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Rapid asymptomatic transmission of COVID-19 during the incubation period demonstrating strong infectivity in a cluster of youngsters aged 16-23 years outside Wuhan and characteristics of young patients with COVID-19: A prospective contact-tracing study

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SUMMARY

Background: The outbreak of coronavirus-disease-2019 (COVID-19) has rapidly spread to many places outside Wuhan. Previous studies on COVID-19 mostly included older hospitalized-adults. Little information on infectivity among and characteristics of youngsters with COVID-19 is available.
Methods: A cluster of 22 close-contacts of a 22-year-old male (Patient-Index) including youngsters with laboratory-confirmed COVID-19 and hospitalized close-contacts testing negative for severe-acute-respiratory-syndrome-coronavirus-2 (SARS-CoV-2) in Anhui Province, China was prospectively-traced.
Results: Since January 23, 2020, we enrolled a cluster of eight youngsters with COVID-19 (median age [range], 22 [16–23] years; six males) originating from Patient-Index returning from Wuhan to Hefei on January 19. Patient-Index visited his 16-year-old female cousin in the evening on his return, and met 15 previous classmates in a get-together on January 21. He reported being totally asymptomatic and were described by all his contacts as healthy on January 19-21. His very first symptoms were itchy eyes and fever developed at noon and in the afternoon on January 22, respectively. Seven youngsters (his cousin and six classmates) became infected with COVID-19 after a-few-hour-contact with Patient-Index. None of the patients and contacts had visited Wuhan (except Patient-Index), or had any exposure to wet-markets, wild-animals, or medical-institutes within three months. For affected youngsters, the median incubation-period was 2 days (range, 1–4). The median serial-interval was 1 day (range, 0–4). Half or more of the eight COVID-19-infected youngsters had fever, cough, sputum production, nasal congestion, and fatigue on admission. All patients had mild conditions. Six patients developed pneumonia (all mild; one bilateral) on admission. As of February 20, four patients were discharged.
Conclusions: SARS-CoV-2-infection presented strong infectivity during the incubation-period with rapid transmission in this cluster of youngsters outside Wuhan. COVID-19 developed in these youngsters had fast onset and various nonspecific atypical manifestations, and were much milder than in older patients as previously reported.
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Introduction

The outbreak of the 2019-novel-coronavirus-disease (COVID-19) caused by severe-acute-respiratory-syndrome-coronavirus-2 (SARS-CoV-2) emerging from Wuhan in December 2019 has been arousing great global health concern, with many unknowns regarding the transmission dynamics and spectrum of illness to be answered.[1–3] SARS-CoV-2 has rapidly spread to many places outside Wuhan, where imported cases with ascertained COVID-19 among travelers returning from Wuhan without direct exposure to any wet-markets or wild-animals have been reported.[2–4] Current epidemiologic data indicate that human-to-human transmission of SARS-CoV-2 has been rapidly occurring.[2,5,6]

The great number of COVID-19 infections may be attributable to the late identification of sources-of-infection and the ability of the host to shed the infection while asymptomatic.[1,7] While a study[8] suggests that transmission may occur during the incubation-period, the validity was questioned by *Science* because the evidence was not directly obtained from the infectious-patient, who actually had developed symptoms, which were controlled by a fever-lowering agent, before disease transmission to others.[9]

Published reports[2,10,11] focused on hospitalized older patients in Wuhan, many of whom had a history of exposure to the Huanan-Seafood-Wholesale-Market, and suggested that COVID-19 mainly affected older adults with frequent chronic comorbidities, and that many of them developed severe pneumonia, for whom organ dysfunction and failure and death can occur. However, the characteristics and infectivity of COVID-19 among youngsters have been rarely reported, and information on SARS-CoV-2-negative close-contacts, patients with mild infections, or those with infections outside Wuhan remains limited.

We collected and analyzed detailed data from a cluster of youngsters aged 16–23 years with laboratory-confirmed COVID-19 in Hefei, China, originating from a 22-year-old youngster (Patient-Index) returning from Wuhan who rapidly transmitted COVID-19 to seven other youngsters of similar ages without recent travel to Wuhan, where rapid transmission had occurred during the incubation-period of illness in Patient-Index. We also identified all the SARS-CoV-2-negative close-contacts of Patient-Index, and further compared them with the SARS-CoV-2-positive patients. We carefully examined the infectivity and transmission dynamics by obtaining valid information directly from the patients and contacts themselves. We are herein describing the demographic, epidemiological, clinical, radiological, and laboratory features, management, and outcomes of the cluster of youngsters with COVID-19 and also the SARS-CoV-2-negative close-contacts.

Methods

Participants

On January 23, 2020, we initially enrolled a 22-year-old male (Patient-Index/1) returning from Wuhan who initially presented to Feidong People's Hospital (Hospital-1; the eastern branch of First Affiliated Hospital of Anhui Medical University [Hospital-2]) in Hefei, with fever, productive cough, myalgia, and lung infiltrates on chest-computed-tomography (CT)-scan. He was suspected to be infected with COVID-19. We immediately formed an expert investigation-team prospectively following-up and tracing all the contacts.

Subsequently, from January 25 through 27, seven young symptomatic close-contacts of Patient-Index (his cousin and six classmates) also presented to hospital (**Table 1**; **Fig. S1**) for management of relevant manifestations and assessment of heath-conditions after having learned about the COVID-19 outbreak in Wuhan and the human-to-human-transmission. All the eight patients tested positive for SARS-CoV-2 using real-time-reverse-transcriptase-polymerase-chain-reaction (rRT-PCR), confirming COVID-19. Starting from January 27, the other contacts of Patient-Index were admitted to Hospital-1 for quarantine (nine; Contacts-1-9) if residing in Feidong, a county >400 kilometers northeast of Wuhan, or directly isolated at home and home-visited by local healthcare-authorities if living in other parts of Hefei (two), and they all tested negative for SARS-CoV-2. This study was approved by the Ethics Committee of Hospital 1. Informed consent was obtained from all patients and contacts.

We prospectively collected information on the demographic, epidemiological, clinical, radiological, and laboratory characteristics and management and outcomes for all the eight youngsters with laboratory-confirmed COVID-19 and the nine admitted SARS-CoV-2-negative contacts of Patient-Index. All data were collected into a standardized and customized data-collection form, and validated by a trained team of physician-scientists. At least two investigators independently reviewed the collected information to double-check the data and verify the accuracy. Follow-up was until February 20.

We directly communicated with and interviewed all SARS-CoV-2-positive patients and SARS-CoV-2-negative contacts themselves, and their family-members, relatives, classmates, friends, and healthcare-workers when necessary, to collect and ascertain all medical-history, epidemiological (exposure-history, timelines of events, close-contact identification, etc.), and symptom data, which were cross-checked with information from multiple sources. We determined exposure-histories during the three months before illness-onset or hospital-admission, including the dates, time, frequencies, and patterns of contacts with any person who had fever, respiratory-symptoms, or other relevant symptoms, with any wild-animals, or with any relevant environments such as any wet-markets or medical-institutes. Information on history of travel to Wuhan and direct contact with people returning from Wuhan within three months before symptom-onset or hospital-admission was also included.

The definitions and management of all suspected and ascertained COVID-19 cases enrolled were according to the World Health Organization (WHO) guidance[12] and the New Coronavirus Pneumonia Prevention and Control Program by the China National Health Commission,[13] and pathogen examinations are detailed in *Supplementary methods*.

Statistics

The incubation-period was defined as days from infection/exposure to illness-onset was estimated. The serial-interval was defined as the time delay between illness-onset dates in successive cases in a transmission-chain.

Continuous variables were shown as median (range), and categorical variables as count (percentage). Blood laboratory-examination findings were illustrated using boxplots, assessed regarding whether the measurements were outside the reference-range, and compared between SARS-CoV-2-positive patients and SARS-CoV-2-negative contacts using the Mann-Whitney-Wilcoxon-test for unpaired samples. Considering the potential type-I-error, the findings should be interpreted as exploratory.

A two-sided p-value of <0.05 was considered statistically-significant. Statistical-analyses were performed using the R 3.6.2 software (https://www.r-project.org/).

Results

Patient-Index/1 is a 22-year-old overweight otherwise-healthy male-nonsmoker and a Wuhan company-employee. He took the high-speed-rail leaving Wuhan in the morning on January 19,

Table 1
Demographic and baseline characteristics of the eight young patients with confirmed 2019 novel coronavirus disease as of February 17, 2020

Characteristics	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8	Summary[1]
Relationship with Patient 1	Index	Younger cousin	Previous classmate	Previous classmate	Previous classmate	Previous classmate	Previous classmate	Previous classmate	-
Age (years)	22	16	22	22	22	21	21	23	22 (16-23)
Male sex	Y	N	Y	Y	N	Y	Y	Y	6/8 (75%)
Height (cm)	170	167	180	175	160	170	180	180	173 (160-180)
Weight (kg)	82	60	77	65	48	85	70	85	74 (48-85)
Body mass index (kg/m^2)	**28.4** ↑	21.5	23.8	21.2	18.6	**29.4** ↑	21.6	**26.2** ↑	22.7 (18.6–29.4)
Current smoker	N	N	N	Y	N	N	N	Y	2/8 (25%)
Comorbidity	None	None	None	None	Chronic gastritis	Fatty liver	Chronic gastritis	None	-
Travel to or passage through Wuhan or other potential epidemic places	Y (Wuhan)	N	N	N	N	N	N	N	1/8 (13%)
Days from exposure to illness onset	≥ 4	3 or 7	3	1	4	2	2	1	2 (1-4)[2]
Days of serial interval	-	4	2	0	3	1	1	0	1 (0-4)[3]
Days from illness onset to first admission	2	1	2	3	2	3	2	3	2 (1-3)
Days from admission of Patient 1 to admission of the underlying patient	-	3	2	1	3	2	1	1	2 (1-3)[3]
Days from illness onset to first respiratory sample collection	4	1	2	4	2	3	2	3	3 (1-4)
Days from illness onset to first blood sample collection	4	2	2	4	3	5	2	3	3 (2-5)
Days from illness onset to first positive rRT-PCR test for SARS-CoV-2	4	1	2	4	2	3	2	3	3 (1-4)
Days from illness onset to diagnosis by two positive rRT-PCR tests for SARS-CoV-2	5	2	3	5	3	4	3	4	4 (2-5)
Days from first admission to transfer	5	3	3	4	3	2	-	-	3 (2-5)[4]
Days from first admission to discharge	-	16	18	-	-	-	21	17	18 (16-21)[5]

[1] Described for continuous and categorical variables, and expressed as median (range) and count/total number of patients with available data (percentage), respectively.
[2] For Patients 3-8.
[3] For Patients 2-8.
[4] For Patients 1-6; the other patients have not been transferred.
[5] For Patients 2, 3, and 8; the other patients remain in hospital. Values shown in bold indicate abnormal ones. ↑, above the upper limit of the normal range; ↓, below the lower limit of the normal range; -, not applicable; Y, Yes; N, No; rRT-PCR, real-time reverse-transcriptase polymerase-chain-reaction.

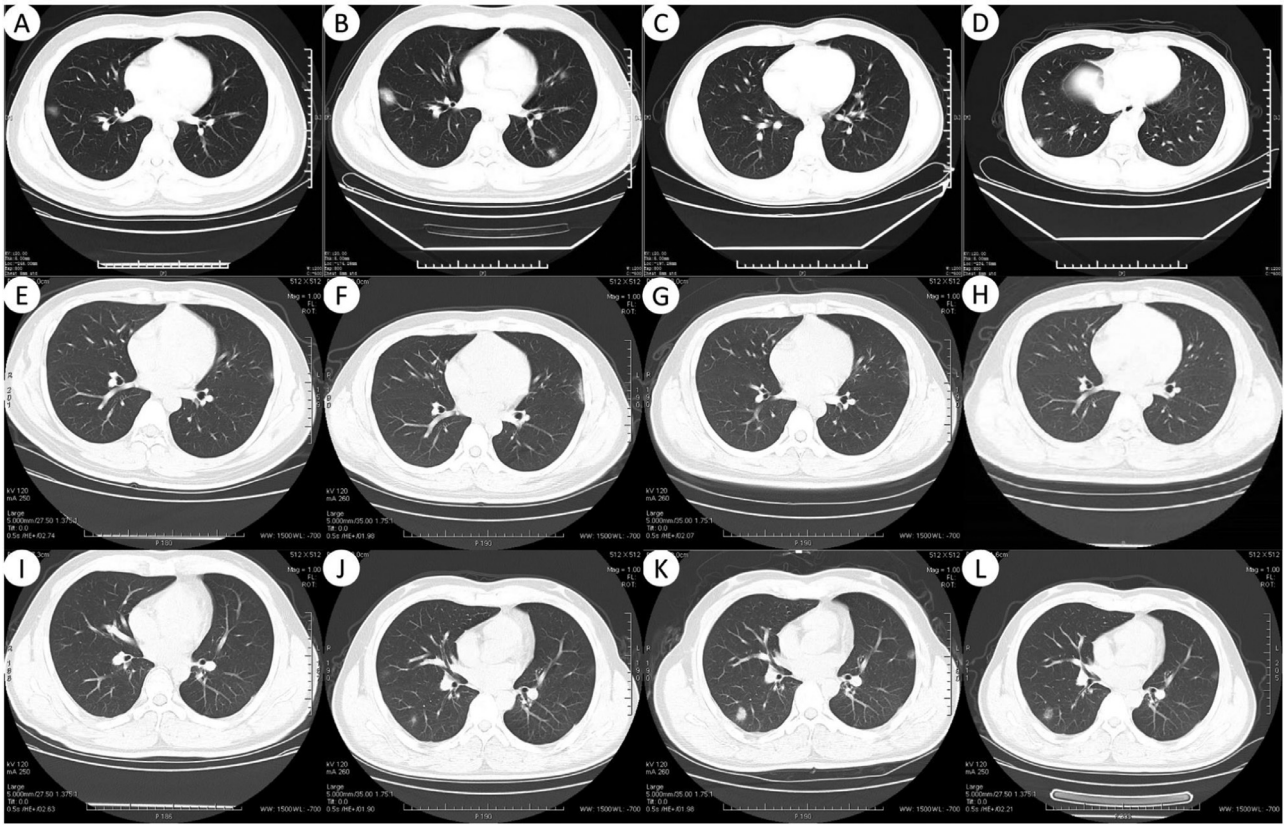

Fig. 1. *Representative transverse chest computed tomography scan images*. (A) Day 1 after illness onset for Patient Index. A few infiltrates (slight slice-like shadow with increased density) in the lower lobe of the right lung were seen. (B) Day 3 after illness onset for Patient Index. In the peripheral zones of both lungs, scattered ground-glass opacities with fuzzy edges were seen, suggesting bilateral pneumonia with highly likely viral nature. (C) Day 2 after illness onset for Patient 3. A few infiltrates and ground-glass opacities were detected in the lower lobe of left lung. (D) Day 3 after illness onset for Patient 4. Ground-glass opacities and infiltrates in the right lung were observed. (E) Day 2 after illness onset for Patient 7. Small patchy and mottling high-density sub-pleural shadows were seen in the upper lobe of left lung. (F) Day 5 after illness onset for Patient 7. The left upper lung lesion progressed. Antiviral therapy started. (G) Day 13 after illness onset for Patient 7. Patchy blurring infiltrates in the peripheral parts of the left lung with obscure boundary remained. (H) Day 21 after illness onset for Patient 7. The patchy ground-glass density shadows and infiltrates with fuzzy edges in the left lung had been obviously absorbed. (I) Day 3 after illness onset for Patient 8. Few strip-like shadows with uneven density were seen in both lungs. (J) Day 6 after illness onset for Patient 8. Multifocal ground-glass density shadows and opacities in the peripheral parts of both lungs were observed. Antiviral therapy started. (K) Day 14 after illness onset for Patient 8. The multiple patchy high-density shadows consistent with novel coronavirus pneumonia with unclear boundary seen in the peripheral parts of both lungs progressed. (K) Day 18 after illness onset for Patient 8. Absorption of pneumonia lesions in both lungs was observed compared to the previous scan.

2020, four days before the "lockdown" of Wuhan, and arrived at his hometown in Feidong in the afternoon for the China Spring-Festival (Fig. 1). In the evening on January 19, he went to visit (talk and have supper with) his cousin, a 16-year-old otherwise-healthy female (Patient-2) and his uncle (Contact-1; later excluded from infection), in their apartment for about 0.5 hours without air-conditioning or wearing a mask. Further exposure and contact details are shown in Supplementary results and Table S1.

At noon on January 20, he met and ate hotpot with a female (Contact-2; later excluded from infection), sitting face-to-face for about one hour, and went shopping together afterwards. The following day on January 21, he took part in a classmate-get-together in Feidong where he had dinner in a restaurant-room with air-conditioning and also windows open at about 11:30-14:00 and afterwards sang Karaoke in a confined-room at about 14:00-16:30 with air-conditioning and with some fruits shared, with 15 of his previous classmates whose hometowns are all in Hefei. Further details on the get-together are shown in Supplementary results, Table S1, and Figs. S1 and S4. Afterwards, he had supper with a 22-year-old otherwise-healthy male (Patient-4) while the others went right back home. Nobody found him unhealthy that day. He reported that he was totally asymptomatic and well before and on January 21. Among his classmates he contacted, six (Patients-3-8) were later confirmed with COVID-19, and the person who first experienced any relevant symptoms was Patients-4 and 8 (both on January 22).

Patient-Index reported that the very first symptom that he experienced was itchy eyes at noon on January 22 (Fig. S1). In the afternoon, he felt dizzy with a fever of 37.5°C developed (measured by himself), and he (starting to wear a mask) attended a local outpatient-clinic in Feidong and was prescribed amoxicillin capsules, paracetamol and amantadine compound capsules, and ambroxol dispersible-tablets, after taking which his temperature returned to normal (36.5°C). On the same day, he also developed mild nasal-congestion and rhinorrhea, both lasting 2 days. On January 23, his body temperature was normal in the morning but rose again to 37.5°C at noon, which was again temporarily controlled by the drugs; however, in the evening he had fever again. On the same day before the onset of fever, Patient-2 went to visit Patient-Index, and brought him some home-made food. They ate and chatted together in his room which was tightly confined with no doors or windows open and without air-conditioning for about 0.5 h. Patient-2 later became infected. Having learned about the COVID-19 emergence in Wuhan and the possible human-to-human-transmission from Internet at noon on January 22, he decided to go to Hospital-1 for further assessment and management in the evening on January 23. Virus-RNA detection using respiratory-samples taken on January 26 and 27 both revealed

positive results on rRT-PCR assays, confirming the SARS-CoV-2 infection (Fig. 1). Assays to detect other pathogens were all negative. Further descriptions of the disease-course and management of Patient-Index are detailed in *Supplementary results*.

Tracing of the contacts of Patient-Index started immediately after his admission to hospital. Before illness onset, he closely contacted 22 people (15 classmates and seven family-members). 16 of the contacts were admitted to hospital under isolation: seven (Patients-2-8) developed COVID-19-relavent symptoms, and were later identified to have laboratory-confirmed SARS-CoV-2-infection, and nine (Contacts-1-9) tested negative for SARS-CoV-2 and had normal CT-scan findings, and were discharged to home-isolation 4-5 days after admission. The other six contacts were quarantined and isolated at home, and closely watched by healthcare-workers; they all tested negative for SARS-CoV-2.

None of the contacts had visited any wet-markets or hospitals, contacted any wild-animals, or eaten any game-meat within three months (Tables S1). None of them had resided in, traveled to, or passed Wuhan, other cities in Hubei, or any region where SARS-CoV-2-transmission was known to be occurring within three months. They reported no contacts with any individual recently returning from such a region, with anyone having any suspicious symptoms (e.g., fever, cough, or other respiratory or relevant digestive symptoms), or with anybody later developing relevant symptoms or confirmed with COVID-19 except Patient-Index within three months (this was ascertained by an investigation by the healthcare-authority in Hefei). They did not have any infected family-members or members having visited Wuhan. None of the contacts had any symptom of illness during exposure.

Patients-2-8 were admitted to hospital under isolation 1-3 days after the admission of Patient-Index on February 25-27. The respiratory-samples of all patients tested positive for SARS-CoV-2 for at least two times. Five of the classmates Patient-Index contacted in the get-together initially tested positive for SARS-CoV-2 on January 26, and another classmate and Patient-Index's cousin initially on January 27. We did not find any evidence of co-infection with other known respiratory viral, bacterial, or fungal pathogens in any of the patients on microbiological-testing.

Of all the eight infected youngsters, the median-age was 22 years (range, 16–23; Table 1), and six were male. Three were company-employees, four university-students, and Patient-2 a senior-high-school-student. Three were overweight. Patients-4 and 8 were current-smokers. Three had mild comorbidities (Patients-5 and 7, chronic gastritis; Patient 6, fatty-liver). While Patient-3 initially reported no coexisting medical-conditions, his blood-pressure was measured to be 150/94 mm Hg on admission. They all immediately wore masks and paid special attention to hand-hygiene after illness-onset.

The median incubation-period for Patients-3–8 was two days (range, 1–4; Table 1). The median serial-interval in the young-cluster was one day (range, 0–4; Patients-4 and 8 had symptom onset on the same day as Patient-Index). Among the eight youngsters with COVID-19, the median duration from illness-onset to first-hospital-admission was two days (range, 1-3). The median interval between illness-onset and second positive-test for SARS-CoV-2 which ascertained the COVID-19 diagnosis was four days (range, 2–5).

The presentations of the eight young-patients are shown in Table 2 and Fig. S2. Because manifestations acquired after hospitalization may be influenced by the hospital-environment and drug-use, we primarily describe those developed before or on admission. We did not identify any patients asymptomatic on admission but testing positive for SARS-CoV-2. All patients had mild clinical-conditions, and developed $\geq$2 symptoms and/or signs before or on admission. Most youngsters (seven) developed fever (except Patient-6). The median body-temperature on admission was 37.5°C (range, 37.0–38.2), and the median highest temperature during disease-course was 38.5°C (range, 37.1–38.9). None had a high fever (temperature >39°C). The fever of Patients-Index, 2, and 5 showed an intermittent pattern, and Patients-3-5 experienced chills. Four patients had productive-cough, and Patients-6 and 7 had dry-cough. Five patients had both fever and cough. Four youngsters experienced fatigue, and three myalgia. Patients-2 and 7 reported experiencing no upper-respiratory-tract-infection symptoms (sore-throat, nasal-congestion, rhinorrhea, and/or sneezing), while five youngsters had more than two such symptoms. Patient-7 reported shortness of breath for two days on admission. None of the youngsters developed dyspnea, or chest-discomfort or pain. Three patients had headache, and Patient-Index reported dizziness. Eye-discomfort was noted in Patients-Index and 3, and backache in Patient-3. Two patients had anorexia, and three nausea, but vomiting did not develop in any of them before or on admission. Only Patient-8 developed diarrhea, and Patient-5 reported abdominal-discomfort. Nobody only presented with digestive-symptoms. Patient-2, the youngest patient (16 years), had only two presentations on admission: intermittent fever for two days and headache for one day, while the others reported 4-11 symptoms. The symptoms on illness onset are described in Supplementary results.

On admission, abnormalities in chest-CT-images suggesting viral-pneumonia were detected in six (all males; 22–23 years) of the eight youngsters confirmed with COVID-19 (Table 2; Fig. 1). None of the conditions were severe. Of the six pneumonia-patients, five had unilateral-involvement, and Patient-8 had bilateral-pneumonia on admission; four had involvement of the lower-lobe, and the other two of the middle-lobe. Of the five patients with unilateral-disease, pneumonia was located in the right-lung in four patients, and in the left-lung in Patient-3. The typical-findings on chest-CT-scan, multifocal-mottling, patchy-shadows, and/or ground-glass-opacities,[2] which were mostly around the peripheral-parts of the lungs and which were compatible with abnormalities seen in viral-pneumonia, were detected in the pneumonia-patients on admission. Patient-Index's pneumonia progressed to bilateral-pneumonia two days after the initial scan. For the youngest patient (Patient-2; 16 years), while no abnormalities were detected the next day after illness-onset, a few infiltrates were noticed in the lower-lob of left-lung six days later.

The blood-routine tests of the seven youngsters with available information on admission showed leucopenia and substantial neutropenia in Patients-2 and 4 (Table 3). Patient-8 had increased neutrophils, but decreased lymphocytes. Patient-7 also had lymphopenia. Patients-1 and 3 had both red-blood-cell count and hemoglobin above the normal-range. Patient-2 had slightly shortened prothrombin-time, while Patient-4 showed mildly extended activated-partial-thromboplastin-time, and Patient-8 slightly increased international-normalized-ratio. Patient-3 had elevation of creatine-kinase and lactate-dehydrogenase reaching the upper-limit of reference-range. Regarding the infection-index, procalcitonin was above the normal-range in Patient-4. Patient-1 had an elevated level of C-reactive-protein. Most patients had normal serum levels of procalcitonin on admission (five of six youngsters with available information).

While testing negative for SARS-CoV-2, Contacts-1-9 also showed some changes in blood-examinations (Table 4; *Supplementary results*). When comparing the laboratory-findings between Patients-1-5 ascertained with COVID-19 with Contacts-1-9 with negative SARS-CoV-2-tests (Fig. S3), all of whom were initially admitted to Hospital-1, lymphocyte-count on admission was lower in the SARS-CoV-2-positive patients than the SARS-CoV-2-negative contacts ($p=0.042$). Initial fibrinogen-concentrations were higher in the patients ($p=0.019$). Levels of sodium were lower in the

Table 2
Symptoms, signs, radiological findings, treatment, and outcomes of the young cluster infected with the 2019 novel coronavirus disease.

Characteristics	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8	Summary[1]
Symptoms and signs									
Fever	Y1 (3 d)	Y1 (2 d)	Y (1 d)	Y1 (3 d)	Y1 (3 d)	N	Y1 (2 d)	Y1 (4 d)	6; 7, 3 (1-4); 0, 0
Body temperature on admission (°C)	38.0	37.2	37.0	37.6	38.2	37.0	37.4	37.7	37.5 (37.0-38.2)
Highest body temperature (°C)	38.4	38.5	37.7	38.5	38.2	37.1	38.0	38.9	38.5 (37.1-38.9)
Intermittent fever	Y	Y	N	N	Y	N	N	N	3/8 (38%)
With chills	N	N	Y	Y	Y	N	N	N	3/8 (38%)
Fatigue	N	N	Y1 (3 d)	Y (1 d)	Y	N	Y1 (2 d)	Y (3 d)	2; 4, 3 (1-3); 1, 0
Myalgia	Y (2 d)	N	Y1 (3 d)	N	Y	N	N	Y (2 d)	1; 3, 2 (2-3); 1, 0
Cough	Y (2 d)	N	Y1 (3 d)	Y (2 d)	Y	Y1 (4 d)	Y1 (2 d)	Y (3 d)	3; 6, 3 (2-4); 1, 0
Sputum production	Y (2 d)	N	Y (1 d)	Y (2 d)	N	N	N	Y (3 d)	0; 4, 2 (1-3); 0, 0
Hemoptysis	Y	N	N	N	N	N	N	N	0; 0; 1, 0
Sore throat	N	N	Y1 (3 d)	N	Y1 (3 d)	N	N	Y1 (4 d)	3; 3, 3 (3-4); 0, 0
Nasal congestion	Y1 (3 d)	N	Y (1 d)	Y (3 d)	Y	Y (2 d)	N	Y1 (4 d)	2; 5, 3 (1-4); 1, 0
Rhinorrhea	Y1 (3 d)	Y	N	N	N	Y (2 d)	N	Y1 (4 d)	2; 3, 3 (2-4); 1, 0
Sneezing	N	Y	Y	Y (2 d)	N	Y (1 d)	N	Y (2 d)	0; 3, 2 (1-2); 2, 0
Shortness of breath	Y	N	N	N	N	Y!	Y1 (2 d)	N	1; 1, 2 (2-2); 2, 1
Chest discomfort	Y!	N	N	Y	Y	Y!	N	Y	0; 0; 5, 2
Chest pain	Y	N	N	N	Y	N	N	N	0; 0; 2, 0
Headache	N	Y (1 d)	N	Y (1 d)	Y (2 d)	N	N	N	0; 3, 1 (1-2); 0, 0
Dizziness	Y1 (2 d)	N	N	N	N	N	N	N	1; 1, 2 (2-2); 0, 0
Eye discomfort	Y1 (3 d)	N	Y (2 d)	N	N	N	N	N	1; 2, 3 (2-3); 0, 0
Backache	N	N	Y1 (3 d)	N	N	N	N	N	1; 1, 3 (3-3); 0, 0
Anorexia	N	N	N	N	Y (1 d)	Y (1 d)	N	Y	0; 2, 1 (1-1); 1, 0
Nausea	Y!	N	Y	Y	Y (1 d)	Y (1 d)	N	Y (1 d)	0; 3, 1 (1-1); 3, 1
Vomiting	Y!	N	N	Y (1 time/d)	Y! (up to 4 times/d)	Y!	N	N	0; 0; 4, 3
Diarrhea	Y! (up to 6 times/d)	Y (up to 6 times/d)	Y! (2 times/d)	Y (1 time/d)	Y! (up to 4 times/d)	N	N	Y (up to 3 times/d, 3 d)	0; 1, 3 (3-3); 5, 3
Abdominal discomfort	Y	N	N	N	Y (1 d)	N	N	N	0; 1, 1; 1, 0
≥2 upper respiratory infection symptoms before/on admission	Y	N	Y	Y	N	Y	N	Y	5/8 (63%)
≥1 digestive symptom before/on admission	N	N	N	N	Y	Y	N	Y	3/8 (38%)
Both fever and cough before/on admission	Y	N	Y	Y	N	N	Y	Y	5/8 (63%)
No. of symptoms on illness onset	5	1	5	1	2	1	4	4	3 (1-5)
No. of symptoms before/on admission	8	2	9	7	6	6	4	11	6 (2-11)
Respiratory rate on admission (breaths/min)	20	20	**22** ↑	20	18	18	18	20	20 (18-22)
Oximetry saturation on admission (%)	97	97	98	97	96	97	98	98	97 (96-98)
Heart rate on admission (beats/min)	86	82	90	90	94	86	94	92	90 (82-94)
Systolic pressure on admission (mm Hg)	120	120	**150** ↑	125	131	124	120	118	122 (118-150)
Diastolic pressure on admission (mm Hg)	80	74	**94** ↑	76	89	78	74	75	77 (74-94)

(*continued on next page*)

Table 2 (*continued*)

Characteristics	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8	Summary[1]
First chest CT findings on admission									
Pneumonia	Y (mild)	N	Y (mild)	Y (mild)	N	Y (mild)	Y (mild)	Y (mild)	6/8 (75%)
Multifocal mottling, patchy shadows, and/or ground-glass opacities	Y	N	Y	Y	N	Y	Y	Y	6/8 (75%)
Location of pneumonia	Lower lobe of right lung	-	Lower lobe of left lung	Middle and lower lobes of right lung	-	Lower lobe of right lung	Lower lobe of right lung	Middle lobe of both lungs	-
Bilateral lung involvement	N	-	N	N	-	N	N	Y	1/6 (17%)
Treatment									
Recombinant human interferon	Y (α-1b; α-2b)	Y (α-1b)	Y (α-1b; α-2b)	Y (α-1b; α-2b)	Y (α-1b)	N	Y	Y	7/8 (88%)
Lopinavir	Y	N	Y	Y	Y	Y	Y	Y	7/8 (88%)
Ritonavir	Y	N	Y	Y	Y	Y	Y	Y	7/8 (88%)
Other antiviral therapy	Y (adenosine monophosphate)	Y (ribavirin; oseltamivir)	N	N	N	N	Y (arbidol; ribavirin)	N	3/8 (38%)
Any antiviral therapy	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Levofloxacin	Y	N	Y	Y	N	N	N	N	4/8 (50%)
Moxifloxacin	N	Y	N	N	Y	Y	N	Y	3/8 (38%)
Other antibiotic therapy	N	N	N	Y (ceftazidime)	N	N	N	N	1/8 (13%)
Any antibiotic therapy	Y	Y	Y	Y	Y	Y	N	Y	7/8 (88%)
Outcomes									
Recovered	N	Y	Y	N	N	N	Y	Y	4/8 (50%)
Discharged	N	Y	Y	N	N	N	Y	Y	4/8 (50%)

[1] For symptom variables, it is shown as: number of patients with the symptom presenting on date of illness onset; number of patients with the symptom presenting before or on date of hospital admission, median (range) of the days from onset of the symptom to admission; number of patients with the symptom presenting after admission; number of patients with the symptom whose association with drug use could not be excluded; for the other variables, it is described for continuous and categorical variables, and expressed as median (range) and count/total number of patients with available data (percentage), respectively.-, not applicable; ↑, above the upper limit of the normal range; ↓, below the lower limit of the normal range; Y, Yes (symptom developed before or on admission; days from onset of the symptom through admission are shown in brackets); Y1, Yes (symptom developed on date of illness onset; days from onset of the symptom through admission are shown in brackets); Y, Yes (symptom developed after admission); Y!, (symptom developed after admission; association with drug use could not be excluded).

Table 3
Laboratory findings of the young cluster with the 2019 novel coronavirus disease, on admission to hospital[1].

Measure	Reference range	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 7	Patient 8	Summary[2]
First admitted hospital	FDCPH; FAHAMU	FDCPH	FDCPH	FDCPH	FDCPH	FDCPH	FAHAMU	FAHAMU	-
Blood routine									
White blood cell count ($\times 10^9$ cells/L)	4.00-10.00; 3.50-9.50	4.77	**2.92** ↓	5.26	**3.82** ↓	4.02	7.79	9.48	↓, 2/7 (29%)
Absolute neutrophil count ($\times 10^9$ cells/L)	2.00-7.00; 1.80-6.30	3.10	**1.20** ↓	3.60	**1.40** ↓	2.10	6.64	**7.89** ↑	↓, 2/7 (29%); ↑, 1/7 (14%)
Absolute lymphocyte count ($\times 10^9$ cells/L)	0.84-4.00; 1.10-3.20	1.23	1.27	1.04	1.75	1.46	**0.77** ↓	**0.86** ↓	↓, 2/7 (29%)
Red blood cell count ($\times 10^{12}$ cells/L)	3.50-5.50; 4.30-5.80	**5.97** ↑	4.71	**5.76** ↑	4.91	4.32	5.20	5.20	↑, 2/7 (29%)
Hemoglobin (g/L)	110-160; 130-175	**162** ↑	132	**166** ↑	151	125	152	159	↑, 2/7 (29%)
Hematocrit (%)	37.0-50.0; 40.0-50.0	49.3	42.4	49.2	45.5	38.5	46.6	46.8	AN
Platelet count ($\times 10^9$ cells/L)	100-300; 125-350	217	209	218	132	246	165	219	AN
Coagulation function									
Prothrombin time (sec)	10.5-14.5; 11.0-16.0	10.9	**10.4** ↓	11.2	12.0	11.7	13.9	15.0	↓, 1/7 (14%)
Activated partial thromboplastin time (sec)	20.0-40.0; 28.0-42.0	26.0	21.8	28.4	**42.2** ↑	25.4	40.5	39.5	↑, 1/7 (14%)
International normalized ratio	0.80-1.20; 0.85-1.15	0.94	0.89	0.96	1.04	1.01	1.06	**1.16** ↑	↑, 1/7 (14%)
Fibrinogen (g/L)	2.00-4.00; 2.00-4.00	3.76	2.38	2.95	2.59	2.41	3.83	3.47	AN
D-dimer (μg/L)	0.00-0.55; 0.00-0.50	-	-	-	0.19	0.19	0.20	0.27	AN
Blood biochemistry									
Total protein (g/L)	65.0-85.0; 63.0-82.0	80.9	65.6	78.0	65.6	69.4	71.2	82.0	AN
Albumin (g/L)	40.0-55.0; 35.0-50.0	53.6	43.4	53.3	40.4	42.8	45.5	47.2	AN
Pre-albumin (mg/L)	200-400; -	261	281	257	**150** ↓	**147** ↓	-	-	↓, 2/5 (40%)
Alanine aminotransferase (U/L)	5-50; 21-72	30	14	20	12	11	27	**20** ↓	↓, 1/7 (14%)
Aspartate aminotransferase (U/L)	13-40; 17-59	29	22	24	16	18	24	29	AN
Alkaline phosphatase (U/L)	40-130; 38-126	84	79	104	78	71	51	78	AN
Total bilirubin (μmol/L)	5.0-20.0; 3.0-22.0	9.0	7.4	10.5	7.8	12.2	12.2	**25.8** ↑	↑, 1/7 (14%)
Direct bilirubin (μmol/L)	0.0-7.0; -	2.1	1.6	2.1	2.1	3.2	-	-	AN
Serum creatinine (μmol/L)	44.0-106.0; 58.0-110.0	69.0	69.6	69.6	83.9	57.7	78.8	104.5	AN
Blood urea nitrogen (mmol/L)	2.76-8.07; 3.20-7.10	4.79	3.84	5.19	3.07	3.51	4.10	4.80	AN
Creatine kinase (U/L)	38-174; 55-170	95	58	**234** ↑	104	74	**52** ↓	66	↓, 1/7 (14%); ↑, 1/7 (14%)
Lactate dehydrogenase (U/L)	110-240; -	224	163	240	111	151	-	-	AN
Hypersensitive troponin I (ng/mL)	-; 0.000-0.034	-	-	-	-	-	0.01	0.01	AN
Myoglobin (ng/mL)	-; 10-46	-	-	-	-	-	**8** ↓	14	↓, 1/2 (50%)
Potassium (mmol/L)	3.50-5.30; 3.50-5.10	4.88	4.50	4.44	4.68	4.08	4.16	4.17	AN
Sodium (mmol/L)	137.0-147.0; 137.0-145.0	141.2	140.4	140.9	141.5	141.8	138.8	137.4	AN
Calcium (mmol/L)	2.15-2.75; 2.10-2.55	2.40	2.23	2.38	2.23	2.28	2.40	2.33	AN
Chloride (mmol/L)	96.0-110.0; 98.0-107.0	107.6	101.0	103.9	103.0	101.5	101.3	**95.2** ↓	↓, 1/7 (14%)
Infection-associated biomarkers									
C-reactive protein (mg/L)	0.00-7.44; 0.00-10.00	**8.01** ↑	-	4.61	2.59	6.18	2.65	1.04	↑, 1/6 (17%)
Procalcitonin (ng/mL)	0.000-0.046; 0.000-0.050	< 0.010	0.032	< 0.010	**0.051** ↑	0.039	-	0.05	↑, 1/6 (17%)
Erythrocyte sedimentation rate (mm/h)	0-15; -	**19** ↑	-	6	**20** ↑	7	-	-	↑, 1/4 (25%)

[1] Laboratory findings for Patient 6 whose blood was initially examined in the Hefei City Infectious Disease Hospital have not been obtained.
[2] Summary data are count/total number of patients with available data (percentage) for abnormal values.-, not available; ↑, value above the upper limit of the normal range; ↓, value below the lower limit of the normal range; AN, all measured values were within normal range; FDCPH, Feidong County People's Hospital; FAHAMU, First Affiliated Hospital of Anhui Medical University.

Table 4
Close contacts of the index patient admitted to hospital and testing negative for SARS-CoV-2 on rRT-PCR for at least two times.

Variable	Contact 1	Contact 2	Contact 3	Contact 4	Contact 5	Contact 6	Contact 7	Contact 8	Contact 9
Baseline characteristics									
Relationship with index patient	Uncle	Classmate	Classmate	Classmate	Classmate	Classmate	Classmate	Classmate	Classmate
Male sex	Y	N	Y	Y	Y	Y	Y	Y	Y
Age (years)	43	23	23	21	23	21	23	23	24
Current smoker	Y	N	N	N	N	N	N	N	N
Exposure									
Date of exposure	Jan 19	Jan 20	Jan 21	Jan 21	Jan 21	Jan 21	Jan 21	Jan 21	Jan 21
Exposure place	Apartment in Feidong	Hotpot restaurant in Feidong	Restaurant & Karaoke room with shared toilet in Feidong	Restaurant & Karaoke room with shared toilet in Feidong	Restaurant & Karaoke room with shared toilet in Feidong	Restaurant & Karaoke room with shared toilet in Feidong	Restaurant & Karaoke room with shared toilet in Feidong	Restaurant & Karaoke room with shared toilet in Feidong	Restaurant & Karaoke room with shared toilet in Feidong
Description of exposure place	Confined room without air conditioning	Room with air conditioning	Room with window open and air conditioning	Room with window open and air conditioning	Room with window open and air conditioning	Room with window open and air conditioning	Room with window open and air conditioning	Room with window open and air conditioning	Room with window open and air conditioning
Exposure duration	1.5 h	1 h	5 h	5 h	5 h	5 h	5 h	5 h	5 h
Clinical characteristics									
Fever	Y (0.5 d; Jan 27; subjective)	Y (0.5 d; Jan 26)	N	N	N	N	N	N	Y (5 h; Jan 26)
Body temperature on admission (°C)	36.6	36.6	36.7	36.2	36.8	36.7	36.6	36.7	36.5
Highest body temperature (°C)	-	37.6 (Jan 26; self-measured)	-	-	-	-	-	-	37.3 (Jan 26; self-measured)
Signs on admission									
Respiratory rate (breaths/min)	20	20	20	20	20	20	20	19	18
Oximetry saturation (%)	98	97	97	97	97	97	96	98	98
Heart rate (beats/min)	80	80	90	76	78	88	78	99	90
Systolic pressure (mm Hg)	127	127	140	120	137	115	125	**141 ↑**	120
Diastolic pressure (mm Hg)	81	81	**96 ↑**	80	77	83	84	81	80
Laboratory findings on admission									
White blood cell count ($\times 10^9$ cells/L)	4.62	4.08	5.99	**3.84 ↓**	8.19	6.55	5.99	**3.76 ↓**	8.99
Neutrophil count ($\times 10^9$ cells/L)	2.90	**1.50 ↓**	3.60	**1.90 ↓**	5.00	3.40	3.30	**1.60 ↓**	4.80
Lymphocyte count ($\times 10^9$ cells/L)	1.06	2.04	1.77	1.35	2.57	2.49	2.19	1.54	2.68
Red blood cell count ($\times 10^{12}$ cells/L)	4.81	3.91	**5.58 ↑**	4.65	**5.54 ↑**	5.22	**5.57 ↑**	5.02	4.77

(*continued on next page*)

Table 4 (*continued*)

Variable	Contact 1	Contact 2	Contact 3	Contact 4	Contact 5	Contact 6	Contact 7	Contact 8	Contact 9
Hemoglobin (g/dL)	151.0	121.0	**168.0 ↑**	148.0	155.0	141.0	157.0	145.0	141.0
Hematocrit (%)	45.70	**36.30 ↓**	49.50	43.60	47.20	44.10	48.00	45.30	43.00
Platelet count ($\times 10^9$ cells/L)	177	200	219	192	203	234	191	206	226
Prothrombin time (s)	**9.10 ↓**	11.30	12.20	12.20	12.10	12.00	10.60	12.10	11.00
Activated partial thromboplastin time (s)	23.90	28.20	30.40	34.80	26.40	26.20	25.40	22.90	25.30
International normalized ratio	**0.78 ↓**	0.97	1.05	1.05	1.04	1.04	0.91	1.04	0.95
Fibrinogen (g/L)	2.08	**1.65 ↓**	2.00	**1.86 ↓**	2.02	2.67	**1.93 ↓**	2.52	2.10
Total protein (g/L)	66.1	67.2	-	69.3	74.1	75.0	**63.9 ↓**	76.4	72.0
Albumin (g/L)	45.5	44.1	-	46.8	48.1	48.1	44.4	46.6	49.9
Pre-albumin (mg/L)	392	**164 ↓**	-	285	230	245	284	258	317
Alanine aminotransferase (U/L)	19	6	-	9	32	22	43	19	38
Aspartate aminotransferase (U/L)	20	20	34	14	28	21	32	20	28
Alkaline phosphatase (U/L)	55	50	-	90	93	49	104	52	97
Total bilirubin (μmol/L)	11.3	13.6	-	12.6	18.7	14.1	11.9	9.6	5.0
Direct bilirubin (μmol/L)	1.9	2.8	-	2.8	4.0	3.0	2.5	1.8	0.7
Serum creatinine (μmol/L)	66.5	57.3	82.3	57.6	80.4	88.1	67.6	76.5	91.9
Blood urea nitrogen (mmol/L)	3.38	2.87	4.71	4.60	5.31	6.10	**2.46 ↓**	5.13	6.36
Creatine kinase (U/L)	60	105	64	61	104	59	89	58	**240 ↑**
Lactate dehydrogenase (U/L)	134	136	159	123	149	115	154	144	176
Potassium (mmol/L)	3.94	3.82	4.76	4.01	4.19	3.96	**5.34 ↑**	4.27	4.76
Sodium (mmol/L)	145.5	144.7	144.1	142.4	144.7	140.7	145.1	143.3	142.8
Calcium (mmol/L)	2.31	2.36	2.47	2.37	2.49	2.40	2.39	2.49	2.53
Chloride (mmol/L)	105.0	109.3	102.6	100.0	101.3	105.9	102.6	102.3	102.3
C-reactive protein (mg/L)	-	-	0.60	0.31	1.67	-	0.23	-	0.91
Procalcitonin (ng/mL)	0.044	0.046	0.039	-	**0.074 ↑**	**0.055 ↑**	0.033	**0.055 ↑**	$<$ 0.01
Erythrocyte sedimentation rate (mm/h)	-	8	3	4	6	11	8	**37 ↑**	2
SARS-CoV-2 testing									
1st sampling date	Jan 27	Jan 27	Jan 27	Jan 27	Jan 27	Jan 27	Jan 27	Jan 27	Jan 28
1st sampling result	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
2nd sampling date	Jan 28	Jan 28	Jan 28	Jan 28	Jan 28	Jan 28	Jan 28	Jan 28	Jan 29
2nd sampling result	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
Date of discharged to home isolation	Jan 31	Feb 1	Feb 1	Jan 31	Jan 31	Jan 31	Feb 1	Jan 31	Jan 31

-, not available; ↑, above normal range; ↓, below normal range; Y, Yes; N, No; rRT-PCR, real-time reverse-transcriptase polymerase-chain-reaction.

patients (p=0.016). Plasma-concentrations of C-reactive-protein were markedly higher in SARS-CoV-2-positive patients (p=0.016).

Management and outcomes of the eight youngsters with laboratory-confirmed COVID-19, and description of all the other contacts are detailed in *Supplementary results*.

Discussion

Currently, our understanding of the spectrum and natural-history of SARS-CoV-2-infection remains limited. We herein provide an assessment of the infectivity, transmission dynamics, and other characteristics of a cluster of eight young-patients aged 16-23 years confirmed with SARS-CoV-2 on rRT-PCR originating from Patient-Index returning from Wuhan who rapidly transmitted COVID-19 when totally asymptomatic, and compare them to the other nine close-contacts of Patient-Index testing negative for SARS-CoV-2. The disease was transmitted outside Wuhan and all patients were diagnosed and managed in Hefei. The young patients admitted with COVID-19 had fast illness-onset and symptoms somehow resembling a common-cold, which were much milder than those of older hospitalized adults with COVID-19 as recently-reported.[1,2,10] While patchy-shadows and ground-glass-opacity on CT-scan were common, they were much less severe than the older patients.[2,10] Not all patients had radiological-changes indicating viral-pneumonia on admission.

Notably, our findings provide valid evidence demonstrating efficient local human-to-human-transmission with strong infectivity of SARS-CoV-2 within this cluster of youngsters during the incubation-period and asymptomatic-phase of COVID-19. SARS-CoV-2 tested positive in six of the 15 young classmates Patient-Index contacted in the get-together when he was totally asymptomatic, with the minimal exposure-duration of only two hours. The attack-rate is high (40%). The symptoms of Patients-4 and 8 developed on the same day as that of Patient-Index. We carefully had interviews directly with both Patient-Index himself and all the other contacts to confirm the absence of any symptoms of Patient-Index before and during the contacts, thus ascertaining the transmission during asymptomatic-phase. We may need to pay special attention to preventing COVID-19 transmission from people looking asymptomatic but with exposure-history. The incubation-period and serial-interval in this young cluster were much shorter than previously-reported for majorly older patients at the earlier stage of the epidemic.[1]

Infected-youngsters may act as important sources-of-infection. Notably, Patient-6 remained afebrile throughout the disease-course. These cryptic cases of walking-SARS-CoV-2-infection might act as potential sources to propagate the epidemic. Since it is difficult to differentiate and screen patients during the incubation-period, further studies on the popularity of this transmission-pattern and the epidemiological-significance of cases with null or mild symptoms are warranted, which would help make relevant control-measures to prevent the future spread of infection. It may be needed to commit sufficient resources to examination in outpatient-clinics and emergency-departments for proactive case-identification, both as part of the containment-strategy in locations without local-spread yet and to permit earlier clinical-management of infected-individuals.

The most likely transmission-scenario is that Patient-Index acquired the SARS-CoV-2-infection in Wuhan, and then transmitted the virus to Patient-2 after two contacts and Patients-3-8 during get-together on January 21 after returning to Feidong on January 19. Patient-2 more likely acquired the infection during the second contact on January 23 with an incubation-period of three days rather than on January 19, since Contacts-1 and 2, with whom Patient-Index had close-contacts in the evening on January 19 and on January 20, respectively, did not develop the infection. These indicate the relatively weak infectivity up till January 20, and the possibility of dynamic changes in infectivity, which possibly became strong enough to enable the disease to affect others sometime on January 20 or 21, still during the incubation-period of Patient-Index. Further studies on the diverse infectivity during different stages of disease and the corresponding time-points are warranted.

Almost half of the previously-reported cases were in adults aged ≥60 years.[1] Younger patients were thought to be less likely infected.[1] Few reports exist on younger patients aged 15–25 years. Delays from illness-onset to admission were generally short in these eight youngsters with COVID-19 in our study, with five hospitalized within two days of illness-onset. The symptoms of these youngsters were all mild and largely-nonspecific, which may be hardly clinically-distinguishable from many other common infectious-diseases, particularly in winter.

The first three most common symptoms on illness-onset were fever, cough, and sore-throat. None initially presented with a digestive-symptom. On admission, half or more of the youngsters with COVID-19 presented with fever, cough, sputum-production, nasal-congestion, and fatigue, which are much milder than previous reports including majorly older hospitalized-patients with frequent comorbidities, who may have lower immune-function than younger people.[2,10] Fever developed in seven of the eight youngsters, with six having fever on illness-onset. Three youngsters developed one or more digestive-manifestations before or on admission, which are more frequent than the previous report on older hospitalized-patients.[2,10] Patient-8 developed diarrhea before admission. About 11% of SARS-CoV[14] and 30% of MERS-CoV patients[15] also had diarrhea. None of the abovementioned symptoms was present in all youngsters. Notably, two youngsters presented with eye-discomfort on admission (one had itchy-eyes as the very initial symptom) and one with backache at illness-onset, which appears to not have been observed in older patients.[2,10]

For the six youngsters showing pneumonia on admission, multifocal ground-glass opacities typical of viral-pneumonia on chest-CT-scans were frequently seen, while their lung-involvement was much milder and more local and limited than older patients.[2,10] Unlike older patients typically having bilateral-pneumonia,[2,10] the pneumonia youngsters mostly had showed unilateral lung-involvement on admission.

Regarding laboratory-examinations, two patients had leucopenia. The absolute neutrophil-counts were reduced in the same two patients, while they were elevated in another patient. Furthermore, lymphopenia occurred in two patients, and two youngsters had both elevated red-blood-cell-count and hemoglobin level. These changes were not consistent with the previous report on older patients with more severe conditions.[10] These may suggest diverse immune-status against the virus. Neutrophilia may be related to cytokine-storm induced by SARS-CoV-2 invasion. Compared with SARS-CoV-2-negative contacts, SARS-CoV-2-positive patients had fewer lymphocytes and higher fibrinogen and C-reactive-protein levels. These suggest that SARS-CoV-2-infection may be associated with deficiency in immune-function and activation of coagulation, which could have been related to inflammatory-response.

As of February 20, 2020, none of the eight young patients had dyspnea, developed any severe clinical-conditions, complications, or adverse-outcomes, were admitted to an intensive-care-unit, required machine-ventilation, or died, which is largely different from the findings in older patients.[2,3,10] They mostly remained stable during hospitalization. These suggest that age, comorbidity, and symptoms on illness-onset or admission may be important prognostic factors.

Our study has some limitations. First, the case number is limited, which necessitates the cautious interpretation of the generalizability of our findings. Collection of data for a larger

cohort would help to enable a more comprehensive understanding of COVID-19 among youngsters. Second, the route of transmission was not totally clear. While the most likely one was via droplets or aerosol or airborne, we did not collect urine or fecal samples, which prevented us from analyzing whether COVID-19 could be transmitted through the fecal-oral pathway. Third, the relative-risk of infection among youngsters compared to older individuals and the association of timing or mode of manifestations and CT and laboratory findings with disease-course, outcomes, and spread need to be further evaluated. Fourth, the serum of patients and contacts was not obtained to evaluate possible viremia. Respiratory-tract samples were used to diagnose COVID-19 through rRT-PCR according to the guidelines,[1,16–19] and they have a higher positive rate than blood and other samples and are more clinically and epidemiologically relevant.[20] There could have been transient viremia in the SARS-CoV-2-negative contacts, which was not captured on admission. The corresponding epidemiological and clinical significances need to be further clarified.

Conclusion

We provide valid evidence supporting efficient asymptomatic human-to-human transmission of SARS-CoV-2 showing strong infectivity based on a cluster of youngsters aged 16–23 years in a local community setting outside Wuhan. COVID-19 was rapidly transmitted by the index patient during the (late) incubation-period to other seven youngsters, demonstrating strong infectivity. The symptoms of the youngsters with COVID-19 had fast-onset, and were generally mild, nonspecific, atypical, and diverse.

Declaration of Competing Interest

None reported.

Author contributions

Drs Lei Huang, Xiuwen Zhang, Xinyue Zhang, and Zhijian Wei contributed equally to this article. LH, XWZ, CYZ, and AMX had the idea for the study and full access to all data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. LH is an epidemiologist and physician scientist with clinical epidemiology as the major subject and public health and statistics as subjects during his PhD, XWZ is an infectious disease specialist with rich work experience in isolation ward, XYZ is a statistician, ZJW is a physician scientist, LLX and JJX have rich experience in clinical communication and data collection, PPL is an emergency medicine specialist, YHX is a professor of laboratory medicine, CYZ is a respiratory medicine and critical care medicine specialist, and AMX is a physician scientist with interest in clinical epidemiology and public health. LH, XWZ, ZYZ, ZJW, CYZ, and AMX played roles in the literature search, study conception and design, patient recruitment, clinical management, sample collection, data collection, analysis, and interpretation, and writing of the report. LLZ, JJX, and YHX played roles in the laboratory assays, data collection, analysis, interpretation, and confirmation and critical revision of the report. PPL played roles in recruitment, clinical management, data collection, and critical revision of the report. All authors reviewed and approved the final version of the manuscript. AMX is the guarantor. The corresponding authors attest that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Role of the funders/sponsors

None of the funders had any role in the study design and the collection, analysis, and interpretation of data or in the writing of the article and the decision to submit it for publication. The researchers confirm their independence from funders.

Data sharing

The data that support the findings of this study are all included in the manuscript, with no additional data available.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jinf.2020.03.006.

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