Journal of the Formosan Medical Association 121 (2022) 1248—1256

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.jfma-online.com

Original Article

Patient delay in a coronavirus disease 2019 (COVID-19) outbreak in Tianjin, China from January to February 2020

Chunxia Cao [a,1], Yue Li [a,1], Shaobo Fu [b], Yongzhong Zhang [a], Ning Li [a], Shike Hou [a,*], Haojun Fan [a,**]

[a] *Institute of Disaster Medicine, Tianjin University, Tianjin, 300072, PR China*
[b] *General Courses Department, Army Military Transportation University of PLA, Tianjin 300161, PR China*

Received 5 February 2021; received in revised form 10 May 2021; accepted 4 November 2021

KEYWORDS
COVID-19;
Patient delay;
Patient interval;
Fever clinics;
Spatial accessibility

Background: Patient delay of COVID-19 patients occurs frequently, which poses a challenge to the overall epidemic situation. In this study, we aimed to evaluate the extent of patient delay, explore its factors, and investigate the effects of patient interval on epidemic situation.
Methods: A retrospective cohort study was conducted with 136 COVID-19 patients in Tianjin, China. Factors associated with patient delay were explored using logistic regression models. The relationship was investigated by spearman correlation analysis and mean absolute error between patient interval of lagging days and epidemic situation.
Results: The factors associated with patient delay of COVID-19 patients were mainly the imported cases, the first presentation to a tertiary hospital, close contacts and spatial accessibility to fever clinic. The longer the patient intervals of lagging days, the greater the number of new-onset and confirmed cases in 3—4 and 5—7 days after the first day symptoms, respectively.
Conclusion: Identification and quarantine of close contacts, promoting the spatial accessibility to fever clinics and creating public awareness are crucial to shortening patient delays to flat the curve for COVID-19.

* Corresponding author. Institute of Disaster Medicine, Tianjin University, No.92 Weijin Road, Nankai District, Tianjin, 300072, People's Republic of China. Fax: +86 02287370177 305.
** Corresponding author.
E-mail addresses: houshike@tju.edu.cn (S. Hou), fanhj@tju.edu.cn (H. Fan).
[1] Chunxia Cao and Yue Li contributed equally to this work.

https://doi.org/10.1016/j.jfma.2021.11.003

Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by 2019 novel coronavirus (2019-nCoV).[1,2] As of February 2nd, 2021, the global number of confirmed cases of COVID-19 has surpassed 102,584,351 including more than 2,222,647 deaths.[3]

Early detection and early reporting remain the leading principles of prevention and control of COVID-19.[4] Nevertheless, COVID-19 has no specific symptoms and it is difficult to identify its symptoms for the public. It is reported that the means of patient interval (PI), the time interval in days between the first symptom onset and first seeking care at a fever clinic of COVID-19 patients, ranged from 2 to 4 days, in which someone's were more than 10 days.[5—8] The patient delay in PI occurs frequently and poses an unprecedented challenge to early detection and early reporting of COVID-19 patients.

Patient delay in seeking care among patients with infectious diseases has been extensively studied, which increases the risk of death and prolonged hospitalization.[9—14] Understanding the factors associated with patient delays is of paramount importance to accurately decrease fatality rate and burden of diseases. The factors influencing health-seeking behavior included demographic factors, patient's condition, psychological factors, family factors, social factors and medical services.[9,14] However, the factors involved in patient delay to our knowledge are not clear in COVID-19 patients.

In addition, it is worth noting that, considering the person-to-person transmission, previous studies indicated the patients before quarantine and presentation have the ability and possibility to transmit the virus to other susceptible people, and hence increase the risk of spatial transmission and potential infection of COVID-19.[15] Early presentation and diagnosis of infectious diseases could allow early quarantine of patients, thereby it could reduce the potential for community communication and epidemic size.[16,17] Nevertheless, the research of the effect of patient interval on transmission of COVID-19 is mostly model-based theoretical studies by infectious disease dynamics theory.[18,19] Few epidemiological studies have examined it based on the data of the real-world.

Here, we used data of COVID-19 patients collected by the Health Commission and Centers for Disease Control and Prevention (CDC) of Tianjin to comprehensively identify the patient delay associated with COVID-19 patients and evaluate the extent of patient delay. We described and analyzed the factors affecting patient delay in COVID-19 patients, with particular attention the socio—demographic profiles, epidemiologic features, health seeking behaviors and control measures. And another purpose of this study is to investigate the association between the patient interval of COVID-19 patients and COVID-19 epidemic situation. The main findings shed new insight on the normalization interventions and COVID-19 control.

Methods

Study setting and design

The study was carried out in Tianjin, China. The population of the municipality is estimated at 15.6 million across its 11 districts and 5 counties. The first COVID-19 patient was detected in Tianjin on January 21, 2020. And subsequently COVID-19 spread rapidly throughout 14 urban areas and suburbs of Tianjin. There were 136 COVID-19 patients (except for patients from overseas) in Tianjin (admission data from January 21 to February 27, 2020), China. Since February 27, there have been no newly reported COVID-19 confirmed cases in Tianjin in the following nearly 4 months. We performed a retrospective cohort study of these COVID-19 patients in Tianjin. This study sought to identify the patient delay of COVID-19 patients, evaluate the extent of patient delay, explore the factors associated with patient delay, and investigate the PI effects on the spread of COVID-19 epidemic based on the data of real-world.

Case definition

The patients were tested COVID-19 positive in laboratory and confirmed according to the diagnostic and treatment guidelines for COVID-19 issued by the Chinese National Health Committee (Version 3—6). A suspect case is a confirmed case if he or she has one of the following etiological evidence. One is that positive result of COVID-19 nucleic acid test applying real-time fluorescent RT-PCR. The other is genetic sequencing results are highly homologous to the known COVID-19.

Data source

The data of COVID-19 patients were obtained from the website of the National Health Commission of Tianjin (http://wsjk.tj.gov.cn/). The information of COVID-19 patients on this website was from epidemiological investigations by the CDC in Tianjin. All the data was checked by two investigators.

Identification and evaluation of patient delay of COVID-19 patients

Date of first symptom was defined as the date when the patient noticed or recognized the primary symptoms related to COVID-19 for the first time in this study. The symptoms related to COVID-19 included the following signs: fever, cough, fatigue and diarrhea, shortness of breath, pneumonia, and other respiratory tract symptoms.[20] Date of first seeking care at a fever clinic was defined as the time when a COVID-19 patient was first to seek care at a fever clinic. At the fever clinics, patients would be quickly confirmed. Once a subject was diagnosed as a suspect case, the doctors of fever clinics would report to the National Health Commission, and the subject would be isolate and transfer promptly according to relevant procedures.

The PI was defined as the time (in days) between the first symptom onset and first seeking care at a fever clinic. In particular, PI was 0 days if the patient had no symptoms at the time of diagnosis. PI was 0.5 days if the patient first sought care at a fever clinic on the day of the first symptom. We computed PI of each patient and divided the cohort into two groups according to the median value of PI. Patients with PI more than median value were considered as the patient with patient delay.

Factors associated with the patient delay among COVID-19 patients

The factors included: the socio—demographic profiles (residence area, gender, age), epidemiologic features (the imported COVID-19 patients, family cluster, social cluster), control measures (contact-based surveillance, home quarantine, centralized quarantine), health seeking behaviors (spatial accessibility to fever clinic, the tier of hospital where the fever clinic was located), dates of key events (first symptom, first seeking care at a fever clinic and diagnosis) of patients (see methods in Supplementary Materials).

PI effects on the COVID-19 epidemic in Tianjin

The source of infection on T day is not just the patients with first symptoms on T day. Therefore, we added PI of patients with first symptoms before T day to PI of T day and then calculated the average cumulative PI on T day ($ACPI_T$) (see methods in Supplementary Materials). Our research assumed that patients cannot infect susceptible persons after quarantine. The patients quarantined before visiting were excluded when calculating $ACPI_T$. The COVID-19 epidemic situation we were concerned about included the number of new-onset and newly reported COVID-19 confirmed cases per day. We evaluated the associations of $ACPI_T$ and the number of new-onset or newly reported COVID-19 confirmed cases after T day, allowing for potential lag effects of as long as 10 days, to explore the relationship between PI and epidemic situation a few days later (Fig. 1).

Statistical analysis

Because some data (6, 4.41%) about PI were not recorded for all participants, we performed multiple imputation to address these missing values. We presented continuous variables as medians and interquartile ranges (IQR). Categorical variables were described as counts and percentages in each category.

We utilized χ^2 test to assess the relationship between patient delay and control measures. Bivariate binary logistic regression models were utilized to examine the relationship between each factor and patient delay. For the evaluation of the independent associations with the patient delay, factors with a $P < 0.2$ in univariate analysis were included in a multivariate logistic regression model. An automatic selection of the factors was performed in a conditional backward process. Odds ratio (OR) and 95% confidence interval (95% CI) were used to quantify the association between the influencing factors and the patient delay.

In order to explore the curve similarity between patient delay of COVID-19 patients and epidemic situation of COVID-19, we used spearman correlation analysis and mean absolute error (MAE) to evaluate the association of $ACPI_T$ and COVID-19 epidemic situation after T days, and further explored the lagging time. Before MAE analysis, we transformed the data by zero-mena normalization (see methods in Supplementary Materials).

Linear regression models were used to further explore the relationships between the lagging $ACPI_T$ and the epidemic situation after square root transformation.

Multiple imputation was performed with SAS (Statistical Analysis System) statistical software, version 9.4 (SAS Inc). Other analyses were performed with SPSS (Statistical Package for the Social Sciences) statistical software, version 26.0 (SPSS Inc). The level of significance was set at $P < 0.05$.

Results

Characteristics of COVID-19 patients

As of 27 February 2020, 136 COVID-19 patients had been confirmed in Tianjin. Nearly four months since then, there have been no COVID-19 patients in Tianjin (except for patients from overseas). On January 22, the National Health Commission of Tianjin released a list of 47 fever clinics in the city, which were located at 30 tertiary hospitals and 17 secondary hospitals (Fig. 2). Table 1 outlines the general characteristics of COVID-19 patients in Tianjin, China.

Patient delay among COVID-19 patients

The median time of PI for COVID-19 patients in the study was 1 day (IQR, 0.5—4 days) in Tianjin, China. Patients with

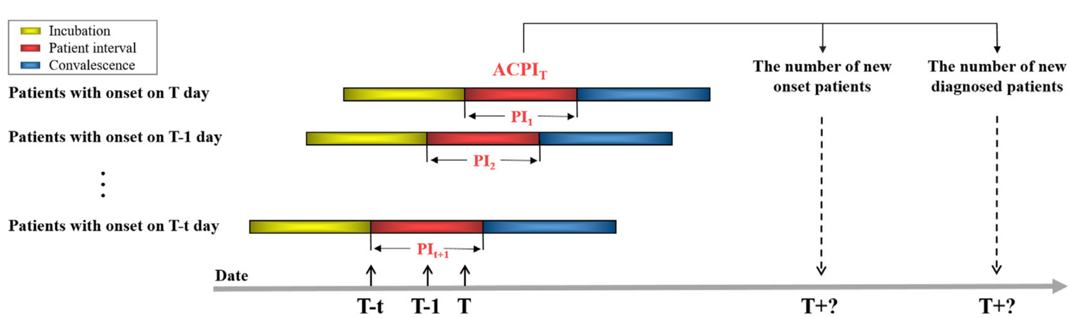

Figure 1 **PI of COVID-19 patients and COVID-19 epidemic situation** (PI was the time interval in days between the first symptom onset and first seeking care at a fever clinic of COVID-19 patients. The range of *T* was from January 14 to February 25, 2020. PI_{t+1} was the average per capita of PI of patients with first symptoms on T—t day. $ACPI_T$ was the average per capita of cumulative PI of patients with first symptoms from T—t to T day.).

PI $\geq$ 1 day were considered as the patient with patient delay. 7 (5.15%) patients had no symptoms at the time of diagnosis, who were all diagnosed in February. 40 patients (29.41%) first sought care at a fever clinic on the first day symptoms. More than 60% of COVID-19 patients have patient delays ranging from 1 to 12 days (Fig. 3).

Factors associated with patient delay in all COVID-19 patients

Factors attributing to patient delay in all COVID-19 patients were explored using univariate and multivariate analysis. The results suggested that patient delay was significantly associated with residence area, the tier of hospital where the fever clinic was located and whether patients were the imported COVID-19 patients, close contact and social cluster. In adjusted models, possibility of patient delay was significantly lower among the imported COVID-19 patients than local [AOR 0.177; 95% CI (0.053–0.592); $P = 0.005$]. Patients with first visit to a tertiary hospital were related to a higher risk of patient delay than those who first visited to a secondary hospital after first symptom [AOR 3.400; 95% CI (1.063–10.872); $P = 0.039$]. These results are shown in Fig. 4.

Patient delay of COVID-19 patients identified as close contacts

47 (34.56%) COVID-19 patients were identified as close contacts before first seeking care at a fever clinic. Table 1 summarizes the general characteristics of COVID-19 patients identified as close contacts in Tianjin. Among close contacts, the patients without quarantine were more likely to have patient delay than the quarantined ($\chi^2 = 5.797$, $P = 0.016$) (Supplementary figure). There was no

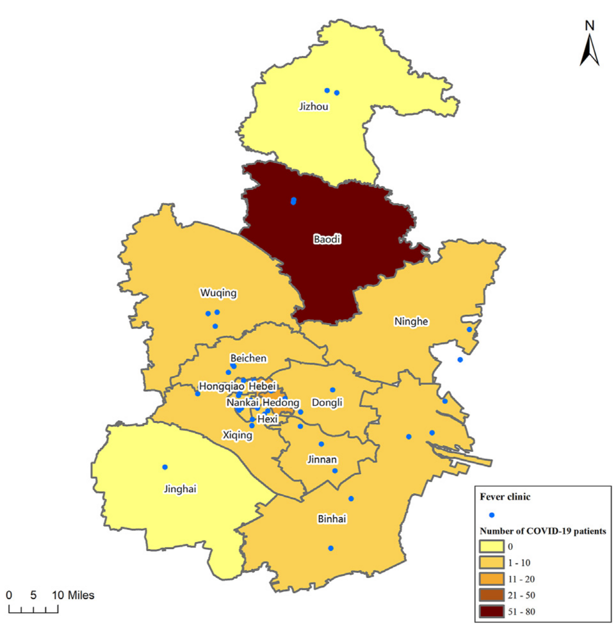

Figure 2 Distribution of 136 patients and 47 fever clinics in Tianjin, China.

Table 1 General characteristics of COVID-19 patients in Tianjin, China.

Characteristics	No close contact	Close contact	Total
Residence area, No. (%)			
Urban	25 (28.1)	20 (42.6)	45 (33.1)
Suburban	60 (67.4)	25 (53.2)	85 (62.5)
Other provinces	4 (4.5)	2 (4.3)	6 (4.4)
Gender, No. (%)			
Male	45 (50.6)	28 (59.6)	73 (53.7)
Female	44 (49.4)	19 (40.4)	63 (46.3)
Age, No. (%)			
0-30 y	14 (15.7)	6 (12.8)	20 (14.7)
31-60 y	52 (58.4)	28 (59.6)	80 (58.8)
>60 y	23 (25.8)	13 (27.7)	36 (26.5)
First symptom onset, No. (%)			
In January	60 (67.4)	16 (34.0)	76 (55.9)
In February	29 (32.6)	24 (51.1)	53 (39.0)
No symptom	0 (0.0)	7 (14.9)	7 (5.1)
Imported COVID-19 patients, No. (%)			
Yes	28 (31.5)	5 (10.6)	33 (24.3)
No	61 (68.5)	42 (89.4)	103 (75.7)
Family Cluster, No. (%)[a]			
Yes	47 (52.8)	36 (76.6)	83 (61.0)
No	42 (47.2)	11 (23.4)	53 (39.0)
Social Cluster, No. (%)[a]			
Yes	30 (33.7)	11 (23.4)	41 (30.1)
No	59 (66.3)	36 (76.6)	95 (69.9)
Tier of hospital, No. (%)[b]			
Secondary hospital	16 (18.6)	7 (17.5)	23 (16.9)
Tertiary hospital	70 (81.4)	33 (82.5)	103 (75.7)
Spatial accessibility, median (IQR)[c]	2.8 (2.8, 5.3)	2.8 (2.5, 4.2)	2.8 (2.8, 5.1)

[a] Some COVID-19 patients had to do with both family clusters and social clusters.
[b] Ten patients had missing values in the tier of hospital.
[c] The number of fever clinics per million population.

statistically significant difference in the patient delay between patients with home and centralized quarantine ($\chi^2 = 2.500$, $P = 0.114$). However, the longest patient delays were 9 days among the close contacts quarantined, and it appeared in home quarantined people. Patient delays for close contacts not quarantined were not statistically significant compared with those not identified as close contacts ($\chi^2 = 0.149$, $P = 0.669$).

Patient delay and its factors among COVID-19 patients identified as non-close contacts

In the univariate analysis, patient delays of COVID-19 patients who were non-close contacts were significantly associated with residence area, age, the date of first symptom onset, spatial accessibility to fever clinic and whether patients were the imported COVID-19 patients and social cluster (Fig. 4). In adjusted models, the possibility of patient delays of the imported COVID-19 cases was significantly lower than local [AOR 0.191; 95% CI (0.061–0.597); $P = 0.004$]. There was an association between patient

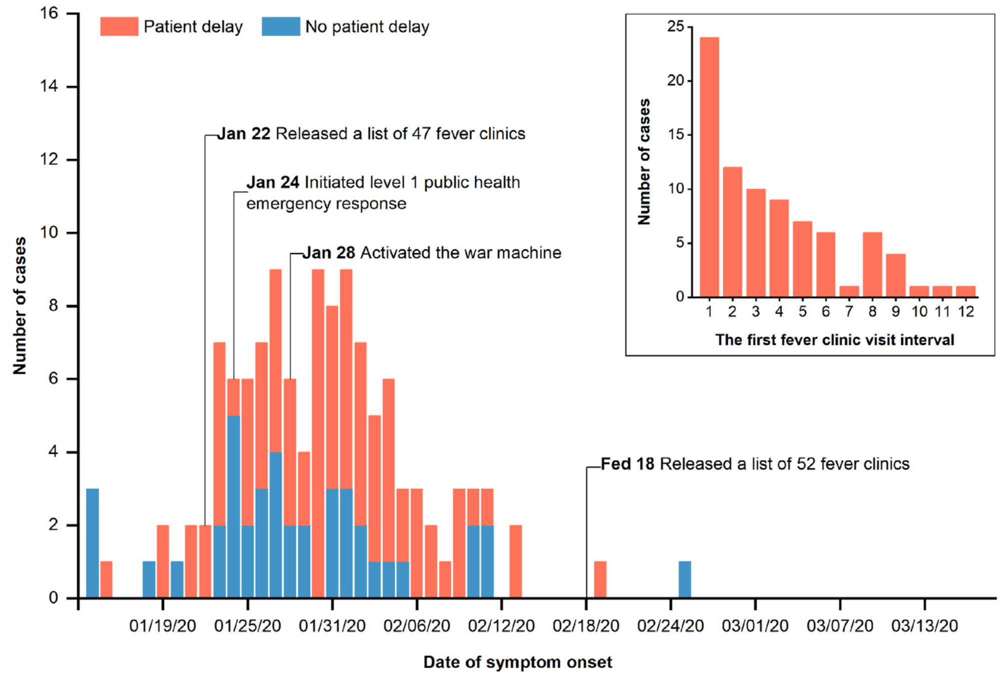

Figure 3 Patient interval of COVID-19 patients in Tianjin, China.

Factors	Crude OR (95%CI)	*Wald* χ^2	*P*	Adjust OR (95%CI)	*Wald* χ^2	*P*
All COVID-19 patients						
Urban	0.410 (0.190-0.883)	5.183	0.023	0.425 (0.168-1.076)	3.260	0.071
Female	1.888 (0.914-3.901)	2.944	0.086			
Age≤30	0.468 (0.179-1.223)	2.401	0.121			
First symptom onset on	1.993 (0.901-4.411)	2.895	0.089			
Imported COVID-19 patients	0.231 (0.101-0.527)	12.129	0.000	0.177 (0.053-0.592)	7.912	0.005
Close contact	0.444 (0.213-0.927)	4.676	0.031	0.402 (0.143-1.131)	2.983	0.084
Family cluster	0.544 (0.256-1.154)	2.517	0.113	0.428 (0.154-1.195)	2.622	0.105
Social cluster	2.873 (1.199-6.884)	5.602	0.018			
Spatial accessibility to fever	0.950 (0.806-1.121)	0.362	0.547			
First visit to a tertiary hospital	2.784 (1.105-7.013)	4.716	0.030	3.400 (1.063-10.872)	4.257	0.039
Non-close contacts						
Urban	0.337 (0.120-0.946)	4.262	0.039			
Female	0.867 (0.344-2.187)	0.091	0.763			
Age≤30	0.220 (0.067-0.722)	6.241	0.012	0.267 (0.066-1.076)	3.450	0.063
First symptom onset on	3.365	4.054	0.044			
Import COVID-19 patients	0.130 (0.046-0.364)	15.094	0.000	0.191 (0.061-0.597)	8.102	0.004
Family cluster	1.046 (0.415-2.640)	0.009	0.924			
Social cluster	3.592	4.512	0.034			
Spatial accessibility to fever	0.770 (0.616-0.962)	5.287	0.021	0.783 (0.611-1.004)	3.718	0.054
First visit to a tertiary hospital	1.733 (0.551-5.448)	0.886	0.347			

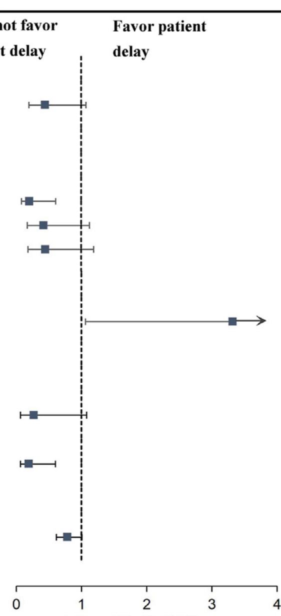

Figure 4 **Univariate and multivariate analysis of factors associated with patient delay in COVID-19 patients in Tianjin** (*: The number of fever clinics per million population.).

delay and spatial accessibility to fever clinic [AOR 0.783; 95% CI (0.611—1.004); $P = 0.054$].

Effect of $ACPI_T$ on the number of new-onset patients with COVD-19

Fig. 5A shows all correlation coefficients between the $ACPI_T$ of lagging time and the number of new-onset patients were statistically significant ($P < 0.01$). The t was the number of days accumulated from T day. When t was from 0 to 8, the results of correlation and MAE analysis showed the $ACPI_T$ had the highest correlation with the number of new-onset patients in 3 or 4 days after the first day symptoms (T day).

To empirically validate the effect of PI on the number of new-onset patients, we provided nine regression models. Supplementary table outlines the results of the regression analysis. All models indicated that the coefficients were significant ($P < 0.01$), suggesting that $ACPI_T$ had effect on the number of new-onset patients. With an increase of 1 unit in the square root transformed $ACPI_T$, the square root transformed number of new-onset patients increased by 0.864—1.731 units in 3 or 4 days after the first day symptoms. In other words, the lagging time was 3 or 4 days.

Effect of $ACPI_T$ on the number of newly reported COVID-19 confirmed cases

The findings showed all correlation coefficients between $ACPI_T$ and the number of newly reported COVID-19 confirmed cases were statistically significant ($P < 0.01$). When t was from 0 to 8, the results of correlation and MAE analysis showed $ACPI_T$ had the highest correlation with the number of new-onset patients in 4—7 and 5—7 days after the first day symptoms (T day), respectively (Fig. 5B).

Supplementary table outlines the results of the linear regression analysis of $ACPI_T$ and the number of newly reported COVID-19 confirmed cases after T day. With an increase of 1 unit in the square root transformed $ACPI_T$, the square root transformed number of newly reported COVID-19 confirmed cases increased by 0.662—1.911 units in 5 or 7 days after the first day symptoms. Models confirmed that the effect of PI on the number of confirmed cases was significant, which suggested that one of keys to suppressing the patient number was to shorten PI.

Discussion

The first goal of this study was to identify the patient delay of COVID-19 patients, evaluate the extent of patient delay and explore the factors associated with patient delay. We found that more than 60% of patients did not visit the fever clinic on the first day symptoms in Tianjin. Patient delays ranged from 1 to 12 days. Factors mainly responsible for patient delay included: socio—demographic profiles, epidemiologic features, health seeking behaviors and control measures. The secondary objective of the study was to investigate the PI effects on the spread of COVID-19 epidemic. We found that the longer the PI of COVID-19 patients, the greater the number of COVID-19 new-onset and newly reported confirmed cases in 3—4 and 5—7 days after the first day symptoms, respectively.

The key points in epidemiology of confirmed COVID-19 patients such as intervals between the first symptom onset and first seeking care have been reported observed. The median of patient interval was about 1—2 days consistent with our findings in which the median of the interval was 1 day (IQR, 0.5—4 days).[6,7] Note that, the health seeking behavior we were concerned about is the first presentation to a fever clinic. The implementation of the fever clinic system was originally suggested by the Chinese authorities during the severe acute respiratory syndrome (SARS) epidemic in 2003, and it is also the unique special outpatient service in the world.[21] Fever clinics were upgraded during the COVID-19 epidemic in 2020, which served for screening, diagnosis of patients with suspected symptoms and promptly transferring confirmed cases to the designated hospital.[22,23] On January 22, the National Health Commission of Tianjin released a list of 47 fever clinics in the Tianjin. On February 18, the number of fever clinics increased to 52. The use of fever clinics likely helped prevent the spread of COVID-19.[24]

Several factors were found to be associated with patient delay in the study districts. Among all COVID-19 patients, prolonged patient delay has not been shown to be more common in urban areas. The results may not be new since urban residents have a higher level of knowledge and recognition of COVID-19 than suburban residents.[25—27] It highlights routes to match control policies with the aim of shortening the patient delay of suburban patients should be concerned. Also, patient delay was significantly associated with whether patients were the imported COVID-19 patients, close contacts and social cluster. These favorable results have been attributed that Chinese authorities took rapidly responsive strategies including patient finding and quarantine of close contacts.[28] Furthermore, we have found that patients who go to the fever clinic of a tertiary

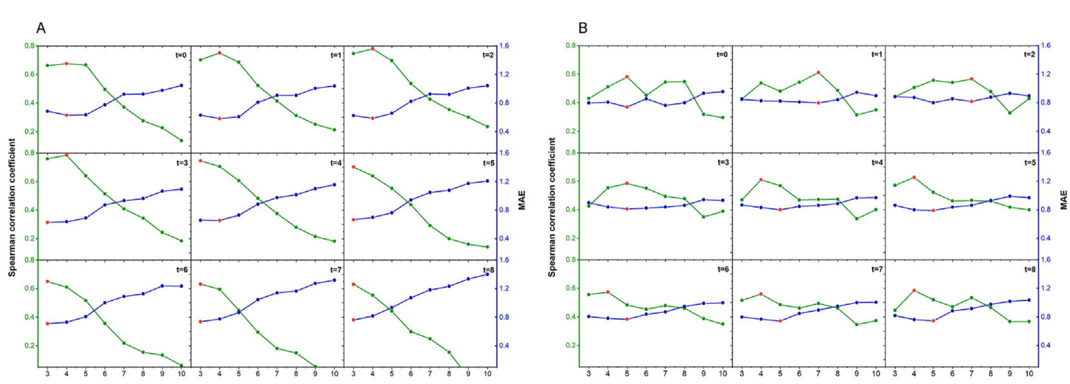

Figure 5 Curve similarity between the epidemic situation and $ACPI_T$ of the lagging day (A: Curve similarity between the number of new-onset patients and $ACPI_T$ of the lagging day; B: Curve similarity between the number of newly reported COVID-19 confirmed cases and $ACPI_T$ of the lagging day. All correlation coefficients were statistically significant ($P < 0.01$). The green points and lines represented the correlation coefficients of the epidemic situation and $ACPI_T$ of the lagging day and their trends. The blue points and lines represented the MAE of the epidemic situation and $ACPI_T$ of the lagging day and their trends. The solid points indicated one day of the largest correlation coefficient or the smallest MAE under the same value of t.).

hospital for the first presentation were more likely to experience patient delay. It is possible that they had more severe symptoms with patient delay. Therefore, they chose to go to a tertiary hospital to seek more advanced level of service.

The current literature showed psychology status would be changed after becoming a close contact.[29] And once one person was defined as a suspect case, confirmed case or asymptomatic infection, according to epidemiological survey, CDC would trace its close contacts. Among close contacts, those who were tracked and quarantined before symptoms were less likely to have patient delay. It suggests that not only did they pay more attention to their symptoms, but also the management staff could send them to hospital in time when they were quarantined. In addition, regardless of whether it is centralized quarantine or home quarantine during contact-based surveillance, these patients are less likely to have patient delay after contact-based surveillance. However, since there was no long delay in PI of patients with centralized quarantine, the effect of centralized quarantine seems to be better. The finding suggested patient delays for close contacts not quarantined were not statistically significant compared with those not identified as close contacts. Therefore, identification and quarantine of close contacts can not only prevent infection of susceptible persons, but also enable patients to visit early.[30,31]

Among non-close contacts, we found that the probability of patient delay increased markedly with age >30 years. Particularly, the mental and physical conditions of the elderly aged and classified as high-risk groups is more vulnerable than younger groups, requiring more attention.[32] Of concern is the fact that patients with onset in February were more likely to have patient delay, compared with patients with onset in January, though patients who had no symptoms at the time of diagnosis were all diagnosed in February. Previous studies have shown that COVID-19 patients were afraid of going to the doctor when they first appeared unwell as the number of confirmed cases continues to rise.[33] Previous studies have shown positive associations between a higher level of spatial accessibility to hospital and lower possibility of patient delay.[34] In agreement with previous studies, our findings indicated that there was an association between COVID-19 patient delay and spatial accessibility to fever clinic. One of keys to shorten PI is to promote the spatial accessibility to fever clinic.

The COVID-19 patients are contagious before presentation and quarantine in the community. In particular, according to the Chinese National Health Committee (Version 8), COVID-19 patients are highly infectious within 5 days after the first day symptoms. The correlation analysis of $ACPI_T$ on the number of new-onset and newly reported COVID-19 confirmed cases after T day showed that all correlation coefficients were statistically significant. The longer the PI of COVID-19 patients, the greater the number of COVID-19 new-onset and newly reported confirmed cases. The result is consistent with the research of the effect of patient interval on transmission of COVID-19 based on infectious disease dynamics model.[18] The results revealed that health seeking early is of considerable importance for the control of COVID-19. $ACPI_T$ affected the number of new-onset patients 3 or 4 days later. These results are consistent with findings of previous research that the serial interval was 3–4 days.[35–37] $ACPI_T$ had relationship with the number of newly reported COVID-19 confirmed cases 5 or 7 days later. The interval between these two lagging times is exactly the similar to the time from onset to diagnosis.[6]

This study has several limitations. First, our findings were based on data of COVID-19 patients in Tianjin where the COVID-19 epidemic situation was in a low prevalence state and aggressive measures were implemented. Similarly, our work may not be generalizable to the situation in entire China or other countries. Second, the main weakness in our study, similar to that of other studies relying on public data, was limited to the information collected on the official website. The study lacked more detailed epidemiological survey data, clinical symptoms and psychological states of patients. Finally, our study did not consider the asymptomatic infections and undocumented COVID-19 patients.

In conclusion, COVID-19 patient delay is associated with socio–demographic profiles, epidemiologic features, health seeking behaviors and control measures. Identification and quarantine of close contacts, promoting the spatial accessibility to fever clinic and creating public awareness could be important in order to shorten PI of COVID-19 patients. The patient interval at a lag is also associated with the number of patients. One of keys to flat the curve for COVID-19 is to shorten PI.

Funding

This work was supported by the National Natural Science Foundation of China (grant number 71533008) and Independent Innovation Fund of Tianjin University (grant number 2020XY-0014 and 2021XSC-0124).

Meetings

None of the manuscript contents have been previously published.

Credit author statement

Chunxia Cao: Conceptualization, Methodology, Writing-Review & Editing. Yue Li: Conceptualization, Methodology, Writing-Original Draft. Shaobo Fu: Resources, Data Curation. Yongzhong Zhang: Validation, Formal analysis. Ning Li: Visualization, Data Curation. Shike Hou: Supervision, Funding acquisition. Haojun Fan: Writing-Review & Editing, Project administration, Funding acquisition.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Acknowledgments

We thank the National Health Commission of Tianjin and Centers for Disease Control and Prevention of Tianjin for their efforts in reporting and updating the data of COVID-19 epidemic situation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jfma.2021.11.003.

References

1. Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A novel coronavirus from patients with pneumonia in China, 2019. *N Engl J Med* 2020;**382**(8):727—33.
2. World Health Organization. *Question and answer on coronaviruses (COVID-19)*. Available from: https://www.who.int/zh/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-covid-19, 2020. [Accessed 2 February 2021].
3. World Health Organization. *WHO coronavirus disease (COVID-19) dashboard*. Available from: https://covid19.who.int/, 2021. [Accessed 2 February 2021].
4. Health commission of China. *Guidance on the normalized prevention and control of COVID-19 epidemic*. Available from: http://www.nhc.gov.cn/xcs/xwbd/202005/3fb9d66a8b3345e5926aa37b0dc5e7bc.shtml, 2020. [Accessed 2 February 2021].
5. Chen J, Qi T, Liu L, Ling Y, Qian Z, Li T, et al. Clinical progression of patients with COVID-19 in Shanghai, China. *J Infect* 2020;**80**(5):1—6.
6. Chen P, Zhang Y, Wen YS, Guo JJ, Jia JW, Ma Y, et al. Epidemiological and clinical characteristics of 136 cases of COVID-19 in main district of Chongqing. *J Formos Med Assoc* 2020;**119**(7):1180—4.
7. Young BE, Ong SWX, Kalimuddin S, Low JG, Tan SY, Loh J, et al. Epidemiologic features and clinical course of patients infected with SARS-CoV-2 in Singapore. *J Am Med Assoc* 2020;**323**(15):1488—94.
8. Li Y, Duan G, Xiong L. Characteristics of COVID-19 near China's epidemic center. *Am J Infect Control* 2020;**48**(9):1051—5.
9. Mesfin MM, Newell JN, Walley JD. Delayed consultation among pulmonary tuberculosis patients: a cross sectional study of 10 DOTS districts of Ethiopia. *BMC Publ Health* 2009;**9**(53):1—10.
10. Carpenter TE, O'Brien JM, Hagerman AD, McCarl BA. Epidemic and economic impacts of delayed detection of foot-and-mouth disease: a case study of a simulated outbreak in California. *J Vet Diagn Invest* 2011;**23**(1):26—33.
11. Bastaki H, Carter J, Marston L, Cassell J, Raita G. Time delays in the diagnosis and treatment of malaria in non-endemic countries: a systematic review. *Trav Med Infect Dis* 2018;**21**(1):21—7.
12. Okeke IN, Manning RS, Pfeiffer T. Diagnostic schemes for reducing epidemic size of African viral hemorrhagic fever outbreaks. *J Infect Dev Ctries* 2014;**8**(9):1148—59.
13. Lin S, Pan H, Wu H, Yu X, Cui P, Han R, et al. Epidemiological and clinical characteristics of 161 discharged cases with coronavirus disease 2019 in Shanghai, China. *BMC Infect Dis* 2020;**20**(1):780.
14. Virenfeldt J, Rudolf F, Camara C, Furtado A, Gomes V, Aaby P, et al. Treatment delay affects clinical severity of tuberculosis: a longitudinal cohort study. *BMJ Open* 2014;**4**(6):1—8.
15. 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. *N Engl J Med* 2020;**382**(13):1199—207.
16. Drain PK, Hyle EP, Noubary F, Freedberg KA, Wilson D, Bishai WR, et al. Diagnostic point-of-care tests in resource-limited settings. Lancet. *Inf Disp* 2014;**14**(3):239—49.
17. Nouvellet P, Garske T, Mills HL, Nedjati GG, Hinsley W, Blake IM, et al. The role of rapid diagnostics in managing Ebola epidemics. *Nature* 2015;**528**(7580):S109—16.
18. Rong XM, Yang L, Chu HD, Fan M. Effect of delay in diagnosis on transmission of COVID-19. *Math Biosci Eng* 2020;**17**(3):2725—40.
19. Lin CY, Huang CH, Lu PL, Hou MF. Management and investigation of individuals with an increased risk of COVID-19 transmission and infection. *J Formos Med Assoc* 2020;**119**:1450—1.
20. Huang CL, Wang YM, Li XW, Ren LL, Zhao JP, Hu Y. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020;**395**(10223):497—506.
21. Beijing Health Bureau Fever Clinic Project Team. Evaluation on the functions and cost of 'fever clinics' during the period of severe acute respiratory syndrome epidemics in Beijing. *Chin J Epidemiol* 2003;**24**(11):999—1004.
22. Sun PY, Zhan SY, Cao GW, Liu Y, Wang C, Dun Z, et al. Qualitative investigation of fever outpatients in Beijing during SARS epidemic. *Chin J Public Health Mangement* 2003;**19**(5):454—6.
23. Zhang J, Zhou L, Yang YQ, Peng W, Wang WJ, Chen XL. Therapeutic and triage strategies for 2019 novel coronavirus disease in fever clinics. *Lancet Respir Med* 2020;**8**(3):11—2.
24. Wang J, Zong L, Zhang J, Sun H, Harold WJ, Sun P, et al. Identifying the effects of an upgraded 'fever clinic' on COVID-19 control and the workload of emergency department: retrospective study in a tertiary hospital in China. *BMJ Open* 2020;**10**(8):e039177.
25. Devaraj S, Patel PC. Change in psychological distress in response to changes in reduced mobility during the early 2020 COVID-19 pandemic: evidence of modest effects from the U.S. *Soc Sci Med* 2020;**17**:270.
26. Javier TV, Samuel PS. The impact of Covid-19 on the education of residents: a Peruvian experience. *J Formos Med Assoc* 2021;**120**:1158—9.
27. Liu X, Luo WT, Li Y, Li CN, Hong ZS, Chen HL, et al. Psychological status and behavior changes of the public during the COVID-19 epidemic in China. *Infect Dis Poverty* 2020;**9**(1):58.
28. Malmberg H, Britton T. Inflow restrictions can prevent epidemics when contact tracing efforts are effective but have limited capacity. *J R Soc Interface* 2020;**17**(170):20200351.
29. Keeling MJ, Hollingsworth TD, Read JM. Efficacy of contact tracing for the containment of the 2019 novel coronavirus (COVID-19). *J Epidemiol Community Health* 2020;**74**:861—6.
30. Javad A. Home quarantine for Taiwanese travelers entering Taiwan. *J Formos Med Assoc* 2020;**119**:1236.
31. Hellewell J, Abbott S, Gimma A, Bosse NI, Jarvis CI, Russell TW, et al. Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts. *Lancet Glob Health* 2020;**8**(4):488—96.
32. Amar HK, Mohamed J, Aida A, Feras A, Khaled B, Ahmed S. Clinical and laboratory findings of COVID-19: A systematic review and meta-analysis. *J Formos Med Assoc* 2021;**120**:1706—18.
33. Xu CL, Jia JB. Qualitative research on novel coronavirus pneumonia patients' psychological experience. *Chinese J Dial & Organ* 2020;**31**(1):20—2.
34. Zyaambo C, Siziya S, Fylkesnes K. Health status and socio-economic factors associated with health facility utilization in rural and urban areas in Zambia. *BMC Health Serv Res* 2012;**12**(11):1—6.

35. Du ZW, Xu XK, Wu Y, Cowling BJ, Meyers LA. Serial interval of COVID-19 among publicly reported confirmed cases. *Emerg Infect Dis* 2020;**26**(6):1341—3.
36. Yang L, Dai JY, Zhao J. Estimation of incubation period and serial interval of COVID-19: analysis of 178 cases and 131 transmission chains in Hubei province, China. *Epidemiol Infect* 2020;**19**(148):117.
37. Nishiura H, Linton NM, Akhmetzhanov AR. Serial interval of novel coronavirus (2019-nCoV) infections. *Int J Infect Dis* 2020; **4**(93):284—6.