Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Demographic, signs and symptoms, imaging characteristics of 2126 patients with COVID-19 pneumonia in the whole quarantine of Wuhan, China

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ABSTRACT

Objective: The accurate knowledge of demographic, signs and symptoms, imaging characteristics of coronavirus disease 2019 (COVID-19) is essential for the accurate management of these patients. However, the claims between the previous papers are not always consistent and may even contradict each other, for example, some claims the virus infects more men than women in Wuhan. In this large-scale cohort study, we aimed to update the demographic, signs and symptoms, imaging characteristics of patients with COVID-19 in the whole quarantine of Wuhan, China.

Methods: A cohort of 2126 patients with a diagnosis of COVID-19 pneumonia (confirmed by real-time reverse transcriptase-polymerase chain reaction, RT-PCR) who were admitted to one hospital in Wuhan were retrospectively enrolled. Data were collected between January 13, 2020, and April 8, 2020, the end of Wuhan quarantine. Demographic, signs and symptoms, imaging characteristics were analyzed. CT imaging characteristics associated with respiratory failure or death were identified.

Results: Of the 2126 patients with COVID-19, 1051 (49.44%) were men and 1075 (50.56%) were women, 1933 (90.92%) have fever and 1328 (62.46%) have dry cough. The mean age was 57.43 years of age (range 1–95). The CT imaging findings were bilateral pneumonia (1883[88.57%]), unilateral pneumonia (243[11.43%]), ground-glass opacity (GGO) or consolidation (1175[55.27%]), pleural effusion (69[3.25%]). Patients with respiratory failure or death were more likely to have pleural effusion on CT than patients without respiratory failure or death ($p < 0.05$).

Conclusion: Men and women have been infected by SARS-CoV-2 in roughly equal numbers. Fever and cough are the most prevalent symptoms at disease onset in patients. Other prevalent symptoms include fatigue, and sputum production. COVID-19 patients with bilateral pneumonia and pleural effusion are more likely to develop respiratory failure or death.

1. Introduction

A pneumonia outbreak of unknown etiology in the city of Wuhan, China was reported by the World Health Organization (WHO) on December 31st, 2019.[1] Scientists traced the disease with a new strain of coronavirus named 2019-nCoV by the WHO, and severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2) by the International Committee on Taxonomy of Viruses.[2,3] The mechanism for a strong person-

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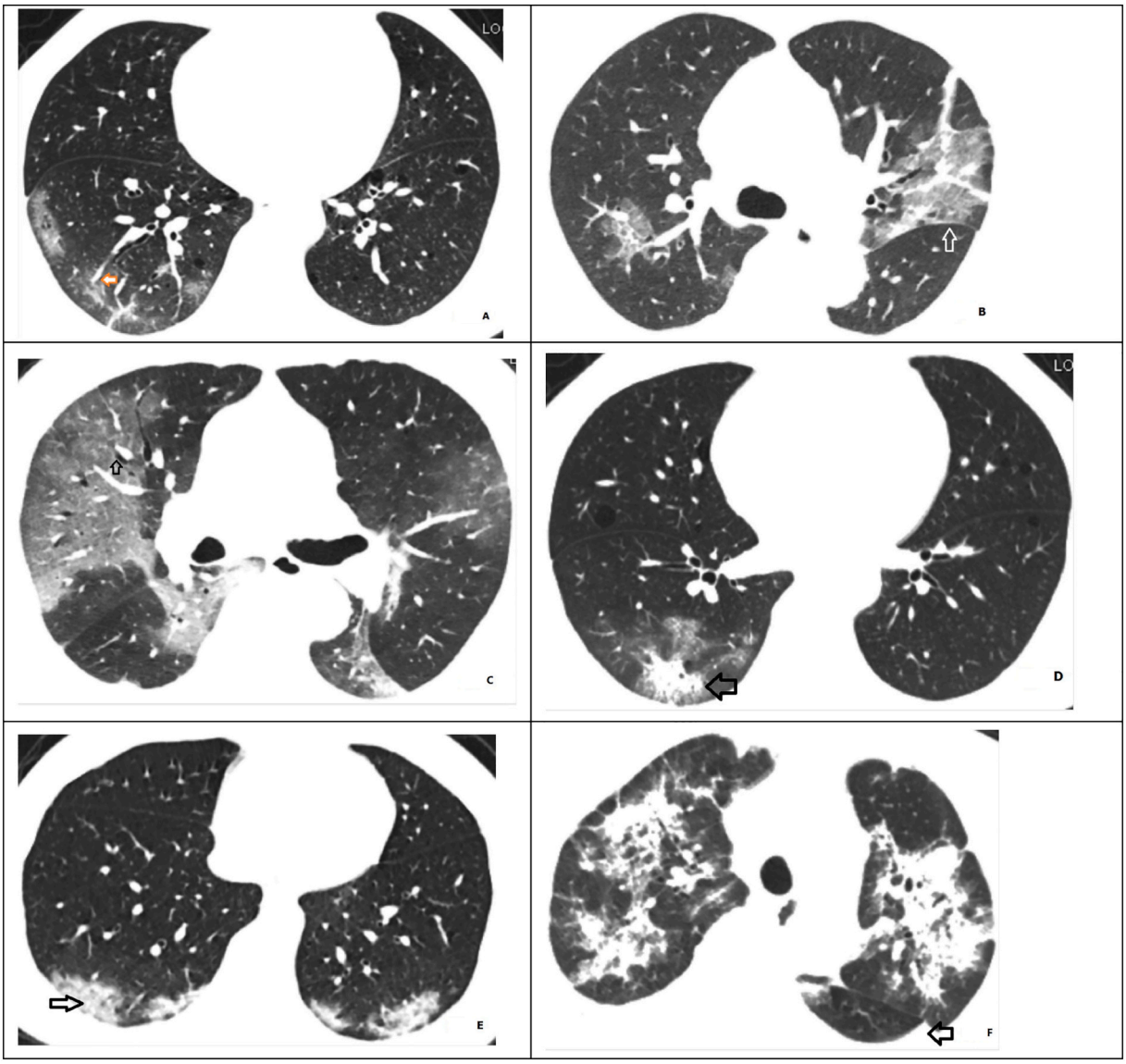

Fig. 1. Transverse thin-section CT scans in patients with COVID-19 pneumonia. (A) 48-year-old man, day 5 after symptom onset: microvascular dilation sign (arrow) in ground-glass opacities in right lower lobes. (B) 65-year-old woman, day 7 after symptom onset: bilateral, peripheral ground-glass opacity with smooth interlobular and intralobular septal thickening (arrow). (C) 66-year-old man, day 12 after symptom onset: extensive ground-glass opacities in both lungs, with air bronchograms. (D) 48-year-old man, day 14 after symptom onset: area of consolidation (arrow) with ground-glass opacities surrounded in lower lobe of right lung. (E) 33-year-old man, day 15 after symptom onset: multifocal consolidations affecting the bilateral, subpleural lung parenchyma (arrow). (F) 73-year-old woman, day 20 after symptom onset: bilateral predominant consolidation pattern with a small amount of pleural effusion (arrow).

to-person transmission of the SARS-Cov-2 was illustrated by the interaction between the viral spike protein and the angiotensin converting enzyme 2 (ACE2) receptor on human respiratory epithelial cells.[3–5]

SARS-CoV-2 has since spread globally, resulting in the ongoing 2019–20 coronavirus disease 2019 (COVID-19). As of 27 January 2021, more than 98.2 million cumulative cases of COVID-19 and 2.1 million deaths have been reported.[6] The COVID-19 pandemic has resulted in travel restrictions and lockdowns in cities and countries. Wuhan was the first city in the world to be imposed a strict quarantine as part of efforts to contain the outbreak of the quickly spreading contagious disease from January 23, 2020 until April 8, 2020.[7]

To better understand and stop the contagious disease, several studies on the demographic, signs and symptoms, imaging characteristics of COVID-19 pneumonia were reported, accurate knowledge of demographic, signs and symptoms, imaging characteristics of COVID-19 is essential for the accurate management of these patients. However, the claims between the previous papers are not always consistent and may even contradict each other, for example, some claims the virus infects more men than women in Wuhan,[8,9,11–13,16,17] other claims more women than men in Wuhan.[14]

Previous studies have shown that the mainly computed tomographic (CT) characteristics of COVID-19 were bilateral and subpleural distribution of GGO, crazy-paving pattern, consolidation, pleural thickening, pleural effusion.[8–18] However, implications of imaging characteristics to COVID-19 patients are not fully understood.

Over the 76 days quarantine period of the city Wuhan, more evidence is available. Therefore, in this large-scale cohort study, we aimed to update the demographic, signs and symptoms, imaging characteristics of patients with COVID-19 and identify imaging characteristics associated with respiratory failure or death in the whole quarantine of Wuhan,

Table 1
Literature review summary: Studies that demonstrated demographic characteristics of COVID-10 pneumonia.

Author(s) [reference no.]	Huang et al[8]	Chen et al[9]	Shi et al[10]	Guan et al[11]	Zhou et al[12]	Wang et al[13]	Xu et al[14]	Yang et al[15]	Rodriguez et al[16]	Cao et al[17]	Current study (– et al)
No. of study	1	1	1	1	1	1	1	1	19	31	1
Patient volume	41	99	81	1099	62	138	90	149	9-1590	10–1099	2126
Name (location) of Institution (s)	China Medical Treatment Expert Group for Covid-19	Wuhan Jinyintan Hospital	Union Hospital, – University of Science & Technology (Wuhan)	China Medical Treatment Expert Group for Covid-19	– Hospital, – University of Science & Technology (Wuhan)	Zhongnan Hospital, Wuhan University (Wuhan)	1st Hospital of Jinan University & Guangzhou 8th People's Hospital	Ruijin Hospital, Shanghai Jiaotong University	Latin American Network of COVID-19 Research	Union Hospital, – University of Science & Technology (Wuhan)	– Hospital, – University of Science & Technology (Wuhan)
Time (by) of study	2020/1/2	2020/1/20	2020/1/23	2020/1/29	2020/1/30	2020/2/3	2020/2/4	2020/2/10	2/23/2020	2020/3/1	2020/4/8
Age mean	49	55.5	49.5	47	52.8 ± 12.2	56	50	45.11	51.97	46.62	57.43
Age range	41–58	21–82		35–58	30–77	22–92	18–86		4–89		1–95
≥60											50.56%
40–59											34.95%
20–39											14.11%
<20											0.38%
Male	73.00%	67.68%	52.00%	58.10%	62.90%	54.30%	43%	54.40%	55.90%	55.60%	49.44%
Female	27.00%	32.32%	48.00%	41.90%	37.10%	45.70%	57%	45.60%	44.10%	44.40%	50.56%

China.

2. Methods

2.1. Study participants and data collection

This was a retrospective study performed at a single university hospital in Wuhan. Patients with confirmed COVID-19 pneumonia who were admitted to Tongji Hospital of Tongji Medical College were retrospectively enrolled. Dataset were made available for research purpose.

All the patients were confirmed by real-time reverse transcriptase-polymerase chain reaction (RT-PCR) of throat swab specimens. The RT-PCR assays were performed by using TaqMan One-Step RT-PCR Kits from Shanghai Huirui Biotechnology Co., Ltd or Shanghai BioGerm Medical Biotechnology Co., Ltd, both of which have approved use by the China Food and Drug Administration (CFDA), using a published protocol, with the primers and probe targeted to the envelope gene of SARS-CoV-2:

reverse primer 5′-AAAGGTCCACCCGATACATTGA-3′; forward primer 5′-TCAGAATGCCAATCTCCCCAAC-3′; probe 5′CY5-CTAGTTA-CACTAGCCATCCTTACTGC-3′BHQ1.[3]

All the images were acquired on one of the three CT systems (uCT 780, United Imaging, China; Optima 660, GE, America; Somatom Definition AS+, Siemens Healthineers, Germany). Patients were imaged in supine positions. The CT scan parameters were as follow: tube voltage, 120 kVp; automatic tube current modulation (ATCM), 30–70 mA s; pitch, 0.99–1.22 mm; matrix, 512 × 512; slice thickness, 10 mm; field of view, 350 × 350 mm; All images were reconstructed with a slice thickness of 0.625–1.250 mm with the same increment. The mean dose-length product (DLP) was 235.16 ± 65.50 mGy*cm. In all CT scans, only 17 cases were enhanced. The CT images were read by two experienced radiologists and hence the findings and observations can be reliable.[12]

Demographic, signs and symptoms, CT images characteristics of the chest of the patients during the hospital admission were obtained from electronic medical records. CT imaging characteristics included GGO, consolidation, crazy-paving pattern, unilateral pneumonia, bilateral pneumonia, pleural thickening, pleural effusion and septal thickening. According to the prognosis, all the patients were divided into group 1 (patients without respiratory failure or death) and group 2 (patients with respiratory failure or death) (Fig. 1).

This study was approved by the institutional review boards of – University Hospital, and was consistent with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The requirement for informed patient consent was waived by the ethics committee for this retrospective study.

2.2. Statistical analysis

Categorical variables were presented as numbers and percentages and continuous variables as mean and standard deviation if they were normally distributed or median and range if they were not. Chi-square test was used to compare the differences between the two groups, and $p < 0.05$ was considered statistically significant.

3. Results

3.1. Demographic characteristics, signs and symptoms characteristics of patients with COVID-19 pneumonia

From January 13 to April 8, 2020, 2126 patients with confirmed COVID-19 were admitted to – Hospital. As shown in Table 1, the median age of patients was 57.43 (range 1–95) years. The population of patients, ages 20 and younger, represented 8 (0.38%), ages 20 to 39 was 300 (14.11%), ages 40 to 59, made up 743 persons (34.95%), ages 60 and

Table 2
Literature review summary: Studies that demonstrated signs and symptoms characteristics of COVID-10 pneumonia.

Author(s) [reference no.]	Huang et al[8]	Chen et al[9]	Shi et al[10]	Guan et al[11]	Zhou et al[12]	Wang et al[13]	Xu et al[14]	Yang et al[15]	Rodriguez et al[16]	WHO report.[18]	Cao et al[17]	Current study (–, et al)
No. of study	1	1	1	1	1	1	1	1	19		31	1
Patient volume	41	99	81	1099	62	138	90	149	9–1590		10–1099	2126
Name (location) of institution (s)	China Medical Treatment Expert Group for Covid-19	Wuhan Jinyintan Hospital	Union Hospital, – University of Science & Technology (Wuhan)	China Medical Treatment Expert Group for Covid-19	– Hospital, – University of Science & Technology (Wuhan)	Zhongnan Hospital, Wuhan University	1st Hospital of Jinan University, Guangzhou 8th People's Hospital	Ruijin Hospital, Shanghai Jiaotong University	Latin American Network of COVID-19 Research	WHO-China Joint Mission on COVID-19	Union Hospital, – University of Science & Technology (Wuhan)	– Hospital, – University of Science & Technology (Wuhan)
Time (by) of study	2020/1/2	2020/1/20	2020/1/23	2020/1/29	2020/1/30	2020/2/3	2020/2/4	2020/2/10	2020/2/23	2020/2/24	2020/3/1	2020/4/8
Fever	98%	83%	73%	43.80%	87.10%	98.60%	78%	76.51%	88.70%	88%	87.30%	90.92%
Dry cough	76%	82%	59%	67.80%	45.16%[b]	59.40%	63%	58.39%	57.60%	68%	58.10%	62.46%
Fatigue	44%[a]		5%	38.10%	22.58%	69.60%	21%		29.4%[d]	38%	35.5%[e]	43.74%
Sputum production	28%		19%	33.70%		26.80%	12%	32.21%	28.50%	33%	29.40%	37.44%
Shortness of breath	55%	31%	42%	18.70%	24.19%	31.20%		1.34%	45.60%	19%	38.30%	25.87%
Chest tightness		2%	22%					14.10%	45.60%		31.20%	22.11%
Muscle or joint pain		11%		14.90%	32.26%	34.80%	28%%	3.36%		15%		19.99%
Headache	8%	8%	6%	13.60%		6.50%	4%	8.72%	8%	14%	9.40%	12.51%
Diarrhea	3%	2%	4%	3.80%	14.52%[c]	10.10%	6%	7.38%	6.10%	4–31%	6.80%	11.10%
Chills				11.50%			7%	14.09%		11%		9.97%
Anorexia			1%			39.90%						9.83%
Nausea or vomiting		1%	5%	5.00%		13.70%	8%	1.34%		5%		8.00%
Dizziness		9%	2%			9.4%%						7.01%
Abdominal pain						2.20%						5.93%
Haemoptysis	5%			0.90%						0.90%		1.03%
Loss of smell										15–30%		
Sore throat		5%		13.90%		17.40%	26%	14.09%	11.00%	14%	12.00%	
Nasal congestion		4%	26%	4.80%				3.36%		5%		
Conjunctival congestion				0.80%								
Pink eyes										0.80%		

[a] Fatigue or myalgia.
[b] Cough & sputum.
[c] Abdominal pain or diarrhea.
[d] Fatigue or myalgia.
[e] Fatigue or myalgia.

Table 3
Literature review summary: Studies that demonstrated imaging characteristics of COVID-10 pneumonia.

Author(s) [reference no.]	Huang et al[8]	Chen et al[9]	Shi et al[10]	Guan et al[11]	Zhou et al[12]	Xu et al[14]	Yang et al[15]	Rodriguez et al[16]	Cao et al[17]	Current study (–, et al)
No. of study	1	1	1	1	1	1	1	19	31	1
Patient volume	41	99	81	1099	62	90	149	9–1590	10–1099	2126
Name (location) of institution (s)	China Medical Treatment Expert Group for Covid-19	Wuhan Jinyintan Hospital	Union Hospital, – University of Science & Technology (Wuhan)	China Medical Treatment Expert Group for Covid-19	– Hospital, – University of Science & Technology (Wuhan)	1st Hospital of Jinan University, Guangzhou 8th People's Hospital	Ruijin Hospital, Shanghai Jiaotong University	Latin American Network of COVID-19 Research	Union Hospital, – University of Science & Technology (Wuhan)	– Hospital, – University of Science & Technology (Wuhan)
Time (by) of study	2020/1/2	2020/1/20	2020/1/23	2020/1/29	2020/1/30	2020/2/4	2020/2/10	2020/2/23	2020/3/1	2020/4/8
Bilateral pneumonia	98%	75%	90%	51.80%		59%		72.90%	75.70%	88.57%
Unilateral pneumonia	2%	25%	60%	48.20%		41%		25%	20.40%	11.43%
GGO or consolidation		14%	93%	56.40%	58.26%	85%	46.04%	68.50%	69.90%	55.27%
Pleural effusion			5%		9.68%	4%	6.71%			3.25%

Table 4
Comparison of imaging characteristics between Group 1 and Group 2.

Characteristics	Group 1 (2094)	Group2 (32)	χ2	p
GGO	1021 (48.76%)	19 (59.38%)	1.422	0.233
Consolidation	262 (12.51%)	7 (21.88%)	1.725	0.189
Crazy-paving pattern	70 (3.34%)	3 (9.38%)	1.879	0.170
Combine GGO with consolidation	162 (7.74%)	6 (18.75%)	3.849	0.050
Unilateral pneumonia	235 (11.22%)	8 (25.00%)	4.627	0.031
Bilateral pneumonia	1859 (88.78%)	24 (75.00%)		
Pleural thickening	648 (30.95%)	9 (28.13%)	0.117	0.732
Pleural effusion	59 (2.82%)	10 (31.25%)	81.140	0.000
Septal thickening	36 (1.72%)	1 (3.13%)	/	0.432

Note: group 1 (patients without respiratory failure or death) and group 2 (patients with respiratory failure or death).

over was 1075 (50.56%). Men (1051 [49.44%]) and women (1075 [50.56%]) have been infected by SARS-CoV-2 in roughly equal numbers. The most common symptoms are fever (1933 [90.92%]) and dry cough (1328 [62.46%]), other signs and symptoms characteristics of patients with COVID-19 pneumonia was shown in Table 2.

3.2. Imaging characteristics of patients with COVID-19 pneumonia

As shown in Table 3, the CT imaging findings were bilateral pneumonia (1883 [88.57%]), unilateral pneumonia (243 [11.43%]), ground-glass opacity (GGO) and consolidation (1175 [55.27%]), pleural effusion (69 [3.25%]). In comparison of all CT imaging characteristics in group 1 and group 2, we found that only bilateral pneumonia and pleural effusion had statistical significance between the two groups, as shown in Table 4.

4. Discussion

Our study comprehensively updated the demographic, signs and symptoms, imaging characteristics of patients with COVID-19. Men and women were infected by SARS-CoV-2 in roughly equal numbers. Fever and cough were the most prevalent symptoms at disease onset in patients. Other prevalent symptoms include fatigue, and sputum production. SARS-CoV-2 more frequently caused infection in both lungs spontaneously. The information provided will further enhance knowledge of this critical disease and may accordingly contribute to improve management of the patients with COVID-19.

4.1. Comparison with other studies

To our knowledge, this report is the largest single-center case series data of hospitalized patients from Wuhan with COVID-19 in the whole quarantine of Wuhan, China.

The main finding for this cohort is that men and women were infected by SARS-CoV-2 in roughly equal number. This finding is different to some of the published data from Wuhan.[8,9,11–13,16,17] The previous claims between the previous papers are not always consistent and may even contradict each other, for example, some claims the virus infects more men than women in Wuhan. The underlying molecular mechanism remains unclear. We speculate that SARS-CoV-2 uses ACE2 to infect human and there is no difference in susceptibility between men and women. Of the publish data from Wuhan, some claims the virus infects more men than women,[8,9,11–13,16,17] other claims more women than men.[14] The potential explanation of this difference is the lack of large sample size of the patient with COVID-19 in Wuhan during the early outbreak.[19]

In our study, the signs and symptoms characteristics of COVID-19

were generally consistent with the previous publications. The finding for this cohort is that fever and cough are the most prevalent symptoms at disease onset in patients, other prevalent symptoms include fatigue, and sputum production. Our results appear to be similar to those of patients in previous studies in Wuhan. We presume that cytokine cascade is the postulated mechanism for multi-organ damages.[4,20]

All patients had abnormal CT imaging findings. Our findings that bilateral pneumonia (88.57%), unilateral pneumonia (11.43%), GGO or consolidation (55.27%), pleural effusion (3.25%), are compatible with previous small sample size radiological publications.[8,10] The mechanism underlying GGO and consolidation is SARS-CoV-2 induces diffuse alveolar injuries by involving angiotensin-converting enzyme,[5,19] which appear as a filling of air spaces in the lungs by transudate or exudate, and collapse of lung alveoli and deep airway or interstitial thickening, be consistent with autopsy observations.[4]

Of all CT imaging characteristics, only bilateral pneumonia and pleural effusion were statistically significant between the patients with respiratory failure or death and the patients without respiratory failure or death. Bilateral pneumonia shows a wider range of lesions, suggesting a more serious disease. Pleural effusion is often the result of a lesion involving the pleura and is indicative of a more serious condition. The presence or absence of GGO, consolidation, crazy-paving pattern, pleural thickening, and septal thickening did not appear to correlate significantly with respiratory failure or death of COVID-19.

Our study has several limitations, mainly due to its retrospective design. Second, all the 2126 hospitalized patients with confirmed by RT-PCR were included until the end the Wuhan quarantine, yet unhospitalized patients were not included in the analyses. Third, it would be optimal to include more patients from Wuhan, other cities in China, or other countries to obtain more comprehensive aspects of COVID-19. Up-to-date studies have been addressed, such as those AI-related works, where AI-driven tools can be of great use for large datasets and even for automation.[21,22] More efforts will be made to understand a more comprehensive aspects of COVID-19 in future studies.

In conclusion, men and women have been infected by SARS-CoV-2 in roughly equal numbers. Fever and cough are the most prevalent symptoms at disease onset in patients. Other prevalent symptoms include fatigue, and sputum production. SARS-CoV-2 more frequently causes infection in both lungs spontaneously. COVID-19 patients with bilateral pneumonia and pleural effusion are more likely to develop respiratory failure or death.

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