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Characteristics of Nosocomial Infections in Children Screened for SARS-CoV-2 Infection in China

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Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

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Background: This study summarizes the characteristics of children screened for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection and reports the case of 1 child who was diagnosed with SARS-CoV-2 infection in Guangzhou Women and Children's Medical Center and the cases of his family members.

Material/Methods: The medical records of 159 children who were admitted to our hospital from January 23 to March 20, 2020, were retrospectively analyzed. Samples from pharyngeal or/and anal swabs were subjected to reverse-transcription polymerase chain reaction (RT-PCR) testing for SARS-CoV-2 within 12 h of patient admission; a second RT-PCR test was done 24 h after the first test.

Results: Of the 159 patients, 151 patients had epidemiological histories, 14 patients had cluster onset, and 8 patients had no epidemiological history but had symptoms similar to coronavirus disease 2019 (COVID-19). The most common symptom was fever (n=125), followed by respiratory and gastrointestinal symptoms. A 7-year-old boy in a cluster family from Wuhan was confirmed with asymptomatic SARS-CoV-2 infection with ground-glass opacity shadows on his lung computed tomography scan, and his swab RT-PCR test had not turned negative until day 19 of his hospitalization. In patients who did not test positive for SARS-CoV-2, influenza, respiratory syncytial virus, and adenovirus were observed. A total of 158 patients recovered, were discharged, and experienced no abnormalities during follow-up.

Conclusions: For SARS-CoV-2 nosocomial infections, taking a "standard prevention & contact isolation & droplet isolation & air isolation" strategy can prevent infection effectively. Children with clustered disease need close monitoring.

MeSH Keywords: COVID-19 • Multiphasic Screening • Pandemics • Pediatrics • Primary Prevention

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Background

The novel coronavirus infection named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by the Coronaviridae Study Group of the International Committee on Taxonomy of Viruses first occurred in China in December 2019 [1]. The World Health Organization named the disease caused by SARS-CoV-2 infection coronavirus disease 2019 (COVID-19) [2]. With the approval of the State Council and as stipulated in the Law of the People's Republic of China on the Prevention and Control of Infectious Diseases, COVID-19 was included in the Class B of infectious diseases; however, measures for the prevention and control of Class A infectious diseases have been adopted for COVID-19 [3].

There have been various types of reports from Guangzhou, China, on COVID-19, which have improved our understanding of the disease, including reports on the transmission via air-conditioning [4], temporal patterns of viral shedding [5], authenticity of reverse-transcription polymerase chain reaction (RT-PCR) testing [6], and efficacy of chloroquine as a treatment option [7].

It has been reported that from a total of 72 314 cases, fewer than 1% were in children younger than 10 years of age [8]. While the majority of children infected by SARS-CoV-2 have a registered household contact with COVID-19 [9], it was found that children have milder symptoms than adults and infants are vulnerable to infection [10]; also, asymptomatic infections in children are not uncommon [11].

Our hospital center was designated for the screening and treatment of children with COVID-19 in Guangzhou, and has been screening and managing pediatric patients to control the spread of the epidemic in Guangzhou. To the best of our knowledge, there have not been any studies reporting the epidemiology and screening of children from this area. Therefore, to shed light on the situation in Guangzhou, this study sought to delineate the clinical characteristics of the children who were screened for SARS-CoV-2 infection using the "standard prevention & contact isolation & droplet isolation & air isolation" strategy.

Material and Methods

Patients

This retrospective study included 159 children who were screened for SARS-CoV-2 infection in the Guangzhou Women and Children's Medical Center from January 23 to March 20, 2020. Children who were younger than 18 years old and met the screening and diagnostic criteria as a suspected case according to the Consensus of Experts in the Diagnosis and Treatment of Children with SARS-CoV-2 Infection in Guangdong Province [12] were selected. The diagnostic criteria of a suspected case included epidemiological history (travel or residence history in Wuhan or in Wuhan's surrounding areas or in communities with confirmed infection cases within 14 days before the onset of illness; history of contact with patients with SARS-CoV-2 infection (positive RT-PCR test) within 14 days before onset; history of contact with patients with fever or respiratory symptoms from Wuhan, Wuhan's surrounding areas, or communities with confirmed cases within 14 days before onset; cluster onset and clinical features (fever and/or respiratory symptoms; radiological imaging results characteristic of pneumonia; normal or decreased white blood cells count in the early stages of onset or decreased lymphocyte count). Diagnosis was based on the presence of 1 of the epidemiological histories and 2 of the clinical features. If there was no clear epidemiological history, 3 of the clinical features were considered for a positive diagnosis.

Patients were excluded if 2 pharyngeal or/and anal swab samples taken for viral nucleic acid RT-PCR tests more than 24 h apart after admission were both negative.

This study was approved by the ethics committee of the hospital (No. 2020-25001) and the requirement for informed consent was waived.

Strategy and screening method

A "standard prevention & contact isolation & droplet isolation & air isolation" strategy was used to control nosocomial infection of SARS-CoV-2 (Supplementary Material). Patients' pharyngeal or/and anal swab samples were taken within the first 12 h of admission and tested by real-time fluorescent RT-PCR for detection of SARS-CoV-2 nucleic acids. A second RT-PCR test was performed 24 h after the first test.

Treatment after screening

Confirmed cases were transferred to the "confirmed ward", and severe or critical patients were transferred to the pediatric intensive care unit. Patients were discharged and a 14-day quarantine at home was advised when both RT-PCR tests were negative. Patients were transferred to another specialty ward to continue isolated treatment if both RT-PCR tests were positive.

Data collection and follow-up

Detailed demographic data, clinical characteristics at admission, and hematologic and imaging indicators of the included patients were extracted from the structured electronic medical records system.

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Table 1. Patient's characteristics.

	Total (n=159)	
Female, n (%)	61	(38.4)
Age, month, median (Q1, Q3)	34	(15, 60)
Age, n (%)		
<1 month	0	
1 month to 1 year	30	(18.9)
1 year to 3 year	69	(43.4)
3 year to 7 year	39	(24.5)
>7 year	21	(13.2)
Onset, day, median (Q1, Q3)	2	(1, 4)
Days of hospitalization in screening wards, day, median (Q1, Q3)	2	(1, 2)
Hours of waiting for the first SARS-CoV-2 RT-PCR test report, mean±SD	9.1±2.6	
Epidemiology, n (%)		
Travel or residence history to Wuhan and surrounding areas, or other communities with confirmed cases within 14 days before the onset of illness	103	(64.8)
History of contact with SARS-CoV-2 infected persons (positive RT-PCR test) within 14 days before the onset of illness	2	(1.3)
Patients with fever or respiratory symptoms from Wuhan or surrounding areas, or from communities with confirmed cases, within 14 days before the onset of illness	41	(25.8)
Cluster onset	14	(8.8)
Non-epidemiological cases	8	(5.0)
Clinical manifestations, n (%)		
Fever	125	(78.6)
Cough/dry cough	77	(48.4)
Sputum production	73	(45.9)
Runny nose	37	(23.3)
Vomiting/diarrhea/ abdominal pain	19	(11.9)
Pulmonary rales	15	(9.4)
Stuffy nose	10	(6.3)
Gasping	10	(6.3)
Tachypnea	6	(3.8)
Seizure	4	(2.5)
Inspiratory triconcave sign/ cyanosis	3	(1.9)
Sore throat	2	(1.3)
Chest pain	1	(0.6)
Myalgias	1	(0.6)
Dizziness/headache	1	(0.6)
Respiratory failure	0	

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Table 1 continued. Patient's characteristics.

	Total (n=159)	
Pulmonary imaging findings (Yes: No=155:4)		
X-ray (n=114)		
No abnormalities	7	(61.4)
Bronchiti	67	(58.8)
Pneumonia	40	(25.2)
CT (n=41)		
No abnormalities	13	(31.7)
Bronchitis	0	
Pneumonia	28	(68.3)
Patchy	13	(46.4)
Ground-glass opacities shadow	5	(17.9)
Strip-like	4	(32.1)
Nodular	1	(3.6)
Consolidation	5	(17.9)
Outcomes		
Healed and discharged	144	(90.6)
Transferred to Confirmed Ward	1	(0.6)
Transferred to other wards	15	(9.4)
Transferred to PICU	1	(0.6)
Follow-up after 21 days		
Normal status	158	(99.4)
Still in hospital	1	(0.6)

All patients were followed up by telephone from 3 days to 3 weeks after discharge. Their family members completed screening tests by viral nucleic acid testing at designated adult hospitals. The follow-up calls collected the subsequent clinical manifestations of the children and family members and the RT-PCR test results of family members at designated adult medical facilities.

Statistical analysis

Statistical analyses were performed using SPSS 22.0 (IBM, Armonk, NY, USA). Descriptive statistics were used to interpret the patterns of the clinical characteristics. The *t* test was used to detect differences in occurrence timing of each etiology group. The count data were expressed as n (%). The comparison between the 2 samples was performed by the Fisher's Exact probability test and the χ^2 test. Two-sided *P* values <0.05 were considered statistically significant.

Results

General patient characteristics

Among the 159 included patients (98 boys and 61 girls), the median age was 34 months (interquartile range: 15, 60); onset occurred an average of 4.79 days after exposure and the average length of hospitalization in the suspected-infection screening wards was 1.61 days (Table 1). The screening flow chart is shown in Figure 1.

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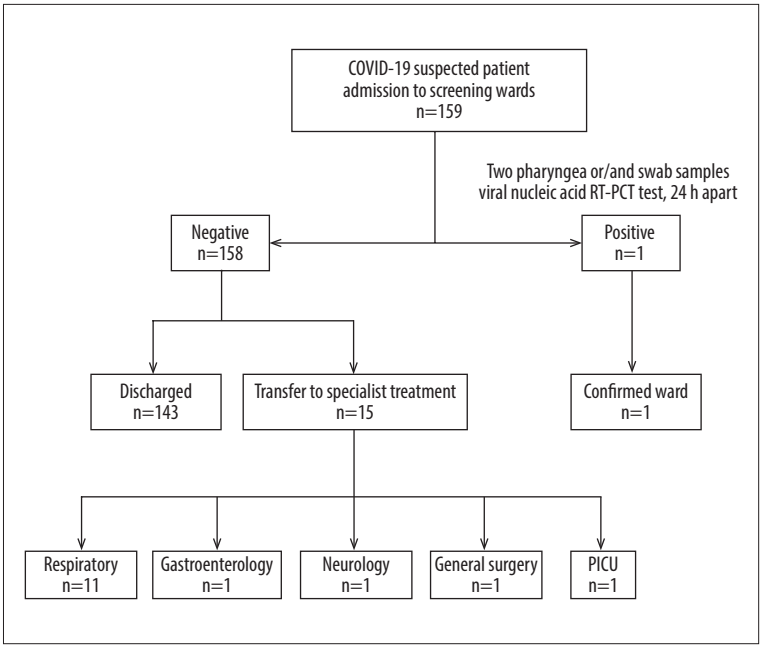

Figure 1. Screening and distribution of suspected patients with COVID-19.

Epidemiology

A total of 64.8% of the study population had travel, residence history of travel, or residence in Wuhan or its surrounding areas or in communities with confirmed cases within 14 days before symptom onset. Among the 2 patients who had a history of contact with infected persons, 1 was confirmed with SARS-CoV-2 infection while the other was found negative by RT-PCR testing. The 25.8% of the population who had history of contact with a patient who had fever or respiratory symptoms from the epidemic area within 14 days before onset tested negative. Fourteen cases had cluster onset and 8 cases had no epidemiological history but had symptoms similar to those of COVID-19. There were 10 families of cluster cases without pathogenic microorganisms detected; however, among them, there were clusters of illnesses in close contact with symptomatic patients in the Hubei epidemic area (Table 1).

Some patients showed unconventional test results and clinical symptoms. Ground-glass opacity (GGO) changes in the chest CT scan was found in a 13-year-old asymptomatic sibling of a patient with confirmed COVID-19 (Figure 2), and she was negative for pharynx and anal swab RT-PCR tests for SARS-CoV-2. Four patients had other detected etiologies, including *Staphylococcus humane* (sepsis), *Klebsiella pneumoniae* (pneumonia), *Escherichia coli* (urinary tract infection), and mumps. There were 10 families of cluster cases without pathogenic microorganisms detected; however, among them, there were clusters of illnesses in close contact with symptomatic patients in the Hubei epidemic area (Table 1).

Clinical characteristics

The clinical manifestation of 159 patients is shown in Table 2. Fever was the most common symptom (n=125), followed by respiratory symptoms (cough=77, sputum=73, and runny nose=37) and gastrointestinal symptoms (vomiting, diarrhea, and abdominal pain). However, a patient with confirmed COVID-19 was asymptomatic, but GGOs were seen in the anterior basal segment of his right lung by CT scanning (Figure 3). No pathogens were detected in 103 patients.

Laboratory evaluation of 57 cases detected non-SARS-CoV-2 etiology, including 2 patients with 2 pathogenic infections (Table 2).

Presentation of 2 families with SARS-CoV-2 infection

In family 1, a 7-year-old boy (case A) with a history of a cluster onset family from Wuhan was confirmed with SARS-CoV-2 by RT-PCR from an anus swab. His early throat swab RT-PCR tests were negative and his anus swab did not turn negative until day 19 of his hospitalization. His chest CT scan showed small GGOs in the right lung (Figure 3). Case A with his family members (grandfather, case B; grandmother, case C; father, case D; mother, case E; and sister, case F) settled in Wuhan before the outbreak of COVID-19 disease in December 2019. On January 22, 2020, they took the high-speed train (G77) from Wuhan to their home in Guangzhou and underwent self-quarantine at home. Case C developed fever on February 11, and later regressed without medical treatment. Case B developed fever on February 15, tested positive for SARS-CoV-2 on February 20, and was hospitalized for isolation treatment. The other family

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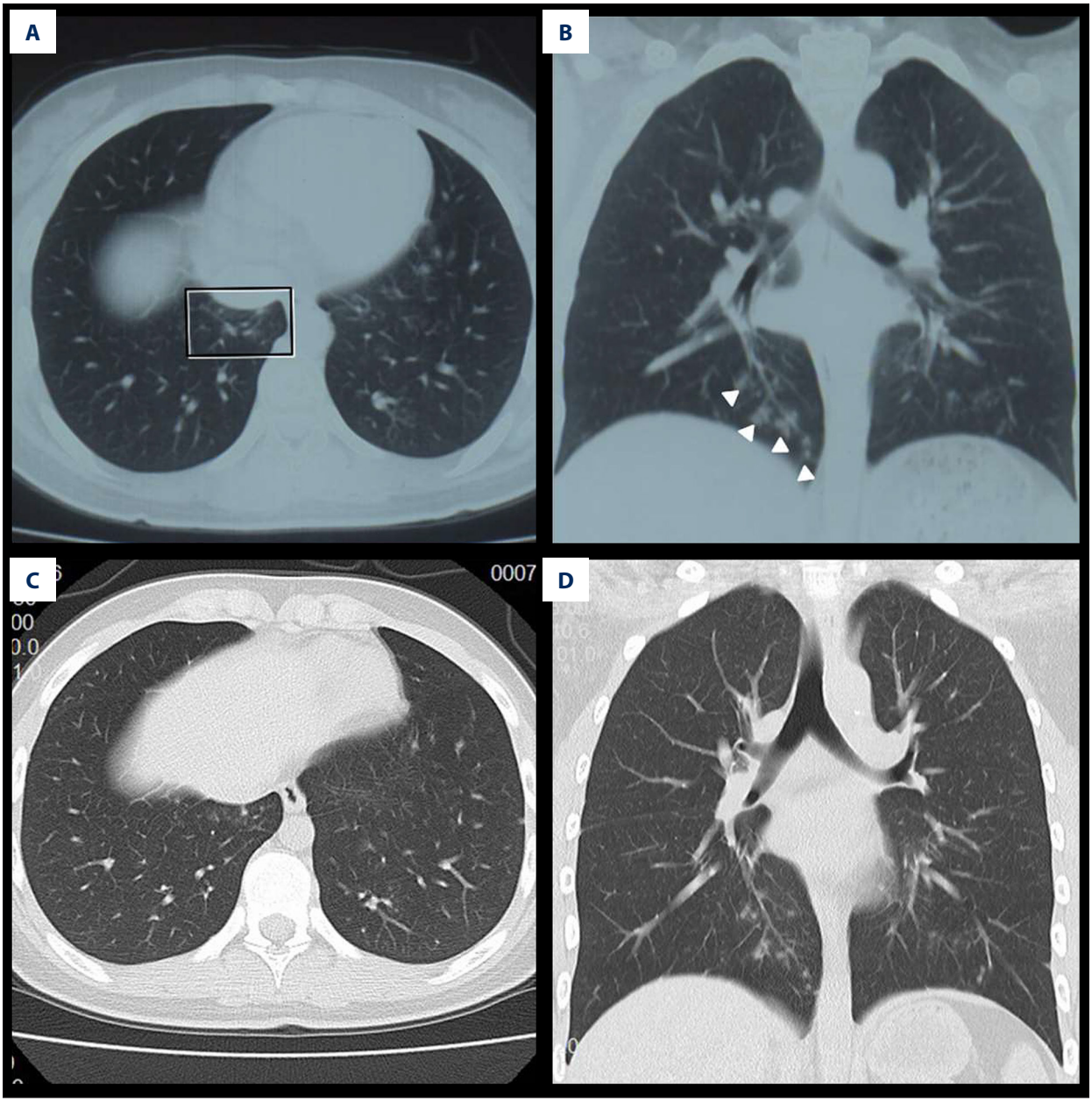

Figure 2. Computed tomography images of a 13-year-old girl (case F from family 1) 2 days after exposure to patients positive for COVID-19 (grandfather and father). (**A**) Ground-glass opacities and (**B**) nodules (arrow) were seen in the medial-basal segment of the right lung. Five days later, the ground-glass opacities were (**C**) absorbed and the nodules were (**D**) smaller.

members were tested by SARS-CoV-2 RT-PCR throat swab tests the next day. Case C tested negative and was isolated at home for observation. The test was positive in case D, who had no fever, cough or other discomforts, and was hospitalized for isolation. Cases E and F were asymptomatic and negative by the RT-PCR test for SARS-CoV-2. However, case F, a 13-year-old girl, showed a similar GGO shadow as her brother (case A) on her chest CT scan (Figure 2) and tested negative multiple times by pharynx and anal swab RT-PCR tests for SARS-CoV-2. These cases are represented in Figure 3, top panel.

Family 2 had 3 members (cases G–I, Figure 4, bottom panel) who lived in Xiaogan, Hubei, and went to Guangzhou on January 24, 2020. Case G, a 1-year-old boy, was admitted to the hospital on February 14, 2020, for fever. CT examination showed a few patchy shadows in the anterior segment of the right upper lobe. A throat swab was negative by RT-PCR testing for SARS-CoV-2. He and his family members, father (case H) and mother (case I), returned to Xiaogan, Hubei, by car from January 20 to 24, 2020, and had contacted relatives who returned from Wuhan and had no fever, cough, or

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other symptoms. On January 24, the family drove home from Xiaogan, Hubei to Guangzhou. Case H had fever on the same day, accompanied by fatigue and pain in both lower extremities. His blood tests and chest CT scan were normal on January 24, but ground-glass nodules in the right upper lobe were revealed on a duplicate CT scan on February 9th, and no SARS-CoV-2 RT-PCR test was performed. From February 13, case I had a mild cough and runny nose without fever and was negative for SARS-CoV-2 by a RT-PCR test.

Etiology of non-SARS-CoV-2 patients

Influenza virus was most common (n=14) in the non-SARS-CoV-2 patients, followed by respiratory syncytial virus and adenovirus. Most patients' blood cell counts and C-reactive protein levels indicated common viral infection, and the blood cell counts and C-reactive protein levels of patients with bacterial infections were consistent with the changes.

Pulmonary imaging examination was done for 154 patients (96.86%) within 24 h of admission, including 112 X-ray examinations and 42 CT examinations. X-ray results showed 7 patients with no abnormal manifestations, while 62 were diagnosed with bronchitis and 43 were diagnosed with pneumonia. The results of a CT examination showed no abnormalities in 13 patients and pneumonia in 29 patients. GGOs were observed in 4 patients with pneumonia, of which 1 SARS-CoV-2-infected patient presented GGOs in the lateral segment of the right middle lobe, mainly distributed in the periphery of the lung. In 3 other cases with GGOs, 1 case had human

Table 2. Clinical characteristics of the 159 patients screened for SARS-CoV-2.

		SARS-CoV-2 n=1	Influenza Virus n=18	RSV n=10	ADV n=5	EV n=5	Human Metapneumovirus n=7	Parainfluenza Virus n=2	Human Bocavirus n=2	MP n=4	Others# n=4	Without detected n=103
Age, months (median, IQR)		84	42 (24, 72)	18 (7.5, 24)	24 (12, 36)	23 (11, 24)	24 (12, 36)	18 (15, 21)	16.5 (12.5, 20.25)	72 (47.25, 84)	102 (73.25, 111)	34 (15, 60)
Clinical manifestations (n)	Fever (n=125)	-	18	10	5	4	7	2	2	4	4	72
	Cough/dry cough (n=77)	-	16	10	2	3	7	2	2	4	2	34
	Sputum (n=73)	-	14	9	2	2	7	2	2	4	0	34
	Runny (n=37)	-	8	4	0	1	6	2	0	0	2	14
	Vomiting/ diarrhea/ abdominal pain (n=19)	-	4	3	0	0	2	0	0	1	1	8
	Pulmonary rales (n=15)	-	3	4	0	1	2	1	0	3	1	3
	Stuffy nose (n=10)	-	4	2	0	0	5	1	0	0	0	0
	Gasp (n=10)	-	0	4	0	0	1	0	0	0	1	4
	Tachypnea (n=6)	-	0	1	0	0	0	0	0	0	1	4
	Seizure (n=4)	-	1	0	0	0	1	0	0	0	0	2
	Inspiratory triconcave sign/ cyanosis (n=3)	-	0	1	0	0	0	0	0	0	1	1
	Sore throat (n=2)	-	2	0	0	0	0	0	0	0	0	0
	Chest pain (n=1)	-	0	0	0	0	0	0	0	0	1	0
	Muscle aches/ weakness (n=1)	-	1	0	0	0	0	0	0	0	0	0
	Dizziness/ headache (n=1)	-	1	0	0	0	0	0	0	0	0	0
	Respiratory failure (n=0)	-	0	0	0	0	0	0	0	0	0	0

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Table 2 continued. Clinical characteristics of the 159 patients screened for SARS-CoV-2.

			SARS-CoV-2 n=1	Influenza Virus n=18	RSV n=10	ADV n=5	EV n=5	Human Metapneu-movirus n=7	Parainfluenza Virus n=2	Human Bocavirus n=2	MP n=4	Others# n=4	Without detected n=103
Laboratory inspection (mean±sd.)	WBC (G/L)		5.5	8.31± 4.51	7.47± 2.76	8.42± 1.08	8.25± 4.39	7.16± 1.5	5.85± 2.05	10.05± 4.60	7.50± 3.87	14.6± 12.02	9.92± 5.57
	Lymphocytes (G/L)		1.77	2.27± 2.08	3.21± 1.39	3.64± 1.63	4.80± 2.06	2.9± 1.16	1.99± 0.60	4.19± 1.26	2.42± 1.36	2.60± 1.31	3.12± 2.05
	Neutrophils, NEUT(G/L)		3.14	4.29± 3.04	3.79± 1.95	3.91± 2.00	7.66± 4.51	3.74± 0.87	1.41± 0.02	4.50± 2.26	4.25± 1.42	16.52± 31.65	5.55± 4.24
	Blood platelet, PLT (G/L)		312	213.56± 88.24	285.7± 60.51	262.4± 69.44	314.80± 73.96	220.57± 69.11	185± 2.83	262.50± 130.82	239± 86.08	240.00± 28.13	275.43± 109.94
	Red blood cell, RBC (T/L)		4.57	4.78± 2.39	3.92± 0.78	4.13± 0.33	4.43± 0.36	4.14± 0.53	4.03± 0.18	4.56± 0.39	4.60± 0.33	3.79± 0.79	4.53± 1.11
	c-Reactive protein, CRP		1.18	8.40± 19.35	12.41± 14.85	5.97± 7.33	9.64± 14.50	17.34± 14.07	4.18± 4.60	13.00± 14.88	27.78± 11.39	38.7± 35.33	17.94± 28.80
	Blood lactic acid		1.60	1.81± 0.60	2.11± 0.73	2.42± 0.90	2.67± 0.75	1.8± 0.95	1.90± 0	2.60± 0.14	1.95± 0.61	2.20± 0.95	2.54± 0.84
	Blood glucose		5.67	5.56± 0.93	5.92± 0.90	5.59± 0.52	5.29± 0.57	6.15± 0.97	4.94± 0	5.94± 1.58	6.05± 1.27	6.16± 1.29	6.15± 1.24
	Arterial oxygen pressure (PaO_2)		10.74	9.72± 4.53	10.31± 2.98	8.85± 3.82	8.73± 4.04	11.48± 6.57	4.70± 0	15.08± 3.31	9.43± 3.74	5.35± 2.11	9.73± 4.82
	Arterial carbon dioxide pressure ($PaCO_2$)		5.28	5.16± 0.66	5.01± 0.57	5.24± 0.49	5.32± .040	4.44± 0.32	6.73± 0	4.70± 0.81	4.57± 0.71	5.76± 0.50	4.69± 0.87
Pulmonary imaging examination (Yea: No=92: 1)	X-ray (n=114)	No abnormalities, 7		0	1	1	1	0	0	2	0	0	0	2
		Bronchitis, 67		0	7	7	1	4	1	2	1	1	1	35
		Pneumonia, 40		0	4	3	1	2	5	1	1	1	0	25
	CT (n=41)	No abnormalities, 13		0	0	0	0	0	0	0	0	0	0	13
		Bronchitis, 0		0	0	0	0	0	0	0	0	0	0	0
		Pneumonia, 28		1	0	2	1	0	2	0	1	4	0	17
		Patchy, 13		0	0	1	0	0	1	0	1	4	0	11
		Ground-glass Opacities shadow, 4		1	0	0	0	0	1	0	0	0	0	2*
		Strip-like, 4		0	0	1	1	0	0	0	0	0	0	2
		Consolidation, 5		0	0	0	0	0	0	0	1	2	1	1
		Nodule, 1		0	0	0	0	0	0	0	0	0	0	1

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Table 2 continued. Clinical characteristics of the 159 patients screened for SARS-CoV-2.

		SARS-CoV-2 n=1	Influenza Virus n=18	RSV n=10	ADV n=5	EV n=5	Human Metapneu-movirus n=7	Parainflu-enza Virus n=2	Human Bocavirus n=2	MP n=4	Others# n=4	Without detected n=103
Treatment	Oseltamivir/ paramivir	0	11	2	2	1	2	1	0	0	0	27
	Interferon	0	0	1	0	0	0	0	0	0	0	3
	Antibiotics	0	1	4	1	3	5	1	1	4	3	48
	IVIG	0	0	2	0	0	1	0	0	0	1	5
	Glucocorticoids, GCs	0	0	0	0	0	0	0	0	0	1	1
	Chinese medicine/ Chinese patent medicine	0	0	0	0	0	0	0	0	0	0	5
Outcome	Healed and dischar-ged (n=144)	0	18	9	5	5	6	2	1	3	3	92
	Transferred to Confirmed Ward(n=1)	1	0	0	0	0	0	0	0	0	0	0
	Transferred to other wards(n=15)	0	0	1	0	0	1	0	1	1	0	11
	Transferred to PICU(n=1)	0	0	0	0	0	0	0	0	0	1	0
Follow-up after 21 days	Normal status (n=160)	1	18	10	5	5	7	2	2	4	4	102
	Still in hospital (n=1)	0	0	0	0	0	0	0	0	0	0	1

* A 13-year-old sister of the confirmed COVID-19 patient had similar changes in her chest CT without any symptom and was negative for multiple times of pharynx and anal swabs RT-PCR test for SARS-CoV-2 nucleic acids. # Four patients detected other etiology, including *Staphylococcus humane* (Sepsis), *Klebsiella pneumoniae* (pneumoniae), *Escherichia coli* (urinary tract infection) and Mumps.

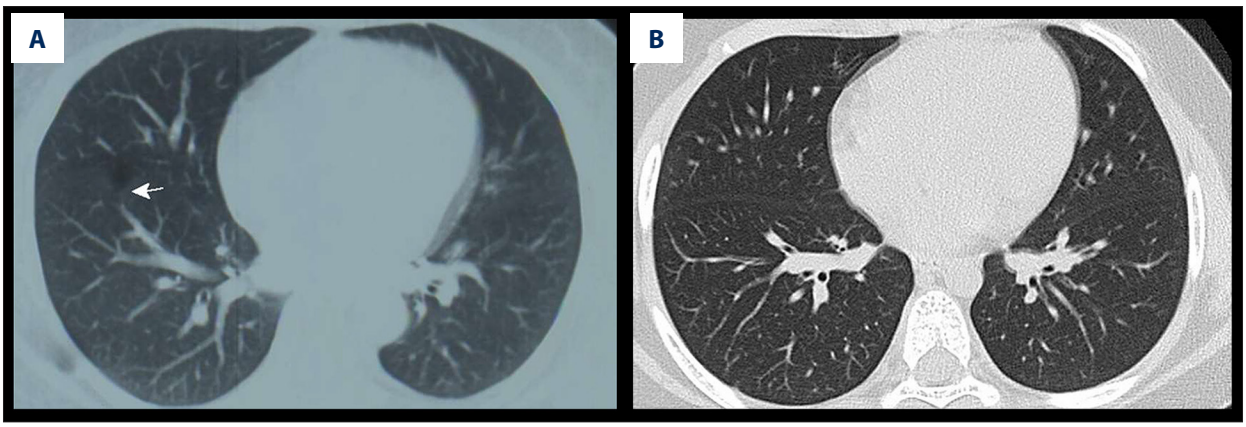

Figure 3. Computed tomography images of a 7-year-old boy (case A from family 1). (**A**) Ground-glass opacities (arrow) were seen in the anterior basal segment of the right lung. (**B**) Seven days later, the ground-glass opacities of the right lung were absorbed completely.

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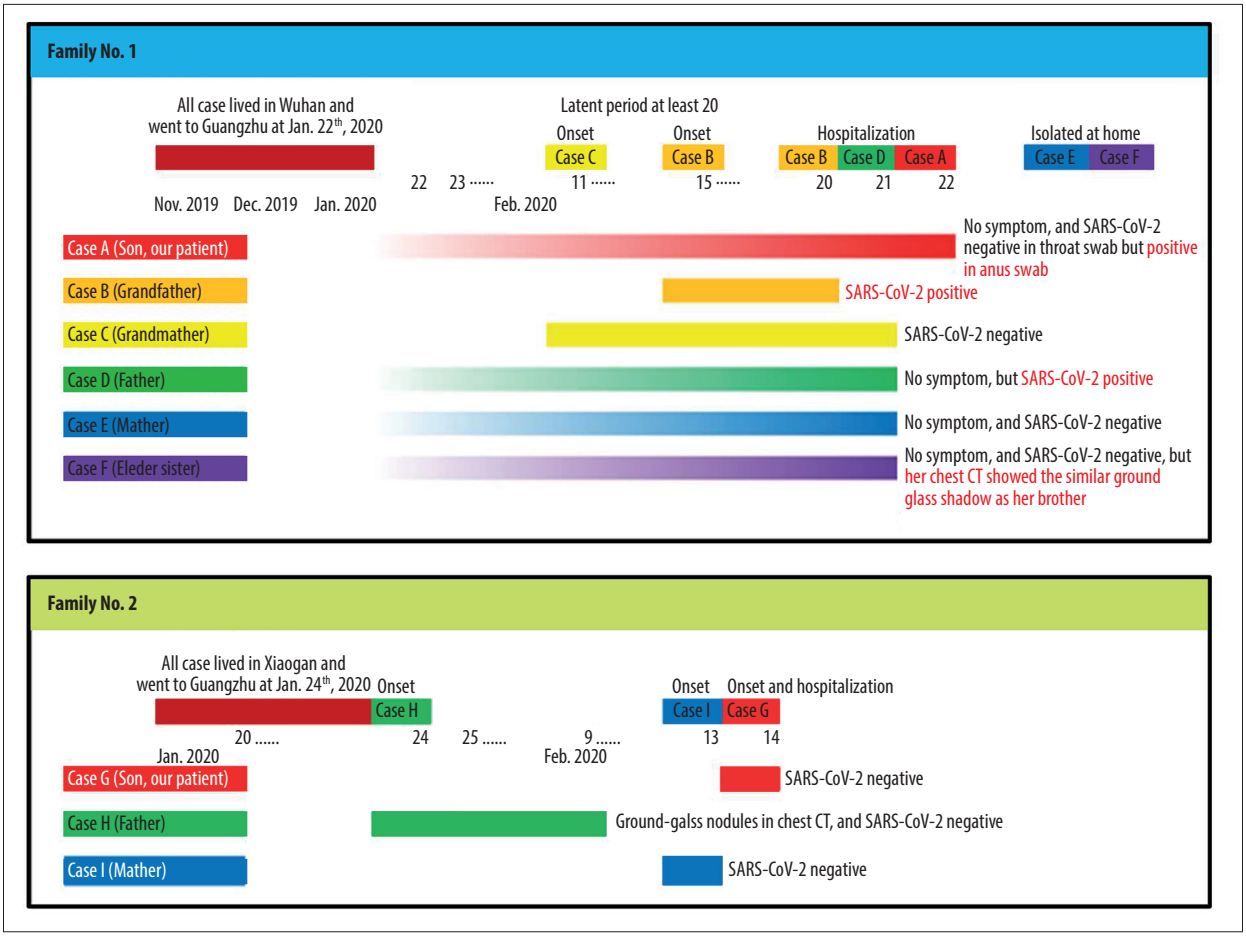

Figure 4. Time-map of onset and diagnosis of the 2 representative families with cluster cases and a history of close contact in Hubei.

metapneumovirus and 2 cases had undetected pathogens. In addition, various CT patterns such as patchy, strip-like, nodular shadow and consolidation were observed.

Diagnosis, treatment, distribution, outcome, and follow-up

Cases of pneumonia (n=57), bronchitis (n=49), and acute upper respiratory tract infection (n=22) were most common in our study. There were 2 patients with sepsis, 1 with mumps, and 1 with congenital heart disease with *Klebsiella pneumoniae* infection. All 159 screening patients were treated symptomatically with anti-pathogenic treatment, such as oseltamivir for influenza, azithromycin for mycoplasma pneumonia, and antibiotics. Intravenous immunoglobulins were used in a few patients who had serious medical conditions. Among those who tested negative for SARS-CoV-2, 15 patients were transferred to single rooms in other specialty wards (Figure 4). Except for the 1 patient transferred to the PICU, 158 patients recovered and were discharged by March 20, 2020. Three days after discharge, there were 8 patients with fever (mainly hypothermia) and 30 patients with cough; 7 days after discharge, there were 2 patients with fever and 14 patients with cough; 14 days after discharge, there were no patients with fever and 6 patients with cough; no abnormalities were seen 21 days after discharge. A 7-day follow-up was done for the 2 representative cluster families; family members had mild fever, cough, and diarrhea symptoms initially, but no abnormalities were seen after 21 days. One family's members (Figure 4, top panel, family 1) who were in close contact with the confirmed person had no symptoms while in isolation at their designated place within 14 days of discharge, and their pharyngeal and anal swabs were negative for multiple consecutive tests.

Discussion

The current study describes the clinical characteristics and management of suspected and confirmed cases of SARS-CoV-2 infection in children in Guangzhou.

The emergence of COVID-19 has attracted global attention, and the WHO has declared the COVID-19 a public health emergency of international concern [13]. Some pediatric patients confirmed with COVID-19 are asymptomatic [14,15]. The

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basic reproduction number of COVID-19 is affected by many factors [16,17] which might make it difficult to assess the true impact of the pandemic. Also, family members are required to accompany the screening patient during hospitalization, impeding epidemic prevention in the pediatric screening ward [18]. The prevention and control strategy of nosocomial infections for SARS-CoV-2 is "standard prevention & contact isolation & droplet isolation & air isolation".

Family clusters and close contact with persons with confirmed SARS-CoV-2 are the primary forms of transmission in pediatric infected patients [14,19]. In the current study, among the 159 patients who were screened, 151 patients had epidemiological histories; but the patient confirmed with SARS-CoV-2 was in a cluster family from Wuhan and in close contact with positive patients. There can be transmission from asymptomatic patients and also from patients in the incubation period to other members in a family cluster [14,20]. Therefore, in addition to managing the sources of infection, cutting off the route of transmission requires leaving the environment with a high viral load or implementing terminal disinfection in enclosed spaces.

The patient with confirmed SARS-CoV-2 in our study was asymptomatic, similar to patients in previous studies [14,18]. Compared to adult patients, pediatric patients with SARS-CoV-2 infection had clinically milder symptoms and show fewer alterations in radiological and laboratory testing parameters [15,21–24]. GGOs in lung CT scan changes are commonly seen in infected pediatric patients, whether they were asymptomatic or had mild or severe symptoms [21,22,25]. We found that GGOs on lung CT scan could be seen in patients with SARS-CoV-2 and human metapneumovirus infection and in children without positive pathogens. The CT scan patterns of COVID-19 pneumonia may overlap with other pneumonia types, especially viral pneumonia [26]. Therefore, it is essential to differentiate between symptoms with respect to pneumonia caused by different pathogens, such as adenovirus, respiratory syncytial virus, severe acute respiratory syndrome, bacterial pneumonia, and mycoplasma pneumonia [26,27].

Most of the children admitted to screening wards had an epidemiological history and similar clinical manifestations consistent with laboratory results of viral infections and changes in lung imaging. But only 1 patient who tested negative by pharyngeal swab was confirmed by anal swab RT-PCR for SARS-CoV-2. Patients negative for SARS-CoV-2 infection had influenza virus, respiratory syncytial virus, adenovirus, and other viral infections which were common for the season, with even cluster onset in some families. It was noteworthy that a 13-year-old sister who had close contact with her brother who was confirmed with SARS-CoV-2 infection, had similar changes in her lung CT scan to her brother but tested negative in multiple anal and pharyngeal swab RT-PCR tests. The positive rate of SARS-CoV-2 on CT chest scans in adults was about 60% [23], and in children was close to 35% [25]; moreover, the positive rate is related to the course of sampling and the detection method [28,29]. Interestingly, patients who were RNA-positive and RNA-negative for COVID-19 shared similar clinical symptoms [30]. Therefore, a single negative RT-PCR test result cannot be an exclusion criterion to deem children fit and rid of SARS-CoV-2 infection. Positive SARS-CoV-2 RT-PCR anal swab test results in our confirmed patient continued until day 19 of hospitalization. Viral RNA measurements suggest that viral shedding from the digestive system is greater and lasts longer than that from the respiratory tract; hence rectal swab testing may be more useful than nasopharyngeal swab testing in judging the effectiveness of treatment and determining the timing of termination of quarantine [21]. From our results, we determined that 2 consecutive negative SARS-CoV-2 RT-PCR tests by anal swab could be a criterion to discharge a pediatric patient from the screening ward. Research suggests that the detection of serum IgM and IgG antibodies simultaneously against SARS-CoV-2 in human blood is a valid criterion [29,31], but we did not implement this in our screening patients.

Our study had limitations including the inherent bias of the retrospective nature of the study. Also, our study population size was small, and a variety of tests suggested by other research groups were not performed. Nevertheless, our study is of importance since we showed that consecutive negative tests from anal swabs might be a good indicator for the discharge of patients.

Conclusions

For SARS-CoV-2 nosocomial infections, using the "standard prevention & contact isolation & droplet isolation & air isolation" strategy can prevent the spread of infection to pediatric patients. For clustered onset pediatric patients, a minimum isolation period longer than 14 days during the epidemic or 2 consecutive negative tests with anal swabs more than 24 h apart could determine the timing of termination of quarantine.

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Conflicts of interest

None.

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Supplementary Material

Standard prevention & contact isolation & droplet isolation & air isolation

1. Organization of Suspected Screening Wards

The center had designated management department for COVID-19 and clarified responsibilities and set up a dedicated isolation building for suspected and confirmed patients. The isolation building includes one Confirmed Ward and two Screening Wards, the latter of which were described in this article. Nosocomial Infection Prevention strategy in the Screening Wards were standard prevention & contact isolation & droplet isolation & air isolation.

2. Area division and protective materials

Screening wards are strictly divided into clean areas, semi-contaminated areas and isolation areas. The personal protective equipment (PPE) for staff with corresponding protection levels and disinfection showed in Supplementary Table 1.

Staff	Workplace	Medical activity	Work clothes	Waterproof isolation gown	Latex gloves	Work hat	Medical protective mask	Protective goggles/ mask	Protection suit	Shoe cover	Long sleeve thick rubber gloves
											
Medical staff	Suspected/ Screening Wards	General medical activities without contacting the patients, non-body fluid exposure risks, such as Inquiry Station, Ward round, Physical Examination etc.	√	√ or fabric isolation gown	√	√	√	√		√ or Work shoes	
Medical staff	Suspected/ Screening Wards	Collection of respiratory samples, venipuncture, handling body fluids and other body fluid spraying actives.	√	√	Double √	√	√ or Power-to-air filter respirator	√		√ or Work shoes	
	Confirmed Ward	All medical activities	√	√ if necessary	Double √	√	√ or Power-to-air filter respirator	√	√	√ or Work shoes	
Cleaning staff	Suspected/ Screening Wads	Cleaning, medical waste disposer	√	√ or fabric isolation gown	√	√	√	√		√ or work shoes, rubber boots	√

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3.Personnel management

Patients management: Evaluate the age and self-care ability of children, set up a reasonable nursing manpower for nursing management, strengthen the guidance of life care for the caregivers of young children, and strengthen psychological evaluation and support for children of school age and adolescence.

Escort management: Visits are strictly forbidden. During in ward, only one escort should be left and relatively fixed. No fever, respiratory tract, digestive tract or other symptoms are detected. Body temperature should be monitored and recorded twice a day. After admission, tests of throat swab specimens for escorts should be preformed twice, and the interval should be more than 24h.

Staff management: Employees should monitor body temperature twice a day, and conduct self-evaluation and reporting on health every day.

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