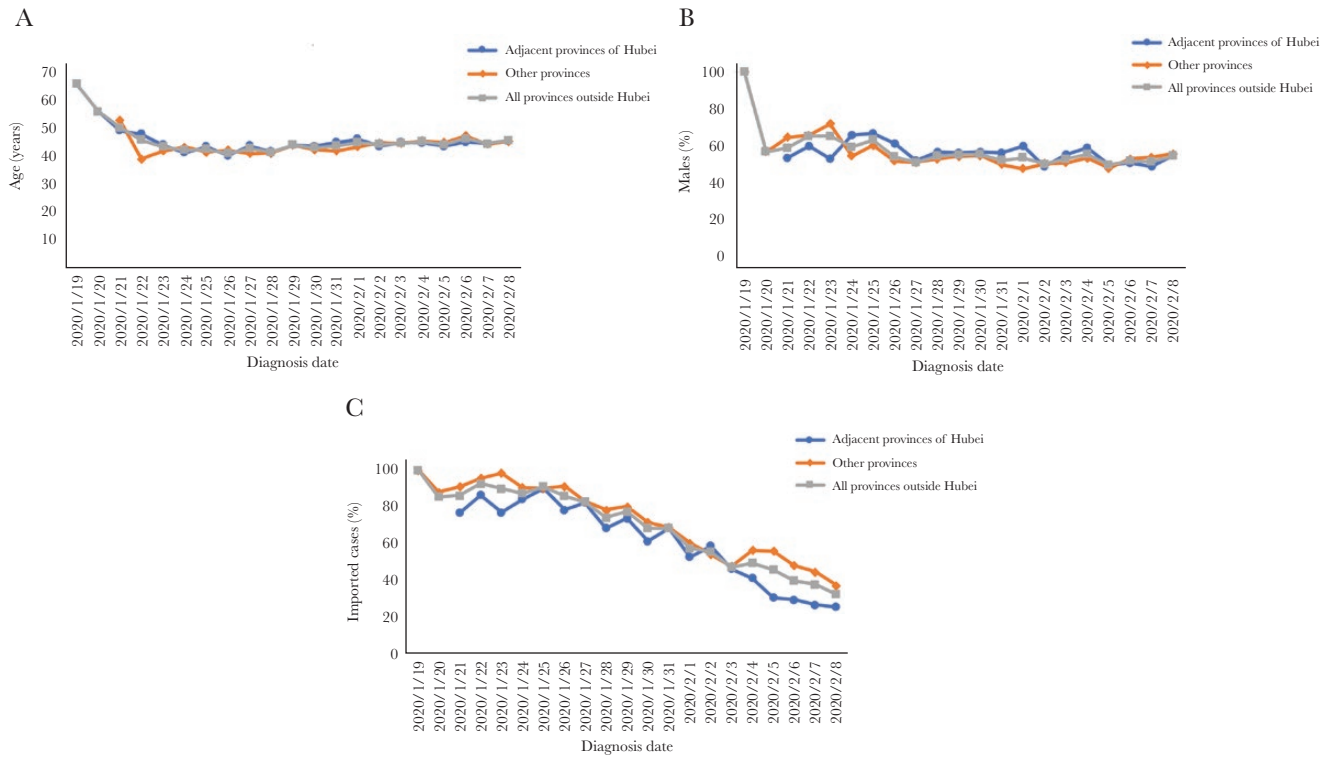

Figure 1. Variation in age (*A*), sex (*B*), and proportion of imported cases (*C*) with diagnosis date.

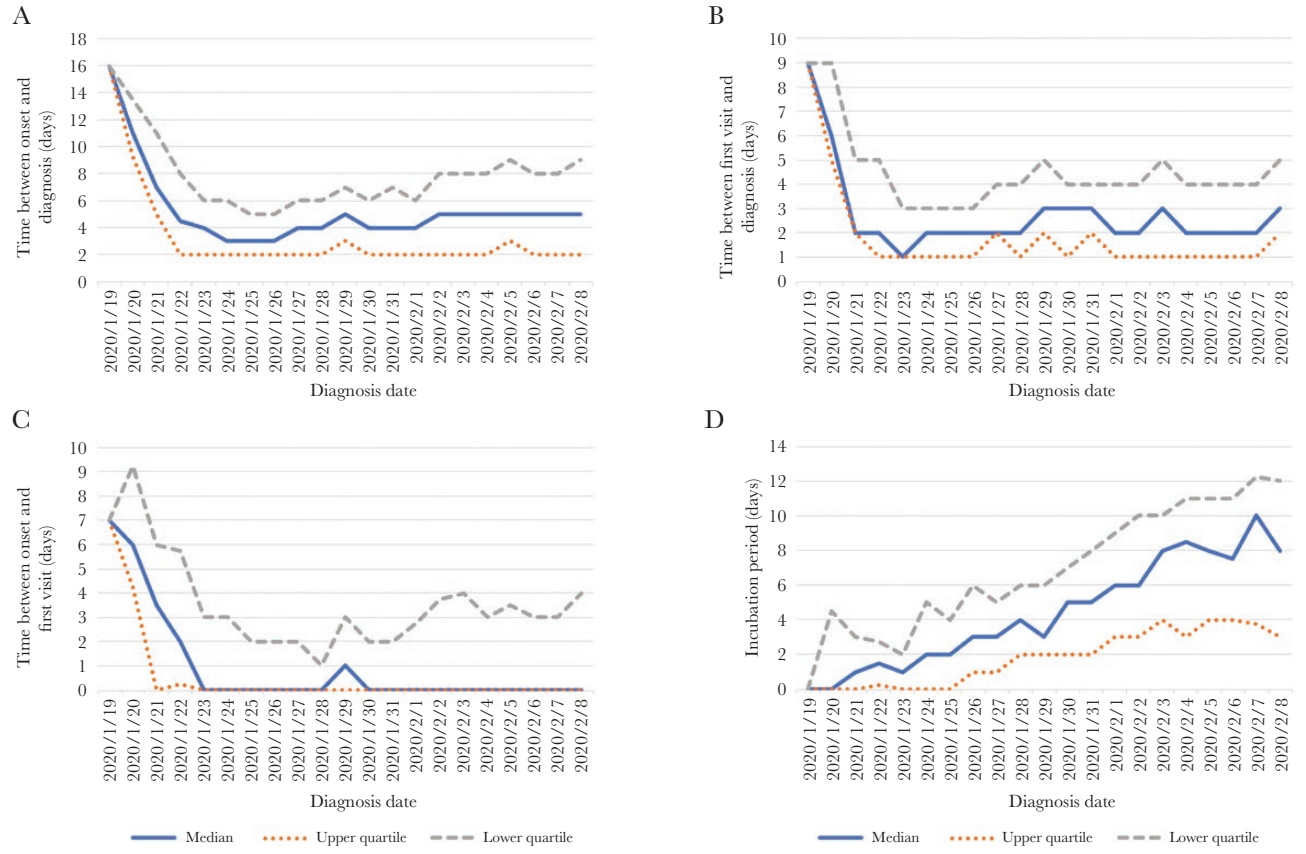

Figure 2. Variation in time intervals with diagnosis date: (*A*) time between onset and diagnosis; (*B*) time between first visit and diagnosis; (*C*) time between onset and first visit; and (*D*) length of incubation period.

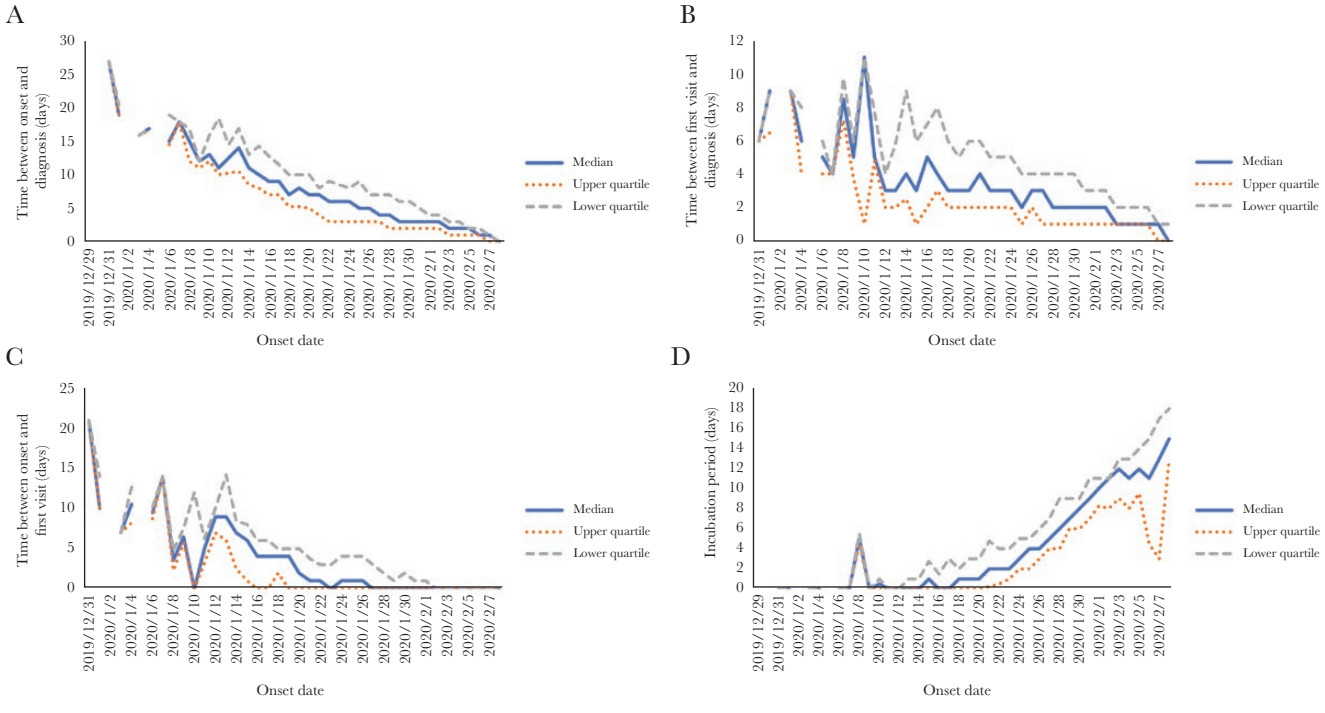

Figure 3. Variation in time intervals with onset date: (*A*) time between onset and diagnosis; (*B*) time between first visit and diagnosis; (*C*) time between onset and first visit; and (*D*) length of incubation period.

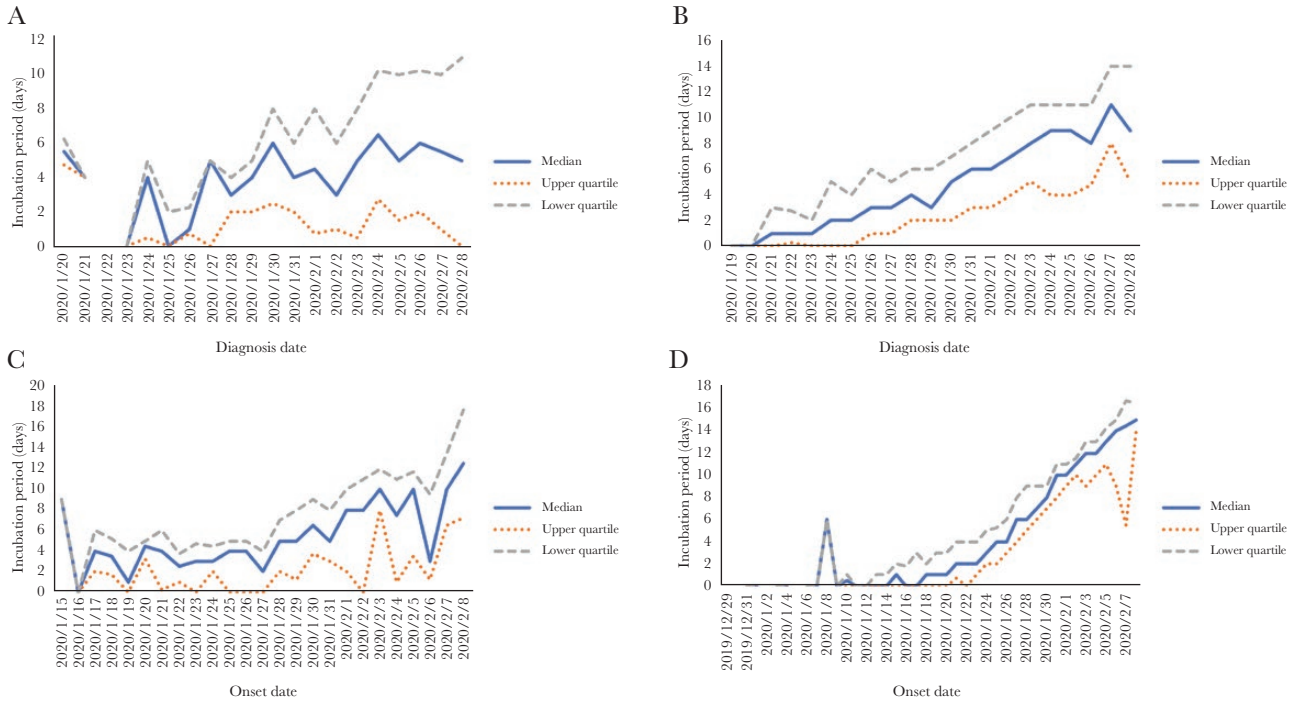

Figure 4. Association between the incubation period and diagnosis date or onset date in imported and nonimported cases. *A*, Variation in incubation period with diagnosis date in nonimported cases. *B*, Variation in incubation period with diagnosis date in imported cases. *C*, Variation in incubation period with onset date in nonimported cases. *D*, Variation in incubation period with onset date in imported cases.

(Figure 3B). Over time, the median time from disease onset to diagnosis decreased rapidly, from 16 days on 19 January to 4 days on approximately 23 January, and then stabilized at 4–5 days after 23 January (Figure 2A). Similar trends were observed for both the time from onset to first visit (Figure 2C) and the time from first visit to diagnosis (Figure 2B); these time intervals decreased rapidly before 23 January and then stabilized at 0 days and 2 days, respectively, after 23 January. We did not observe a significant difference in the length of time from disease onset to the first visit or the length of time from the first visit to diagnosis between imported cases and nonimported cases.

DISCUSSION

In this study, we collected information on 7015 confirmed COVID-19 cases (over 50% male; average age 44.24 years). The most common symptoms were fever and cough. We observed a decreasing trend in the proportion of imported cases in provinces outside Hubei Province and decreasing trends in the time intervals between onset and diagnosis, onset and first visit, and first visit and diagnosis from 19 January to 8 February. Based on 2907 confirmed cases, the median incubation period of COVID-19 was 5 days, and more than 95% of cases had an incubation period of less than 13 days. An increasing trend in the incubation period with the time of diagnosis or onset was observed in this study, especially among imported cases.

We found that the median incubation period was slightly longer than that found in the 1099 cases reported by Guan et al (5 days vs 3 days) [11] but similar to that reported by Li et al (5 days vs 5.2 days) [5] and was supported by a reported family clustering case in which 5 family members experienced the onset of symptoms 3–6 days after exposure [16]. Moreover, the longest incubation period was 24 days in this study, which is consistent with the longest incubation period reported by Guan et al [11]. It should be noted that we extracted the date of last contact with infected persons as the date of contact to calculate the incubation period. When actual contact was earlier than this date, it may lead to an underestimation of the incubation period. In addition, it would appear equally likely that infection might have occurred through contact with some other infected but unidentified person at some time after contact with the known infected person, resulting in an overestimate of the incubation period.

Since the outbreak of COVID-19, mandatory traffic restrictions have been adopted across China to prevent further spread of the epidemic. For example, Wuhan stopped all traffic inside and outside the city on 23 January, and no residents could leave Wuhan unless they had very special circumstances. In the following days (24–26 January), transportation in other cities and surrounding counties in Hubei Province also stopped. Our study showed that from 23 January the incubation period among imported confirmed cases outside Hubei Province

showed a gradual upward trend, but this trend was not obvious in nonimported cases. We also observed that the proportion of imported cases decreased from 100% on 19 January to 33.19% on 8 February. This situation suggested that imported cases started to decrease after traffic restrictions were imposed. After the closure of Hubei Province, new imported cases no longer increased and cases that had been imported into other provinces outside Hubei Province gradually developed, thus prolonging the incubation period. The main transmission routes of COVID-19 that have been confirmed thus far are respiratory droplets and contact transmission [5, 11, 16, 17], while other possible transmission routes (such as aerosol and digestive tract transmission) have not been confirmed [10, 15]. Therefore, the opportunities for infection with SARS-CoV-2 did not change, which might partly explain the relatively stable incubation period among nonimported cases.

In the present study, we observed that the median time from disease onset to diagnosis decreased very rapidly, from 16 days on 19 January to 4 days on and after 23 January. This phenomenon should be attributed to the gradual recognition of COVID-19 and the rapid application of nucleic acid antibody detection. Our results also found that the time between disease onset and diagnosis for imported cases was significantly shorter than that for nonimported cases. This indicated that physicians were more likely to consider the possibility of COVID-19 among pneumonia cases from Wuhan or Hubei Province. In addition, the rapidly decreasing time interval from onset to the first visit and from the first visit to diagnosis, especially after 23 January, also illustrated the effectiveness of the traffic restriction measures in Hubei Province and the improvement in diagnostic capacities.

In summary, our analysis provided evidence that the various policies and isolation measures taken by Hubei Province have been effective since the outbreak of COVID-19. Imported cases started to decrease after traffic restrictions were imposed and the incubation period gradually increased.

Supplementary Data

Supplementary materials are available at *The Journal of Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

Author contributions. W. C., X. N., M. Z., and G. M. participated in study design. X. N., G. M., L. F., and M. W. performed data analysis. X. N., G. M., Q. T., L. F., M. W., Y. X., and W. C. drafted the manuscript. All authors assisted in collecting data, provided critical review of the manuscript, and approved the final draft for publication.

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