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.

Microbial Pathogenesis 147 (2020) 104390

Contents lists available at ScienceDirect

Microbial Pathogenesis

journal homepage: www.elsevier.com/locate/micpath

Clinical characteristics, laboratory findings, radiographic signs and outcomes of 61,742 patients with confirmed COVID-19 infection: A systematic review and meta-analysis

Ali Pormohammad [a,*], Saied Ghorbani [b,1], Behzad Baradaran [c,d], Alireza Khatami [b], Raymond J. Turner [a,**], Mohammad Ali Mansournia [e,***], Demetrios N. Kyriacou [f,g], Juan-Pablo Idrovo [h], Nathan C. Bahr [i]

[a] Department of Biological Sciences, University of Calgary, Calgary, AB, Canada
[b] Department of Virology, Faculty of Medicine, Iran University of Medical Science, Tehran, Iran
[c] Immunology Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[d] Department of Immunology, Faculty of Medicine, Tabriz University of Medical Sciences, Tabriz, Iran
[e] Department of Epidemiology and Biostatistics, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
[f] Department of Emergency Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL, USA
[g] Department of Preventive Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL, USA
[h] Division of GI, Trauma and Endocrine Surgery, Department of Surgery, University of Colorado, Denver Aurora, Colorado, USA
[i] Division of Infectious Diseases, Department of Medicine, University of Kansas, Kansas City, KS, USA

ARTICLE INFO

Keywords:
COVID-19
SARS-CoV-2
Coronavirus
Severe acute respiratory syndrome coronavirus
meta-Analysis

ABSTRACT

Introduction: In the current time where we face a COVID-19 pandemic, there is no vaccine or effective treatment at this time. Therefore, the prevention of COVID-19 and the rapid diagnosis of infected patients is crucial.
Method: We searched all relevant literature published up to February 28, 2020. We used Random-effect models to analyze the appropriateness of the pooled results.
Result: Eighty studies were included in the meta-analysis, including 61,742 patients with confirmed COVID-19 infection. 62.5% (95% CI 54.5–79, $p < 0.001$) of patients had a history of recent travel endemic area or contact with them. The most common symptoms among COVID-19 infected patients were fever 87% (95% CI 73–93, $p < 0.001$), and cough 68% (95% CI 55.5–74, $p < 0.001$)), respectively. The laboratory analysis showed that thrombocytosis was present in 61% (95% CI 41–78, $p < 0.001$) CRP was elevated in 79% (95% CI 65–91, $p < 0.001$), and lymphopenia in 57.5% (95% CI 42–79, $p < 0.001$).
The most common radiographic signs were bilateral involvement in 81% (95% CI 62.5–87, $p < 0.001$), consolidation in 73.5% (95% CI 50.5–91, $p < 0.001$), and ground-glass opacity 73.5% (95% CI 40–90, $p < 0.001$) of patients. Case fatality rate (CFR) in <15 years old was 0.6%, in >50 years old was 39.5%, and in all range group was 6%.
Conclusions: Fever and cough are the most common symptoms of COVID-19 infection in the literature published to date. Thombocytosis, lymphopenia, and increased CRP were common lab findings although most patients included in the overall analysis did not have laboratory values reported. Among Chinese patients with COVID-19, rates of hospitalization, critical condition, and hospitalization were high in this study, but these findings may be biased by reporting only confirmed cases.

* Corresponding author.
** Corresponding author.
*** Corresponding author.
E-mail addresses: pormohammadali@yahoo.com, ali.pormohammad@ucalgary.ca (A. Pormohammad), turnerr@ucalgary.ca (R. J. Turner), mansournia_m@sina.tums.ac.ir (M.A. Mansournia).
[1] Equally first author.

https://doi.org/10.1016/j.micpath.2020.104390
Received 18 April 2020; Received in revised form 2 June 2020; Accepted 6 July 2020
Available online 15 July 2020

1. Introduction

In December 2019, the new COVID-19 coronavirus was recognized as a cause of respiratory illness. The first reports of pneumonia were from people who worked or lived in the Huanan seafood wholesale market in Wuhan, China raising concerns about a zoonotic viral infection [1,2]. Phylogenetic analysis showed that the COVID-19 belong to the beta-coronavirus [1]. Epidemiological studies have shown that the virus is spread relatively easily and can be transmitted by aerosol, droplets, and through infected surfaces [3]. The COVID-19 has now spread to more than 50 countries from December 2019 to February 2020 [4]. Most symptoms are non-specific in patients with respiratory disease. According to the latest WHO report, out of 83,652 confirmed cases of COVID-19 worldwide, 2791 deaths occurred in China and 67 deaths is recorded in other countries [4].

Thus far, 6 coronaviruses that are able to infect humans have been identified, coronavirus infections are typically asymptomatic or associated with mild respiratory symptoms [1]. The first coronavirus to cause severe disease in humans was the Severe Acute Respiratory Syndrome virus (SARS), which was appeared in the Guangdong province of southern China in 2002, there were 8098 reported case and 774 deaths [5]. In Saudi Arabia in 2012, the Middle East respiratory syndrome coronavirus (MERS-CoV), which was transmitted from the camels to humans, caused 2458 infections with 848 deaths [6].

Clinical studies have shown that COVID-19 can rapidly cause pulmonary damage and severe respiratory symptoms [3]. There is no vaccine or targeted treatment currently available for COVID-19 infection. Treatment is largely supportive although multiple experimental antiviral medications are being evaluated [7,8]. Thus, prevention and rapid diagnosis of infected patients is crucial. To date, the published clinical studies are quite small and give variable findings. With this in mind, here we evaluate the clinical features and laboratory findings using a large sample size of COVID-19 infected patients in order to assist in its understanding, prevention and treatment.

2. Methods

2.1. Search strategy

This study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA) guidelines [9]. We searched all studies published up to February 28, 2020 from the following databases: Embase, Scopus, PubMed, Web of Science and the Cochrane library. Search medical subject headings (MeSH) terms used were: “COVID-19”, “Coronavirus”, “severe acute respiratory syndrome coronavirus”, and all their synonyms like “Wuhan Coronavirus”, “SARS-CoV-2”, and “COVID-19”. Moreover, we searched for unpublished and grey literature with Google scholar, Center for Disease Controls (CDC) and WHO databases. We also examined references of included articles to find additional relevant studies. There was no language restriction and all included studies are written in English or Chinese languages, the latter were translated by https://translate.goo

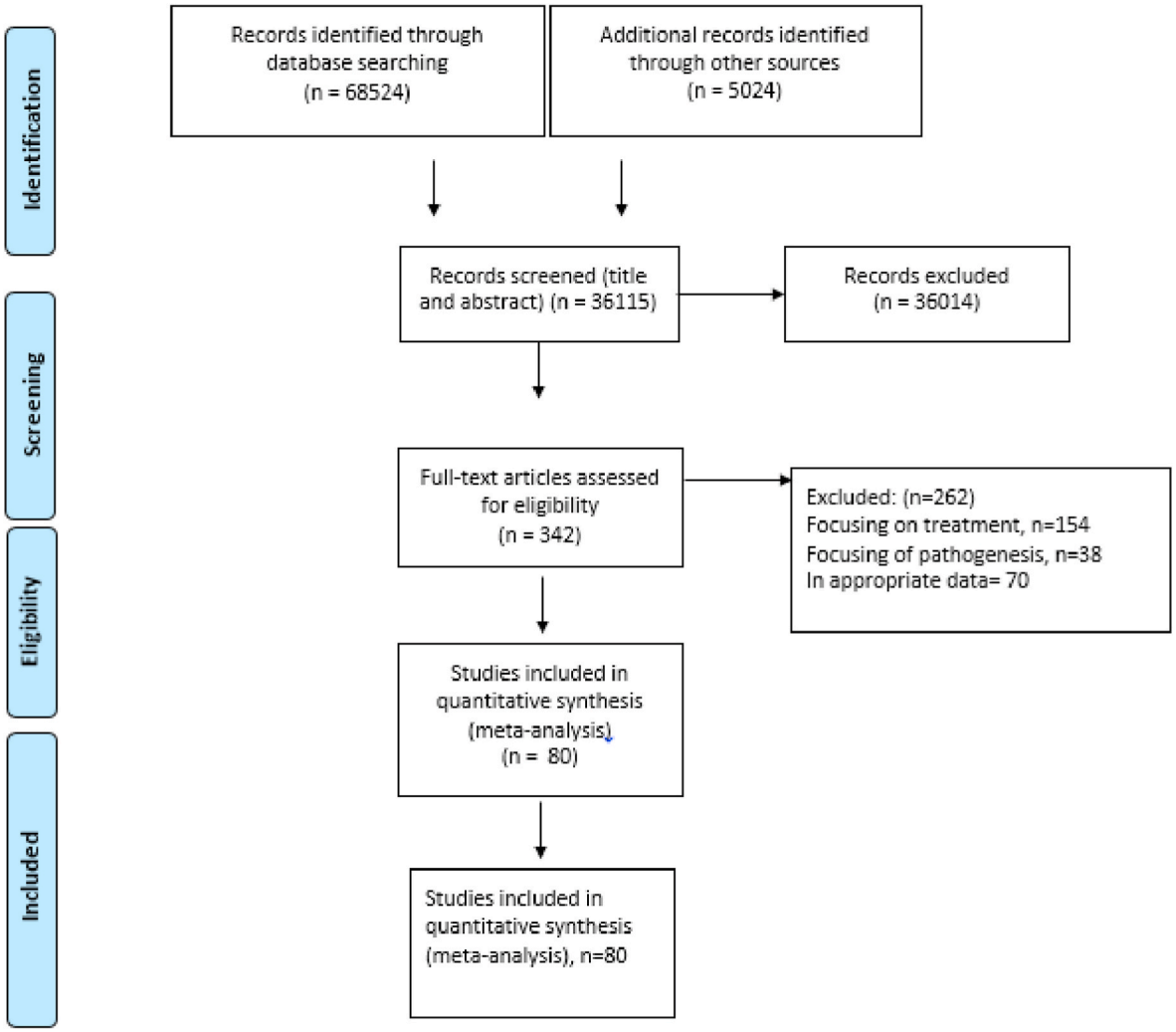

Fig. 1. Flow Diagram of Literature Search and Study Selection (PRISMA flow chart).

Table 1
Characterization of Included Studies with total 61, 742 COVID-19 Confirmed Patients. All Studies are Retrospective, from China, and Published in 2020.

First Author	Sampling Center	Sample collection time	Patient follow up (days)	N Confirmed Patients	Mean age in years (IQR)	N sex (male)	Reference standard
Nanshan Chen [14]	Wuhan Jinyintan Hospital	Jan 1 to Jan 20, 2020	5–24	99	55·5 (21–82)	67	RT-PCR
Kaiyuan Sun [30]	Multicenter	Jan 20- Jan 29, 2020	42	288	49 (2–89)	62.3	CDC guideline
Jie Li [31]	Dazhou Central Hospital	22 January- February 10, 2020	1–21	17	45.1 (32–65)	9	RT-PCR
Dawei Wang [15]	Zhongnan Hospital of Wuhan	January 1-January 28, 2020	6–34	138	56 (42–68)	75	RT-PCR
Chaolin Huang [16]	Jin Yintan Hospital (Wuhan)	Dec 31, 2019-UN	NA	41	49 (41–58)	30	RT-PCR
Weijie Guan [17]	Multicenter	NA	NA	1099	47 (35–58)	640	RT-PCR
Yang Yang [32]	NA	NA	51 days	4021	49	2211	NA
Lei Chen (Chinese) [13]	Tongji hospital in Wuhan	January 14–29, 2020	15 day	29	56 (26–79)	21	RT-PCR
Adam Bernheim [3]	Multicenter	January 18-February 2, 2020	12 days	121	45 (18–80)	61	RT-PCR & CT scan
Feng Pan [33]	Union Hospital	12 Jan-6 Fen 2020	NA	21	40 (25–63)	15	RT-PCR
jin Zhang [18]	No.7 hospital of Wuhan	Jan 16th to Feb 3rd, 2020	NA	140	57 (25–87)	71	RT-PCR
Yichun Cheng [19]	Tongji hospital in Wuhan	January 28-February 11, 2020	10 (7–13)	710	63 (51–71)	374	RT-PCR
Ming-Yen [34]	Hong Kong-Shenzhen Hospital	NA	NA	21	56 (37–65)	13	RT-PCR
Sijia Tian [35]	Beijing Emergency Medical Service	Jan 20 to Feb 10, 2020	Feb.10 20	262	47.5 (1–94)	127	RT-PCR
Qun Li [20]	NA	NA	NA	425	15–89 (26–82)	240	WHO guideline
De Chang [36]	3 hospitals in Beijing	January 16- January 29, 2020	Feb.4 2020	13	34 (34–48)	10	NA
Xiao-Wei Xu [21]	Zhejiang province	10 January −26 January 2020	10 days	62	41 (32–52)	36	WHO guideline
Fengxiang Song [22]	Center for Disease Control, Shanghai	January 20- January 27, 2020	NA	51	49 (16–76)	25	CT scan & nucleic acid test
Michael Chung [37]	Multicenter	January 18–27, 2020	NA	21	51 (29–77)	13	CT scan, NA
Zunyou Wu (CDC) [38]	Multicenter	through February 11, 2020	15 days	44,672	30–79	22,981	nucleic acid test result
Bicheng Zhang [39]	hospitalized death	January 11, 2020 to February 10	30 day	82	72.5	54	rt-pcr
Bing-Liang Lin [40],	Multicenter	January 20 to February 19,	29 day	91	50	52	rt-pcr
Bo Hu [41]	Multicenter	January 8 to February 9	20 day	50	62	34	rt-pcr
Chuansheng Zheng [42]	Union Hospital, Wuhan	16 Jan 2020 to 15 Feb,	30 day	64	35	23	rtpcr
Lin Fu [43]	Union Hospital	January 1 to January 30	30 day	200		99	rtpcr
Fei Zhou [44]	Multicenter			191	56	119	rtpcr
Guo-Qing Qian [45]	Multicenter	as of 11 February	NA	91	50	37	rt-pcr and clinical
Guqin Zhang [46]	Zhongnan Hospital	anuary 2 to February 10,	NA	221	55	108	rtpcr
Qiannan Guo [47]	Tongji Hospital	UN	UN	11	57.55	9	rtpcr
Hang Fu [48]	Chengdu, hospital	Jan 1 to Feb 20,	NA	52	44.5		rtpcr
Heshui Shi [49]	Union Hospital	Dec 20, 2019, and Jan 23	NA	81	49·5	42	rtpcr
Huijun Chen [50]	Multicenter	20-Jan	NA	9	26–40		rtpcr
Jian Wu [51]	Multicenter	22-Jan	NA	80	46.1	39	rtpcr
Jianlei Cao [52]	Multicenter	3-Jan	NA	102			rtpcr
Jie Liu [53]	Union Hospital	16 Jan 2020 to 15 Feb	NA	64	35	23	rtpcr
Jing Yuan [54]	Shenzhen hospital	Jan 23 23rd 2020 to Feb 21 21st	NA	25	28	8	rtpcr
Jinjun Zhang [55]	Multicenter	Jan 20 to Feb 20,	30 DAY	478	46.9	238	rtpcr
Jin-Wei Ai [56]	Hubei	UN	UN	102	50.38	52	rtpcr
Jiong Wu [57]	Yancheng City	22-Jan	NA	80	44	42	rtpcr
Jun Chen [58]	Shanghai	Jan 20 to Feb 6,	14 DAY	249	51	126	rtpcr
Kaiyuan Sun [59]	Multicenter	Jan 13 and Jan 31	NA	507	46	281	rtpcr
Kaiyue Diao [60]	Wuhan	January 17th to February 5th	30 DAY	6	47.5	3	rtpcr
Kenneth W. Tsang [61]	Hong Kong	February 22, 2003, and March 22	30 DAY	10	52.5	5	rtpcr
Kui Liu [62]	Multicenter	December 30, 2019 to January 24	24 DAY	137	57	61	rtpcr
L. Zhang [63]	Multicenter	Jan 13, 2020, to Feb 26	40 DAY	28	65	17	rtpcr
Lei Liu [64]	Hospital in Chongqing	January 20 to February 3,	14 DAY	51	45	32	rtpcr
lei shu [65]	Wuhan Stadium Cabin Hospital	Feb 13 to Feb 29,	16 DAY	545	50	264	rtpcr
Lei Wang [66]	Zhengzhou University	Jan 21 to Feb 05, 2020,	14 DAY	18	39	10	rtpcr
Li Yan [67]	Tongji Hospital	January 10th to February 18th	18 DAY	375	58.83	220	rtpcr
Li-Li Ren [68]	wuhan	December 18 to December 29, 2019	12 DAY	5	UN	3	rtpcr
Lin Fu [69]	Union Hospital	January 1 to January 30	30 DAY	200	UN	99	rtpcr
Xiang Li [70]	Multicenter	24-Feb-20	NA	292	47·83	134	rtpcr

(*continued on next page*)

Table 1 (*continued*)

Bing-Liang Lin [40],	Multicenter	January 20 to February 19,	29 day	91	50	52	rt-pcr
Matt Arentz [71]	Evergreen hospital	February 20, 2020, and March 5	15 DAY	21	70	11	rtpcr
Naibin Yang [72]	Zhejiang	25th January to 28th February	NA	10	33	3	rtpcr
Ping Wu [73]	Yichang Central People's Hospital	February 9 to 15	NA	38	65.8	25	rtpcr
Qifang Bi [74]	Shenzhen,	January 14 to February 12	25 DAY	391	45	187	rtpcr
Qiurong Ruan [75]	Multicenter			150			rtpcr
Tao Yao [76]	Renmin hospital		NA	55	70.7	37	rtpcr
Wen Zhao [77]	Beijing YouAn Hospital	21st Jan and 8th February	14 DAY	77	52	34	rtpcr
Yani Kuang [78]	Zhejiang	January 17,	NA	143	47	77	rtpcr
Yani Kuang [79]	Zhejiang,	1-Jan	NA	944	47.4	476	rtpcr
Wan Chen [80]	Hospital of Guangxi Zhuang	15-Jan	NA	85	41	34	rtpcr
Xiaomin Luo [81]	Renmin hospital	Jan 30 to Feb 25	25 DAY	403	56	193	rtpcr
Xiaoyu Han [82]	Union Hospital,	December 20 th and February 2	12 DAY	17	40	5	rtpcr
Xun Li [83]	wuhan	As of February 13	NA	25	71.48	10	rtpcr
Yan Deng [84]	wuhan	January 1,	NA	225	54	124	rtpcr
Yang Wu [85]	wuhan	13-Jan	NA	14	59	5	ct and rtpcr
Yangli Liu [86]	Guangdong,	December 8, 2019,	NA	13			rtpcr
Yanli Liu [87]	Hospital of Wuhan	January 2 to February	NA	109	55	59	rtpcr
Ying Huang [88]	wuhan	Jan 21 and Feb 10	20 DAY	36	69.22	25	rtpcr
Ying Wen [89]	Multicenter		NA	417	45.4	197	rtpcr
Yingjie Wu [90]	wuhan	12-Jan	NA	402		198	rtpcr
Yuhui Wang [91]	wuhan	January 16 to February 17	30 DAY	90	45	33	rtpcr
Zhibing Lu [92]	Multicenter	January 1 to February15	15 DAY	123	57.78	61	rtpcr
Zhiliang Hu [93]	Multicenter	from Jan 28 to Feb 9, 2020	19 DAY	24			rtpcr
Ping Yu [94]	Shanghai	7-Jan-20	NA	4	74.25		ct scan
Ali Aminian [95]	tehran	9-Feb	NA	4	63.5		ct scan
Hui Yu [96]	wuhan	Feb. 1 to Mar. 3,	NA	105	1–16 year	64	ct scan
Matthieu Million [97]	France, multi center	March 3rd to March 31s	NA	1061	43.6	492	Ct scan/rt pcr
					14–95		
Bai shaoli	Gansu Prov center	22-january	NA	8	53.71	4	Rt pcr

NA = not known, RT-PCR= Real Time Polymerase Chain Reaction, CDC= Centers for Disease Control and Prevention, WHO= World Health Organization, CT scan = CT scan of chest, N = number, IQR = interquartile range.

gle.com/. Additional search strategy details are provided in Table S1 (supplementary material) [10].

2.2. Study selection

Duplicate studies were removed using EndNote X7 (Thomson Reuters, New York, NY, USA). Records were initially screened by title and abstract by independently two authors (AP, SG). The full-text of potentially eligible records was retrieved and examined. Any discrepancies were resolved by consensus.

2.3. Inclusion criteria

Studies had to fulfil the following pre-determined criteria to be eligible for inclusion in our meta-analysis. Studies were included if they reported the number of confirmed cases of patients with demographic data, [AND] [OR] clinical data, [AND] [OR] laboratory data, [AND] [OR] risk factor data. Confirmed patients were defined as any patient with positive nucleic acid testing (most of the studies with Real-Time PCR) or those meeting CDC and WHO criteria at the time of their publication.

2.4. Exclusion criteria

Studies were excluded if they did not report number of confirmed cases, were letters to the editor or individual case reports or reviews. News reports were also excluded.

2.5. Data extraction

All included publications were published in 2020 and all patients are from China. The following items were extracted from each article: first author, Center and study location in China, sample collection time period, patient follow-up time, reference standard for infection confirmation, number of confirmed cases, and all demographic, clinical, laboratory data, and risk factor data. Two of our authors (AP and SG) independently extracted data and differences were resolved by consensus.

2.6. Quality assessment

Quality assessments of studies were performed by two reviewers independently according to the Critical Appraisal Checklist recommended by the Joanna Briggs Institute [11], and disagreements were resolved by consensus. The checklist is composed of nine questions that reviewers addressed for each study. The 'Yes' answer for each question received one point. Thus, final scores for each study could range from zero to nine (Table S2 in Supplementary Material).

2.7. Analysis

Data cleaning and preparation was done in Microsoft Excel 2010 (Microsoft©, Redmond, WA, USA) and further analyses were carried out via Comprehensive Meta-Analysis Software Version 2.0 (Biostat, Englewood, NJ). Determination of heterogeneity among the studies was undertaken using the chi-squared test (Cochran's Q) to assess the appropriateness of pooling data. We used Random effect model (M − H heterogeneity) for pooled results [12]. P values reflect study heterogeneity with <0.05 being significant. We also used the Begg's and Egger's tests based on the symmetry assumption to detect publication bias.

3. Results

3.1. Characteristics of included studies

The process of study selection is displayed in Fig. 1. A total of 36,115 reports were screened for the analysis of patients with COVID-19, 36,014 were excluded after title and abstract screening and the full text of 342 reports were reviewed in full text. We excluded studies that did not report sufficient data and finally 80 studies met the inclusion criteria (Fig. 1). Characteristics of the selected articles are summarized in Table 1. Of the 80 studies that were included in the analysis, 79

Table 2
Demographics, baseline characteristics, and clinical outcomes of patients with confirmed COVID-19.

	Clinical presentation*	Confidence interval 95%	Heterogeneity test, I2 (%)**	Heterogeneity test, P Value**	Number of Studies
Age, years	48 (mean)	43–50	98	<0.001	23
Sex (Male)	55 (%)	50–57.5	88.4	<0.001	24
Fever	87 (%)	73–93	98	<0.001	18
Cough	68 (%)	55.5–74	86	<0.001	18
Fatigue	39 (%)	29–52.5	93	<0.001	14
Sputum production/Expectoration	31 (%)	19–39	92	<0.001	9
Myalgia	24 (%)	14–43	92	<0.001	9
Dyspnea	24 (%)	12.6–32	92	<0.001	11
Sore throat	14 (%)	7.8–17	52	0.06	9
Headache	14 (%)	8.3–18	77	<0.001	16
Diarrhea	8 (%)	4.6–11.4	70	<0.001	18
Rhinorrhea	7 (%)	3–12	0	0.43	6
Nausea and vomiting	6.5 (%)	2.7–13	84	<0.001	6
Outcome					
Hospitalized	81 (%)	68–94	95	<0.001	7
Critical condition/ICU	25.6 (%)	6.7–48	99	<0.001	8
CFR (all age group)	6 (%)	4–8.5	89.6	<0.001	49

*Age is an exception, presented in mean age in years. ** Greater than 50% is considered high heterogeneity, less than 50% is considered low heterogeneity. A low p value (<0.05) is consistent with high heterogeneity. Case fatality rate (CFR).

Table 3
Meta-analysis on clinical presentation of case fatality rate (CFR) in different age groups of confirmed COVID-19 cases.

Age groups (year)	CFR (%)	Confidence Interval		patients		Heterogeneity test*	
		Lower limit (%)	Upper limit (%)	Number Studies	Included patients	I-squared	P-value
All Range	6	4	8.5	49	54,252	89.6	<0.001
>50	39.5	28.5	52	14	1935	97	<0.001
<15	0.6	0	0.9	1	82	0	1

Case fatality rate (CFR), * Greater than 50% is considered high heterogeneity, less than 50% is considered low heterogeneity. A low p value.

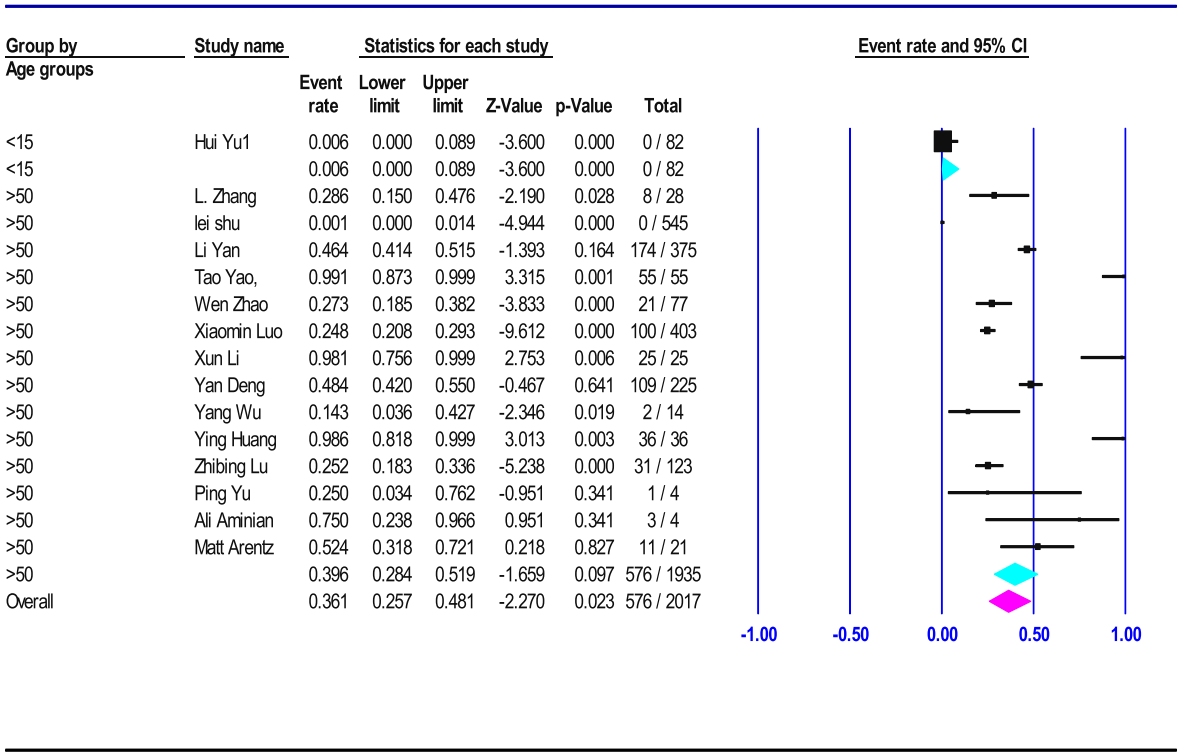

Fig. 2. Forest plot of the meta-analysis on clinical presentation of case fatality rate (CFR) in different age groups of confirmed COVID-19 cases.

studies were in English and the one of them was in the language of Chinese [13]. All studies were retrospective, published in 2020, and all patients were from China.

3.2. Quality assessment

Quality assessment of included studies were performed based on the Critical Appraisal Checklist and the final scores for quality of included

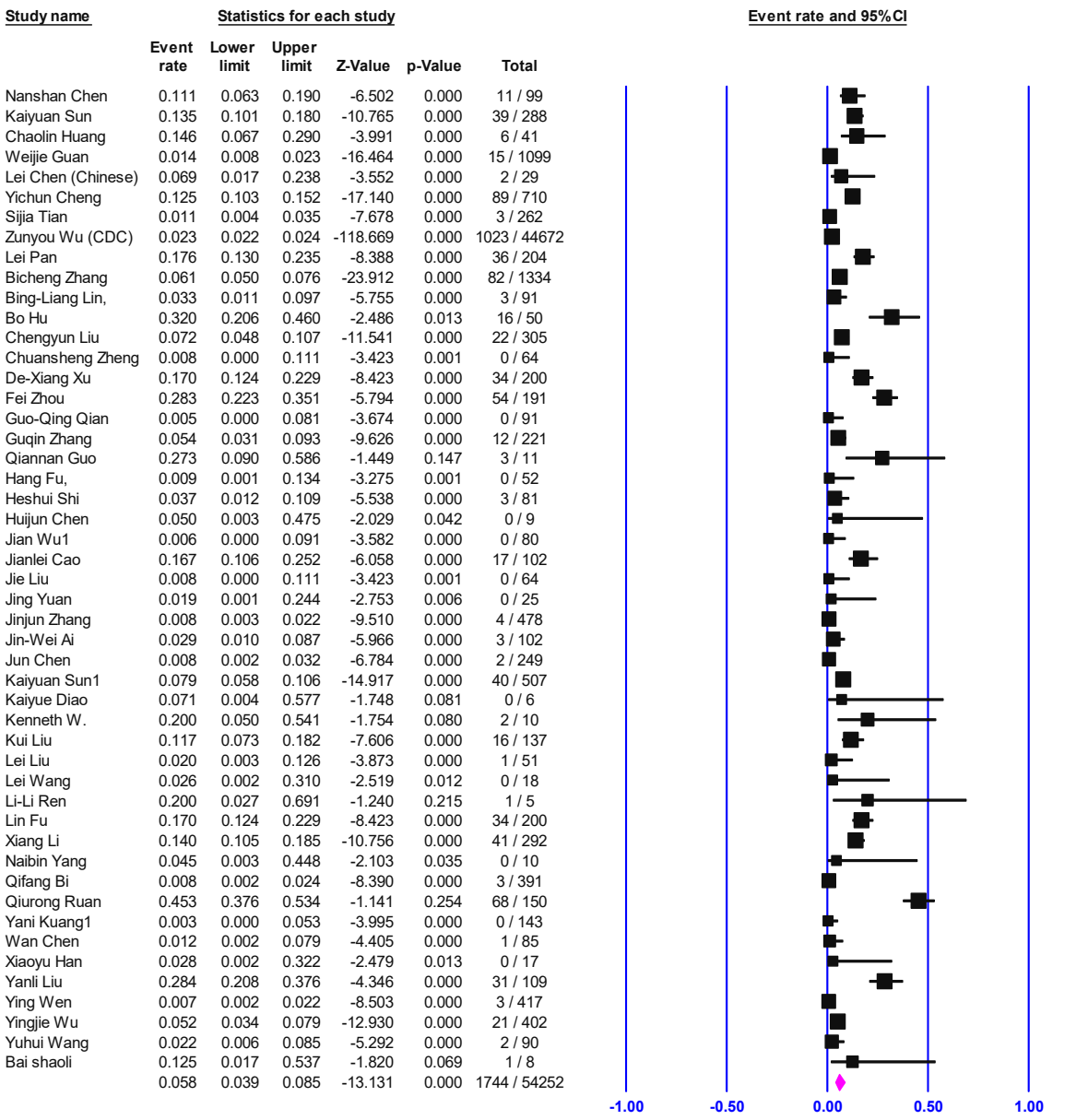

Fig. 3. Forest plot of the meta-analysis on clinical presentation of case fatality rate (CFR) in all age groups of confirmed COVID-19 cases.

studies are represented in Table S2 (in supplementary material). In brief, studies by Chen [14], Wang [15], Huang [16], Guan [17], Zhang [18], Cheng [19], Li [20], Wei Xu [21], and Song [22] had the highest quality of the studies available in the purpose of this study.

3.3. Demographics, baseline characteristics, and clinical characterization

Table 2 shows that 61, 742 confirmed patients with COVID-19 infection were included in the Meta-analysis, of which 55% (95% CI 50–57.5, $p < 0.001$) were male. The most of the patients had fever 87% (95% CI 73–93, $p < 0.001$) and cough 68% (95% CI 55.5–74, $p < 0.001$). A much smaller proportion of patients had sore throat 14% (95% CI 7.8–17, p 0.06), headache 14% (95% CI 8.3–18, $p < 0.001$), diarrhea 8% (95% CI 4.6–11.4, $p < 0.001$), rhinorrhea 7% (95% CI 3–12, p 0.43) or nausea and vomiting 6.5% (95% CI 2.7–13, $p < 0.001$). Most patients required hospitalization 81% (95% CI 68–94, $p < 0.001$), 25.6% (95% CI 6.7–48, $p < 0.001$) were deemed to be in critical condition and the mortality rate was 6% (95% CI 4–8.5, $p < 0.001$) between all infected patients. Table 3 shows that case fatality rate (CFR) in <15 years old age groups was 0.6% (95% CI 0–0.9, p 1), >50 years old was 39.5% (95% CI 28.5–52, $p < 0.001$) (Fig. 2), all range group was 6% (95% CI 4–8.5, $p < 0.001$) (Fig. 3).

3.4. Clinical characteristics, and Comorbid conditions of patients infected with COVID-19

The majority of patients, 62.5% (95% CI 54.5–79, $p < 0.001$), had a history of recent travel endemic area or contact with them. A significant minority of patients (39.5%, 95% CI 20–56, $p < 0.001$) had a history of chronic diseases and 26.5% (95% CI 9.6–49, $p < 0.001$) had exposure at the seafood market(s) (Table 4).

Table 4
Clinical Characteristics and Comorbid Conditions of patients with confirmed COVID-19.

Risk Factor	Patients with risk factor (%)	Confidence interval 95%	Heterogeneity test, I2 (%)*	Heterogeneity test, P Value*	Number of Studies reporting
History of recent travel endemic area or contact with them	62.5	54.5–79	96	<0.001	11
Chronic diseases	39.5	20–56	95	<0.001	6
Exposure to seafood market	26.5	9.6–49	95	<0.001	8
Sick contacts with respiratory illness	18	4.5–39.6	97	<0.001	7
Hypertension	18	8.5–24.6	97.5	<0.001	17
ARDS	17.5	4–26.7	95.7	<0.001	8
Diabetes	9	4–15	96	<0.001	11
Current smoker	8.2	3.7–15	69	0.01	8
Chronic liver disease	7	3.8–8.4	6	0.38	12
Digestive system disease	4.5	2.5–4.9	95	<0.001	8
Health care worker	16	2–4.6	79	0.008	12
Past smoker	4	1.1–7.5	80	0.02	6
Cardiovascular and cerebrovascular diseases	3.3	2.2–2.5	98	<0.001	14
Chronic respiratory disease	3.2	0.6–8	93	<0.001	7
Cancer	2.7	0.4–7.4	96.3	<0.001	9

ARDS = acute respiratory distress syndrome * Greater than 50% is considered high heterogeneity, less than 50% is considered low heterogeneity. A low p value (<0.05) is consistent with high heterogeneity.

Table 5
Laboratory features for confirmed patients with COVID-19.

		Confidence interval 95%	normal range	Total Patient Number	Number of Studies
Leucocytes (WBCs) (mean)	6.2 (× 10^9 per L)	5.3–6.9	3.5–9.5	2961	17
Increased[a]	18.3 (%)	6.4–25.6			
Decreased	28 (%)	21–33			
Neutrophils (mean)	4.6 (× 10^9 per L)	3.1–5.1	1.8–6.3	1212	12
Lymphocytes (mean)	0.94 (× 10^9 per L)	0.9–1.06	1.1–3.2	3161	18
Decreased	57.5 (%)	42–79			
Platelets (mean)	196.5 (× 10^9 per L)	167–205	125–350	2900	15
Decreased	13 (%)	5–30			
Increased	61 (%)	41–78			
CRP[a] (mean)	32 (mg/L)	19.7–46.5	0–0.5	880	10
Increased	79 (%)	65–91			
Hemoglobin (mean)	113 (g/L)	106–132	130–175	2862	12
ESR(mean)**	44 (mm/h)	46–57	0–15	320	4
Albumin (mean)	36.8 (g/L)	24.5–46	40–55	420	5
Decreased	81%	72–87			
Interleukin-6 (mean)	8.1 (pg/mL)	6.8–8.6	0.0–7	509	6
Increased	56%	42–61			
LDH* (mean)**	286	268–294	120–250	2383	12
Increased	69.3 (%)	58–83			

CRP= C Reaction Protein, ESR = Erythrocyte sedimentation rate. WBCs= White blood cells.

[a] Increased or Decreased refers to values above or below the normal range.

3.5. Laboratory findings of patients infected with COVID-19

The laboratory analysis and features showed that the most infected patients had increased platelets 61% (95% CI 41–78, $p < 0.001$), and CRP 79% (95% CI 65–91, $p < 0.001$), while others showed decreased lymphocytes, 57.5% (95% CI 42–79, $p < 0.001$) (Table 5).

3.6. Chest X-ray and CT scan findings in patients infected with COVID-19

Analysis showed that the most abnormality which finding with Chest X-ray and CT are bilateral involvement of chest radiography 81% (95% CI 62.5–87, $p < 0.001$), consolidation 73.5% (95% CI 50.5–91, $p < 0.001$), and ground-glass opacity 73.5% (95% CI 40–90, $p < 0.001$) (Table 6).

4. Discussion

COVID-19 belongs to the Coronaviridae family and is the newest serious zoonotic virus after the related viruses SARS and MERS [23,24]. Prior to 2002, coronaviruses were associated with mild respiratory illness, but with the emergence of SARS in 2002, MERS in 2012, and now in late 2019, COVID-19, establishes that coronaviruses can be associated with severe respiratory disease. Genetic variation and phylogenetic analysis of these viruses show that the COVID-19 virus has 84% homology to other beta-coronaviruses, 96% sequence similarity at the whole genome level to a bat coronavirus and 79.5% similarity to the SARS virus [8,25]. These results suggest that bats are important coronavirus reservoirs.

A study by Adam Bernheim et al. showed that among 121 COVID-19 patients, fever, cough and sputum production were the most common clinical symptoms [3]. Our study found utilizing data from 52,251 patients with COVID-19 infection, that in additional to these, fatigue and myalgia (muscle soreness) were also common.

The large data set here finds that 81% of patients required hospitalization, 25.6% were found to be in critical condition and the mortality rate was 6% between all infected patients. The mortality rate is lower than some studies (for example, 11% in Nanshan et al. [14]), but still higher than many viral infections. It should be recognized that these numbers are bias due to the data set including publications related to screening practices (e.g. only those with symptoms being screened) increased the % value. The true mortality rate from COVID-19 is almost certainly much lower than that found in this study. As more data emerges from screening asymptomatic or mildly symptomatic individuals in China and around the world, the true mortality rate will be better understood. Additionally, at the time of submission of this

Table 6
Chest X-ray and CT scan Findings in Patients with Confirmed COVID-19.

	Abnormality (%)	Confidence interval 95%	Heterogeneity test, I2 (%)[a]	Heterogeneity test, P Value[a]	Number of Studies
Bilateral involvement of chest radiography	81	62.5–87	93	<0.001	18
Consolidation	73.5	50.5–91	89	<0.001	9
Ground-glass opacity	73.5	40–90	97	<0.001	16
Unilateral involvement of chest radiography	18.5	8.5–29.5	94	<0.001	9

[a] Greater than 50% is considered high heterogeneity, less than 50% is considered low heterogeneity. A low p value (<.05) is consistent with high heterogeneity. CT scan = CT scan.

manuscript only ~50% of reported infected patients had recovered (gisanddata.maps.arcgis.com). Lymphopenia, age, multilobular infiltration, smoking history, hypertension, and bacterial co-infection have been reported as mortality risk factors. Underlying cardiovascular disease (40%) and bilateral pneumonia (81%) were common among those who have died. Recent travel endemic area or contact with them, exposure to persons with respiratory symptoms, and seafood market exposures were common amongst those contracting COVID-19. Among 2361 COVID-19 patients with laboratory data available, leukocytosis was found in 18.3% and leukopenia in 28% with lymphocytopenia in 57.5%. Among 2200 patients, thrombocytosis occurred in 61% and in a smaller sample (n = 290) CRP was increased in 79%.

A study by Yu Zhao et al. showed that ACE2 is a COVID-19 virus receptor and that it is normally expressed on pulmonary alveolar epithelial cells [26]. ACE2 activates the RAS cascade, which can lead to hypertension. The pathology in this pathway can also stimulate fibrogenesis, inflammation, cell hypertrophy, and cell proliferation [27,28]. ACE2 expression is increased in people with pulmonary ARDS and acute respiratory injury [29]. The data collected here shows that ARDS occurred in 17.5% of reported patients with COVID-19 infection.

4.1. Limitations

Several limitations of this study exist. Publication bias and study heterogeneity are unavoidable in this type of study, therefore it should be considered when interpreting the outcomes of the reports and our final data set. Further, this study likely overestimates disease severity due to lack of screening of asymptomatic or mildly symptomatic individuals and subsequent publication bias related to these factors. It is very likely that many infected persons have not been detected, thus falsely elevating the rates of hospitalization, critical condition, and mortality.

5. Conclusions

Fever and cough are the most common symptoms of COVID-19 infection in the literature published to date. Thombocytosis, lymphopenia, and increased CRP were common lab findings although most patients included in the overall analysis did not have laboratory values reported. The most common radiographic sign was bilateral involvement in and consolidation. Among Chinese patients with COVID-19, rates of hospitalization, critical condition, and hospitalization were high in this study, but these findings may be biased by reporting of only confirmed cases.

Declaration of competing interest

The authors have declared that no competing interests exist.

Acknowledgments

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.micpath.2020.104390.

Funding

Dr. Bahr receives funding from the National Institute of Neurological Disorders and Stroke of the National Institutes of Health, K23 NS110470.

Author contributions

Conceived and designed the study: AP, SG, Comprehensive research: SG, AK, AP, Analyzed the data: A P, MAM, Wrote and revised the paper: AP, SG, BB, AK, RT, MAM, NB, DK, JPI, Participated in data analysis and manuscript editing: AP, SG, BB, AK, RT, MAM, NB, DK, JPI.

Ethical statement

The manuscript is a systematic review, so the ethical approval was not required for the study.

References

[1] N. Zhu, D. Zhang, W. Wang, X. Li, B. Yang, J. Song, et al., A novel coronavirus from patients with pneumonia in China, N. Engl. J. Med. (2019), 2020.
[2] J.F.-W. Chan, S. Yuan, K.-H. Kok, K.K.-W. To, H. Chu, J. Yang, et al., A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster, Lancet (2020).
[3] A. Bernheim, X. Mei, M. Huang, Y. Yang, Z.A. Fayad, N. Zhang, et al., Chest CT findings in coronavirus disease-19 (COVID-19): relationship to duration of infection, Radiology (2020) 200463.
[4] Who. Rational Use of Personal Protective Equipment for Coronavirus Disease 2019 (COVID-19) 2020, Feb 27.
[5] W. Lam, N. Zhong, W. Tan, Overview on SARS in Asia and the world, Respirology 8 (2003) S2–S5.
[6] J. Zheng, S. Hassan, A.N. Alagaili, A.N. Alshukairi, N.M. Amor, N. Mukhtar, et al., Middle East respiratory syndrome coronavirus seropositivity in camel handlers and their families, Pakistan, Emerg. Infect. Dis. 25 (2019) 2307.
[7] A. Contini, Virtual Screening of an FDA Approved Drugs Database on Two COVID-19 Coronavirus Proteins, 2020.
[8] A. Zhavoronkov, V. Aladinskiy, A. Zhebrak, B. Zagribelnyy, V. Terentiev, D. S. Bezrukov, et al., Potential COVID-2019 3C-like Protease Inhibitors Designed Using Generative Deep Learning Approaches, 2020.
[9] D. Moher, A. Liberati, J. Tetzlaff, D.G. Altman, Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement, Ann. Intern. Med. 151 (2009) 264–269.
[10] A. Pormohammad, S. Ghorbani, A. Khatami, R. Farzi, B. Baradaran, D.L. Turner, et al., Comparison of confirmed COVID-19 with SARS and MERS cases-Clinical characteristics, laboratory findings, radiographic signs and outcomes: a systematic review and meta-analysis, Rev. Med. Virol. (2020 Jun 5), e2112.
[11] Z. Munn, S. Moola, D. Riitano, K. Lisy, The development of a critical appraisal tool for use in systematic reviews: addressing questions of prevalence, Int. J. Health Pol. Manag. 3 (2014) 123.
[12] N. Mantel, W. Haenszel, Statistical aspects of the analysis of data from retrospective studies, J. Natl. Cancer Inst. 22 (1959) 719–748.
[13] L. Chen, H. Liu, W. Liu, J. Liu, K. Liu, J. Shang, et al., Analysis of clinical features of 29 patients with 2019 novel coronavirus pneumonia, Chin. J. Tuberc. Respir. Dis. (Zhonghua Jiehe He Huxi Zazhi) 43 (2020) E005.
[14] N. Chen, M. Zhou, X. Dong, J. Qu, F. Gong, Y. Han, et al., Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study, Lancet (2020).

[15] D. Wang, B. Hu, C. Hu, F. Zhu, X. Liu, J. Zhang, et al., Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China, Jama (2020).

[16] C. Huang, Y. Wang, X. Li, L. Ren, J. Zhao, Y. Hu, et al., Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China, Lancet 395 (2020) 497–506.

[17] W-j Guan, Z-y Ni, Y. Hu, W-h Liang, C-q Ou, J-x He, et al., Clinical Characteristics of 2019 Novel Coronavirus Infection in China, MedRxiv, 2020.

[18] Jj Zhang, X. Dong, Y.Y. Cao, Yd Yuan, Yb Yang, Yq Yan, et al., Clinical Characteristics of 140 Patients Infected by SARS-CoV-2 in Wuhan, China, Allergy, 2020.

[19] Y. Cheng, R. Luo, K. Wang, M. Zhang, Z. Wang, L. Dong, et al., Kidney Impairment Is Associated with In-Hospital Death of COVID-19 Patients, medRxiv, 2020.

[20] Q. Li, X. Guan, P. Wu, X. Wang, L. Zhou, Y. Tong, et al., Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia, N. Engl. J. Med. (2020).

[21] X.-W. Xu, X.-X. Wu, X.-G. Jiang, K.-J. Xu, L.-J. Ying, C.-L. Ma, et al., Clinical findings in a group of patients infected with the 2019 novel coronavirus (SARS-Cov-2) outside of Wuhan, China: retrospective case series, bmj (2020) 368.

[22] Song F, Shi N, Shan F, Zhang Z, Shen J, Lu H, et al. Emerging coronavirus 2019-nCoV pneumonia. Radiology. 2020:200274.

[23] W. Ji, W. Wang, X. Zhao, J. Zai, X. Li, Homologous recombination within the spike glycoprotein of the newly identified coronavirus may boost cross-species transmission from snake to human, J. Med. Virol. (2020).

[24] P. Sun, S. Qie, Z. Liu, J. Ren, J. Xi, Clinical Characteristics of 5732 Patients with 2019-nCoV Infection, 2020. Available at: SSRN 3539664.

[25] P. Zhou, X.-L. Yang, X.-G. Wang, B. Hu, L. Zhang, W. Zhang, et al., Discovery of a novel coronavirus associated with the recent pneumonia outbreak in humans and its potential bat origin, BioRxiv (2020).

[26] Y. Zhao, Z. Zhao, Y. Wang, Y. Zhou, Y. Ma, W. Zuo, Single-cell RNA Expression Profiling of ACE2, the Putative Receptor of Wuhan 2019-nCov, BioRxiv, 2020.

[27] C.T. Cole-Jeffrey, M. Liu, M.J. Katovich, M.K. Raizada, V. Shenoy, ACE2 and microbiota: emerging targets for cardiopulmonary disease therapy, J. Cardiovasc. Pharmacol. 66 (2015) 540.

[28] Y.C. Li, Molecular mechanism of vitamin D in the cardiovascular system, J. Invest. Med. 59 (2011) 868–871.

[29] Y. Imai, K. Kuba, J.M. Penninger, Angiotensin-converting enzyme 2 in acute respiratory distress syndrome, Cell. Mol. Life Sci. 64 (2007) 2006–2012.

[30] K. Sun, J. Chen, C. Viboud, Early Epidemiological Analysis of the 2019-nCoV Outbreak Based on a Crowdsourced Data, medRxiv, 2020.

[31] J. Li, S. Li, Y. Cai, Q. Liu, X. Li, Z. Zeng, et al., Epidemiological and Clinical Characteristics of 17 Hospitalized Patients with 2019 Novel Coronavirus Infections outside Wuhan, China, medRxiv, 2020.

[32] Y. Yang, Q. Lu, M. Liu, Y. Wang, A. Zhang, N. Jalali, et al., Epidemiological and Clinical Features of the 2019 Novel Coronavirus Outbreak in China, medRxiv, 2020.

[33] Pan F, Ye T, Sun P, Gui S, Liang B, Li L, et al. Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia. Radiology. 2020:200370.

[34] M.-Y. Ng, E.Y. Lee, J. Yang, F. Yang, X. Li, H. Wang, et al., Imaging profile of the COVID-19 infection: radiologic findings and literature review, Radiology: Cardiothorac. Imag. 2 (2020), e200034.

[35] S. Tian, N. Hu, J. Lou, K. Chen, X. Kang, Z. Xiang, et al., Characteristics of COVID-19 Infection in Beijing, 2020.

[36] D. Chang, M. Lin, L. Wei, L. Xie, G. Zhu, C.S.D. Cruz, et al., Epidemiologic and clinical characteristics of novel coronavirus infections involving 13 patients outside Wuhan, China, Jama (2020).

[37] Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X, et al. CT imaging features of 2019 novel coronavirus (2019-nCoV). Radiology. 2020:200230.

[38] Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese center for disease Control and prevention. J. Am. Med. Assoc..

[39] B. Zhang, X. Zhou, Y. Qiu, F. Feng, J. Feng, Y. Jia, et al., Clinical Characteristics of 82 Death Cases with COVID-19, medRxiv, 2020.

[40] B. Wu, Z.-Y. Lei, K.-L. Wu, J.-R. He, H.-J. Cao, J. Fu, et al., Epidemiological and Clinical Features of Imported and Local Patients with Coronavirus Disease 2019 (COVID-19) in Hainan, 2020. China.

[41] Z. Peng, B. Hu, D. Wang, C. Hu, M. Hu, F. Zhu, et al., Clinical Features of Critically Ill Patients with COVID-19 Infection in China, 2020.

[42] J. Liu, L. Ouyang, P. Fu, Y. Cao, D. Yang, X. Han, et al., Epidemiological, Clinical, Radiological Characteristics and Outcomes of Medical Staff with COVID-19 in Wuhan, China: A Single-Centered, Retrospective Case Series Analysis, 2020.

[43] L. Fu, J. Fei, H.-X. Xiang, Y. Xiang, Z.-X. Tan, M.-D. Li, et al., Analysis of death risk factors among 200 COVID-19 patients in Wuhan, China: a hospital-based case-cohort study, in: Fang-Fang, Liu Hong-Yan, Zheng Ling, Li Ying, Zhao Hui, Xu De-Xiang (Eds.), Analysis of Death Risk Factors Among, vol. 200, 2020.

[44] F. Zhou, T. Yu, R. Du, G. Fan, Y. Liu, Z. Liu, et al., Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study, Lancet (2020).

[45] G.-Q. Qian, N.-B. Yang, F. Ding, A.H.Y. Ma, Z.-Y. Wang, Y.-F. Shen, et al., Epidemiologic and clinical characteristics of 91 hospitalized patients with COVID-19 in Zhejiang, China: a retrospective, multi-centre case series, QJM: Int. J. Med. (2020).

[46] G. Zhang, C. Hu, L. Luo, F. Fang, Y. Chen, J. Li, et al., Clinical Features and Outcomes of 221 Patients with COVID-19 in Wuhan, China, MedRxiv, 2020.

[47] Q. Guo, K-pB. Nampoukime, K. Ma, H. Wang, Clinical Features of 11 COVID-19 Patients with History of Thoracotomy: A Descriptive Study in Wuhan, China, 2020. China (3/5/2020).

[48] H. Fu, H. Xu, N. Zhang, H. Xu, Z. Li, H. Chen, et al., Association between Clinical, Laboratory and CT Characteristics and RT-PCR Results in the Follow-Up of COVID-19 Patients, medRxiv, 2020.

[49] H. Shi, X. Han, N. Jiang, Y. Cao, O. Alwalid, J. Gu, et al., Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study, Lancet Infect. Dis. (2020).

[50] H. Chen, J. Guo, C. Wang, F. Luo, X. Yu, W. Zhang, et al., Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records, Lancet 395 (2020) 809–815.

[51] J. Wu, J. Liu, X. Zhao, C. Liu, W. Wang, D. Wang, et al., Clinical characteristics of imported cases of coronavirus disease 2019 (COVID-19) in Jiangsu province: a multicenter descriptive study, Clin. Infect. Dis. (2020).

[52] J. Cao, X. Hu, W. Cheng, L. Yu, W.-J. Tu, Q. Liu, Clinical features and short-term outcomes of 18 patients with corona virus disease 2019 in intensive care unit, Intensive Care Med. (2020) 1–3.

[53] J. Liu, L. Ouyang, P. Guo, H. sheng Wu, P. Fu, Y. liang Chen, et al., Epidemiological, Clinical Characteristics and Outcome of Medical Staff Infected with COVID-19 in Wuhan, China: A Retrospective Case Series Analysis, medRxiv, 2020.

[54] J. Yuan, S. Kou, Y. Liang, J. Zeng, Y. Pan, L. Liu, Clinical Characteristics on 25 Discharged Patients with COVID-19 Virus Returning, medRxiv, 2020.

[55] J. Zhang, S. Yang, Y. Xu, J. Liu, J. Guo, S. Tian, et al., Epidemiological and Clinical Characteristics of COVID-19 Infection outside Wuhan, A Multicenter Study, China, 2020.

[56] J. Ai, J. Chen, Y. Wang, X. Liu, W. Fan, G. Qu, et al., The Cross-Sectional Study of Hospitalized Coronavirus Disease 2019 Patients in Xiangyang, Hubei Province. medRxiv, 2020.

[57] J. Wu, X. Wu, W. Zeng, D. Guo, Z. Fang, L. Chen, et al., Chest CT findings in patients with coronavirus disease 2019 and its relationship with clinical features, Invest. Radiol. 55 (2020) 257–261.

[58] J. Chen, T. Qi, L. Liu, Y. Ling, Z. Qian, T. Li, et al., Clinical progression of patients with COVID-19 in Shanghai, China, J. Infect. (2020).

[59] K. Sun, J. Chen, C. Viboud, Early epidemiological analysis of the coronavirus disease 2019 outbreak based on crowdsourced data: a population-level observational study, Lancet Digit. Health (2020).

[60] K. Diao, P. Han, T. Pang, Y. Li, Z. Yang, HRCT imaging features in representative imported cases of 2019 novel coronavirus pneumonia, Precis. Clin. Med. 3 (2020) 9–13.

[61] K.W. Tsang, P.L. Ho, G.C. Ooi, W.K. Yee, T. Wang, M. Chan-Yeung, et al., A cluster of cases of severe acute respiratory syndrome in Hong Kong, N. Engl. J. Med. 348 (2003) 1977–1985.

[62] K. Liu, Y.-Y. Fang, Y. Deng, W. Liu, M.-F. Wang, J.-P. Ma, et al., Clinical characteristics of novel coronavirus cases in tertiary hospitals in Hubei Province, Chin. Med. J. (2020).

[63] L. Zhang, F. Zhu, L. Xie, C. Wang, J. Wang, R. Chen, et al., Clinical characteristics of COVID-19-infected cancer patients: a retrospective case study in three hospitals within Wuhan, China, Ann. Oncol. (2020).

[64] L. Lei, G. Jian-Ya, W. Hu, X. Zhang, L. Gua, C. Liu, Clinical Characteristics of 51 Patients Discharged from Hospital with COVID-19 in Chongqing, MedRxiv, China, 2020.

[65] L. Shu, X. Wang, M. Li, X. Chen, L. Shi, M. Wu, et al., Clinical Characteristics of 545 Cases Confirmed COVID-19 in Wuhan Stadium Cabin Hospital, 2020. Available at: SSRN 3552844.

[66] L. Wang, Y.-H. Gao, L.-L. Lou, G.-J. Zhang, The clinical dynamics of 18 cases of COVID-19 outside of Wuhan, China, Eur. Respir. J. 55 (2020).

[67] L. Yan, H.-T. Zhang, Y. Xiao, M. Wang, C. Sun, J. Liang, et al., Prediction of Criticality in Patients with Severe Covid-19 Infection Using Three Clinical Features: a Machine Learning-Based Prognostic Model with Clinical Data in Wuhan, medRxiv, 2020.

[68] L.-L. Ren, Y.-M. Wang, Z.-Q. Wu, Z.-C. Xiang, L. Guo, T. Xu, et al., Identification of a novel coronavirus causing severe pneumonia in human: a descriptive study, Chin. Med. J. (2020).

[69] L. Fu, J. Fei, H.-X. Xiang, Y. Xiang, Z.-X. Tan, M.-D. Li, et al., Influence Factors of Death Risk Among COVID-19 Patients in Wuhan, China: a Hospital-Based Case-Cohort Study, medRxiv, 2020.

[70] X. Li, Y. Hu, S. Zhu, Y. Li, L. Huang, Y. Li, et al., Epidemiological Feature and Outcome of 292 Hospitalized Patients with COVID-19 under Adequate Medical Resource Condition, 2020. Available at: SSRN 3550016.

[71] M. Arentz, E. Yim, L. Klaff, S. Lokhandwala, F.X. Riedo, M. Chong, et al., Characteristics and outcomes of 21 critically ill patients with COVID-19 in Washington State, Jama (2020).

[72] N. Yang, Y. Shen, C. Shi, A.H.Y. Ma, X. Zhang, X. Jian, et al., In-flight Transmission Cluster of COVID-19: A Retrospective Case Series, medRxiv, 2020.

[73] P. Wu, F. Duan, C. Luo, Q. Liu, X. Qu, L. Liang, et al., Characteristics of ocular findings of patients with coronavirus disease 2019 (covid-19) in Hubei Province, China, JAMA Ophthalmol. (2020).

[74] Q. Bi, Y. Wu, S. Mei, C. Ye, X. Zou, Z. Zhang, et al., Epidemiology and Transmission of COVID-19 in Shenzhen China: analysis of 391 cases and 1,286 of their close contacts, MedRxiv (2020).

[75] Q. Ruan, K. Yang, W. Wang, L. Jiang, J. Song, Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan, China, Intensive Care Med. (2020) 1–3.

[76] T. Yao, Y. Gao, Q. Cui, J. Shen, B. Peng, Y. Chen, et al., Clinical Characteristics of 55 Cases of Deaths with COVID-19 Pneumonia in Wuhan, China, Retrospective Case Series, 2020.
[77] W. Zhao, S. Yu, X. Zha, N. Wang, Q. Pang, T. Li, et al., Clinical Characteristics and Durations of Hospitalized Patients with COVID-19 in Beijing: a Retrospective Cohort Study, medRxiv, 2020.
[78] Y. Kuang, S. He, S. Lin, R. Zhu, R. Zhou, J. Wang, et al., Clinical Characteristics and CT Manifestations of 143 Hospitalized Patients with 2019 Novel Coronavirus Disease (COVID-19) outside Wuhan: A Multi-Center Study in Taizhou City, 2020. Zhejiang, China. Zhejiang, China (3/14/2020).
[79] Y. Kuang, H. Zhang, R. Zhou, S. Lin, M. Lin, J. Wang, et al., Epidemiological and Clinical Characteristics of 944 Cases of 2019 Novel Coronavirus Infection of Non-COVID-19 Exporting City, 2020. Zhejiang, China. Zhejiang, China (February 20, 2020).
[80] W. Chen, C. Chen, L. Huang, K. Ye, L. Lv, Z. Qin, et al., Clinical Characteristics of 85 Patients Infected by SARS-CoV-2 in Guangxi, 2020. China.
[81] X. Luo, H. Xia, W. Yang, B. Wang, T. Guo, J. Xiong, et al., Characteristics of Patients with COVID-19 during Epidemic Ongoing Outbreak in Wuhan, China, MedRxiv, 2020.
[82] X. Han, Y. Cao, N. Jiang, Y. Chen, O. Alwalid, X. Zhang, et al., Novel coronavirus pneumonia (COVID-19) progression course in 17 discharged patients: comparison of clinical and thin-section CT features during recovery, Clin. Infect. Dis. (2020).
[83] X. Li, L. Wang, S. Yan, F. Yang, L. Xiang, J. Zhu, et al., Clinical characteristics of 25 death cases with COVID-19: a retrospective review of medical records in a single medical center, Wuhan, China, Int. J. Infect. Dis. (2020).
[84] Y. Deng, W. Liu, K. Liu, Y.-Y. Fang, J. Shang, K. Wang, et al., Clinical characteristics of fatal and recovered cases of coronavirus disease 2019 (COVID-19) in Wuhan, China: a retrospective study, Chin. Med. J. (2020).
[85] J. Hou, X. Wan, Q. Shen, Y. Leng, Z. Xia, B. Zhao, et al., Epidemiologic and Clinical Characteristics of Surgical Patients Infected with COVID-19 in Wuhan, 2020. Available at: SSRN 3550044.
[86] Y. Liu, H. Chen, K. Tang, Y. Guo, Clinical manifestations and outcome of SARS-CoV-2 infection during pregnancy, J. Infect. (2020).
[87] Y. Liu, W. Sun, J. Li, L. Chen, Y. Wang, L. Zhang, et al., Clinical Features and Progression of Acute Respiratory Distress Syndrome in Coronavirus Disease 2019, MedRxiv, 2020.
[88] Y. Huang, H. Zhou, R. Yang, Y. Xu, X. Feng, P. Gong, Clinical Characteristics of 36 Non-survivors with COVID-19 in Wuhan, China, medRxiv, 2020.
[89] Y. Wen, L. Wei, Y. Li, X. Tang, S. Feng, K. Leung, et al., Epidemiological and Clinical Characteristics of COVID-19 in Shenzhen, the Largest Migrant City of China, medRxiv, 2020.
[90] Y. Wu, W. Guo, H. Liu, B. Qi, K. Liang, B. Xu, et al., Clinical Outcomes of 402 Patients with COVID-2019 from a Single Center in Wuhan, China, medRxiv, 2020.
[91] Y. Wang, C. Dong, Y. Hu, C. Li, Q. Ren, X. Zhang, et al., Temporal changes of CT findings in 90 patients with COVID-19 pneumonia: a longitudinal study, Radiology (2020) 200843.
[92] Z. Lu, M. Chen, Y. Fan, X. Wu, L. Zhang, T. Guo, Clinical Characteristics and Risk Factors for Fatal Outcome in Patients with 2019-Coronavirus Infected Disease (COVID-19) in Wuhan, 2020. Available at: SSRN 3546069.
[93] Z. Hu, C. Song, C. Xu, G. Jin, Y. Chen, X. Xu, et al., Clinical characteristics of 24 asymptomatic infections with COVID-19 screened among close contacts in Nanjing, China, Sci. China Life Sci. (2020) 1–6.
[94] P. Yu, J. Zhu, Z. Zhang, Y. Han, A familial cluster of infection associated with the 2019 novel coronavirus indicating possible person-to-person transmission during the incubation period, J. Infect. Dis. (2020).
[95] A. Aminian, S. Safari, A. Razeghian-Jahromi, M. Ghorbani, C.P. Delaney, COVID-19 outbreak and surgical practice: unexpected fatality in perioperative period, Ann. Surg. 10 (2020).
[96] H. Yu, J. Shao, Y. Guo, Y. Xiang, C. Sun, H.-T. Zhang, et al., Data-driven discovery of clinical routes for severity detection in COVID-19 pediatric cases, medRxiv (2020).
[97] M. Million, J.-C. Lagier, P. Gautret, P. Colson, P.-E. Fournier, S. Amrane, et al., Full-length Title: Early Treatment of COVID-19 Patients with Hydroxychloroquine and Azithromycin: A Retrospective Analysis of 1061 Cases in Marseille, France. Travel Medicine and Infectious Disease, 2020, p. 101738.