Clinical presentations, laboratory and radiological findings, and treatments for 11,028 COVID-19 patients: a systematic review and meta-analysis

Carlos K. H. Wong1,2,5, Janet Y. H. Wong3,5, Eric H. M. Tang1, C. H. Au1 & Abraham K. C. Wai4*

This systematic review and meta-analysis investigated the comorbidities, symptoms, clinical characteristics and treatment of COVID-19 patients. Epidemiological studies published in 2020 (from January–March) on the clinical presentation, laboratory findings and treatments of COVID-19 patients were identified from PubMed/MEDLINE and Embase databases. Studies published in English by 27th March, 2020 with original data were included. Primary outcomes included comorbidities of COVID-19 patients, their symptoms presented on hospital admission, laboratory results, radiological outcomes, and pharmacological and in-patient treatments. 76 studies were included in this meta-analysis, accounting for a total of 11,028 COVID-19 patients in multiple countries. A random-effects model was used to aggregate estimates across eligible studies and produce meta-analytic estimates. The most common comorbidities were hypertension (18.1%, 95% CI 15.4–20.8%). The most frequently identified symptoms were fever (72.4%, 95% CI 67.2–77.7%) and cough (55.5%, 95% CI 50.7–60.3%). For pharmacological treatment, 63.9% (95% CI 52.5–75.3%), 62.4% (95% CI 47.9–76.8%) and 29.7% (95% CI 21.8–37.6%) of patients were given antibiotics, antiviral, and corticosteroid, respectively. Notably, 62.6% (95% CI 39.9–85.4%) and 20.2% (95% CI 14.6–25.9%) of in-patients received oxygen therapy and non-invasive mechanical ventilation, respectively. This meta-analysis informed healthcare providers about the timely status of characteristics and treatments of COVID-19 patients across different countries.

PROSPERO Registration Number: CRD42020176589

Following the possible patient zero of coronavirus infection identified in early December 20191, the Coronavirus Disease 2019 (COVID-19) has been recognized as a pandemic in mid-March 20202, after the increasing global attention to the exponential growth of confirmed cases3. As on 29th March, 2020, around 690 thousand persons were confirmed infected, affecting 199 countries and territories around the world, in addition to 2 international conveyances: the Diamond Princess cruise ship harbored in Yokohama, Japan, and the Holland America's MS Zaandam cruise ship. Overall, more than 32 thousand died and about 146 thousand have recovered4.

A novel bat-origin virus, 2019 novel coronavirus, was identified by means of deep sequencing analysis. SARS-CoV-2 was closely related (with 88% identity) to two bat-derived severe acute respiratory syndrome (SARS)-like coronaviruses, bat-SL-CoVZC45 and bat-SL-CoVZXC21, but were more distant from SARS-CoV (about 79%) and MERS-CoV (about 50%)5, both of which were respectively responsible for two zoonotic human coronavirus epidemics in the early twenty-first century. Following a few initial human infections6, the disease could easily be transmitted to a substantial number of individuals with increased social gathering7 and population mobility during holidays in December and January8. An early report has described its high infectivity9 even before the
infected becomes symptomatic. These natural and social factors have potentially influenced the general progression and trajectory of the COVID-19 epidemiology.

By the end of March 2020, there have been approximately 3000 reports about COVID-19. The number of COVID-19-related reports keeps growing everyday, yet it is still far from a clear picture on the spectrum of clinical conditions, transmissibility and mortality, alongside the limitation of medical reports associated with reporting in real time the evolution of an emerging pathogen in its early phase. Previous reports covered mostly the COVID-19 patients in China. With the spread of the virus to other continents, there is an imminent need to review the current knowledge on the clinical features and outcomes of the early patients, so that further research and measures on epidemic control could be developed in this epoch of the pandemic.

**Methods**

**Search strategy and selection criteria.** The systematic review was conducted according to the protocol registered in the PROSPERO database (CRD42020176589). Following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guideline throughout this review, data were identified by searches of MEDLINE, Embase and references from relevant articles using the search terms “COVID”, “SARS-CoV-2”, and “novel coronavirus” (Supplementary material 1). Articles published in English up to 27th March, 2020 were included. National containment measures have been implemented at many countries, irrespective of lockdown, curfew, or stay-at-home orders, since the mid of March 2020, except for China where imposed Hubei province lockdown at 23rd January 2020. Studies with original data including original articles, short and brief communication, letters, correspondences were included. Editorials, viewpoints, infographics, commentaries, reviews, or studies without original data were excluded. Studies were also excluded if they were animal studies, modelling studies, or did not measure symptoms presentation, laboratory findings, treatment and therapeutics during hospitalization.

After the removal of duplicate records, two reviewers (CW and CHA) independently screened the eligibility criteria of study titles, abstracts and full-texts, and reference lists of the studies retrieved by the literature search. Disagreements regarding the procedures of database search, study selection and eligibility were resolved by discussion. The second and the last authors (JW and AW) verified the eligibility of included studies.

**Outcomes definitions.** Signs and symptoms were defined as the presentation of fever, cough, sore throat, headache, dyspnea, muscle pain, diarrhea, rhinorrhea, anosmia, and ageusia at the hospital admission.

Laboratory findings included a complete blood count (white blood count, neutrophil, lymphocyte, platelet count), procalcitonin, prothrombin time, urea, and serum biochemical measurements (including electrolytes, renal-function and liver-function values, creatine kinase, lactate dehydrogenase, C-reactive protein, Erythrocyte sedimentation rate), and treatment measures (i.e. antiviral therapy, antibiotics, corticosteroid therapy, mechanical ventilation, intubation, respiratory support, and renal replacement therapy). Radiological outcomes included bilateral involvement identified and pneumonia identified by chest radiograph.

Comorbidities of patients evaluated in this study were hypertension, diabetes, chronic obstructive pulmonary disease (COPD), cardiovascular disease, chronic kidney disease, liver disease and cancer.

In-patient treatment included intensive care unit admission, oxygen therapy, non-invasive ventilation, mechanical ventilation, Extracorporeal membrane oxygenation (ECMO), renal replacement therapy, and pharmacological treatment. Use of antiviral and interferon drugs (Lopinavir/ritonavir, Ribavirin, Umifenovir, Interferon-alpha, or Interferon-beta), antibiotic drugs, corticosteroid, and inotropes (Nor-adrenaline, Adrenaline, Vasopressin, Phenylephrine, Dopamine, or Dobutamine) were considered.

**Data analysis.** Three authors (CW, EHMT and CHA) extracted data using a standardized spreadsheet to record the article type, country of origin, surname of first author, year of publications, sample size, demographics, comorbidities, symptoms, laboratory and radiology results, pharmacological and non-pharmacological treatments.

We aggregated estimates across 90 eligible studies to produce meta-analytic estimates using a random-effects model. For dichotomous outcomes, we estimated the proportion and its respective 95% confidence interval. For laboratory parameters as continuous outcomes, we estimated the mean and standard deviation from the median and interquartile range if the mean and standard deviation were not available from the study, and calculated the mean and its respective 95% confidence intervals. Random-effect models on DerSimonian and Laird method were adopted due to the significant heterogeneity, checked by the I² statistics and the pooled estimates of < 25%, 25–75% and ≥ 75% is considered as low, moderate, high likelihood of heterogeneity. Publication bias was estimated by Egger’s regression test. Funnel plots of outcomes were also presented to assess publication bias.

All statistical analyses were conducted using the STATA Version 13.0 (Statacorp, College Station, TX). The random effects model was generated by the Stata packages ‘Metaprop’ for proportions and ‘Metan’ for continuous variables.

**Results**

The selection and screen process are presented in Fig. 1. A total of 241 studies were found by our searching strategy (71 in PubMed and 170 in Embase). 46 records were excluded due to duplication. After screening the abstracts and titles, 100 English studies were with original data and included in full-text screening. By further excluding 10 studies with not reporting symptoms presentation, laboratory findings, treatment and therapeutics, 90 studies and 76 studies with more than one COVID-19 case were included in the current systematic review and meta-analysis respectively. 73.3% studies were conducted...
in China. Newcastle–Ottawa Quality Assessment Scale has been used to assess study quality of each included cohort study. 30% (27/90) of included studies had satisfactory or good quality. The summary of the included study is shown in Table 1.

Of those 90 eligible studies, 11,028 COVID-19 patients were identified and included in the systematic review. More than half of patients (6336, 57.5%) were from mainland China. The pooled mean age was 45.8 (95% CI 38.6–52.5) years and 49.3% (pooled 95% CI 45.6–53.0%) of them were male.

For specific comorbidity status, the most prevalent comorbidity was hypertension (18.1%, 95% CI 15.4–20.8%), followed by cardiovascular disease (11.8%, 95% CI 9.4–14.2%) and diabetes (10.4%, 95% CI 8.7–12.1%). The pooled prevalence (95% CI) of COPD, chronic kidney disease, liver disease and cancer were 2.0% (1.3–2.7%), 5.2% (1.7–8.8%), 2.5% (1.7–3.4%) and 2.1% (1.3–2.8%) respectively. Moderate to substantial heterogeneity between reviewed studies were found, with I² statistics ranging from 39.4 to 95.9% (p values between < 0.001–0.041), except for liver disease (I² statistics: 1.7%, p = 0.433). Detailed results for comorbidity status are displayed in Fig. 2.

Regarding the symptoms presented at hospital admission, the most frequent symptoms were fever (pooled prevalence: 72.4%, 95% CI 67.2–77.7%) and cough (pooled prevalence: 58.5%, 95% CI 50.7–60.3%). Sore throat (pooled prevalence: 16.2%, 95% CI 12.7–19.7%), dyspnoea (pooled prevalence: 18.8%, 95% CI 14.7–22.8%) and muscle pain (pooled prevalence: 22.1%, 95% CI 18.6–25.5%) were also common symptoms found in COVID-19 patients, but headache (pooled prevalence: 10.5%, 95% CI 8.7–12.4%), diarrhoea (pooled prevalence: 7.9%, 95% CI 6.3–9.6%), rhinorrhea (pooled prevalence: 9.2%, 95% CI 5.6–12.8%) were less common. However, none of the included papers reported prevalence of anosmia and ageusia. The I² statistics varied from 68.5 to 97.1% (all

Figure 1. PRISMA flowchart reporting identification, searching and selection processes.
| Study          | Region/country | State/city                  | Hospital                                           | Period of confirmed cases                  | N    | Mean age (SD) (year) | Male (%) | Severe (%) |
|---------------|----------------|-----------------------------|----------------------------------------------------|-------------------------------------------|------|---------------------|----------|------------|
| Xu et al.17   | China          | Guangzhou city             | Guangzhou Eighth Peoples Hospital                 | 23 Jan 2020—4 Feb 2020                    | 90   | 51.3 (NA)           | 43.3%    | NA         |
| Cao et al.18  | China          | Wuhan city                 | Zhongnan Hospital                                 | 3 Jan 2020–1 Feb 2020                     | 102  | 52.7 (22.6)         | 52.0%    | NA         |
| Xiong et al.19| China          | Wuhan city                 | Tongji hospital                                  | 11 Jan 2020–5 Feb 2020                    | 42   | 49.5 (14.1)         | 59.5%    | NA         |
| Arentz et al.20| US             | Washington State           | Evergreen Hospital                               | 20 Feb 2020–5 Mar 2020                    | 21   | NA                  | 52.4%    | 71.4%      |
| Huang et al.21| China          | Wuhan city                 | Jin Yin-tan Hospital                             | 16 Dec 2019–2 Jan 2020                    | 41   | 49.3 (13.1)         | 73.2%    | NA         |
| Guan et al.22 | China          | 30 provinces, autonomous regions, and municipalities in mainland China | Second Affiliated Hospital of Anhui Medical University and Suzhou Municipal Hospital | 11 Dec 2019–29 Jan 2020                    | 1099 | 46.7 (17.1)         | 58.0%    | 15.7%      |
| Zhao et al.23 | China          | Anhui province             | Second Affiliated Hospital of Anhui Medical University and Suzhou Municipal Hospital | 23 Jan 2020–5 Feb 2020                    | 19   | 43.7 (23.2)         | 57.9%    | 0.0%       |
| Xu et al.24   | China          | Zhejiang province          | Seven hospitals                                  | 10 Jan 2020–26 Jan 2020                   | 62   | 41.7 (15.2)         | 56.5%    | NA         |
| Chan et al.25 | China          | Guangdong province         | The University of Hong Kong-Shenzhen Hospital     | 10 Jan 2020–15 Jan 2020                   | 7    | 46.2 (22.5)         | 50.0%    | NA         |
| Chen et al.26 | China          | Wuhan city                 | Jin Yin-tan Hospital                             | 1 Jan 2020–20 Jan 2020                    | 99   | 55.5 (13.1)         | 67.7%    | 17.2%      |
| Peng et al.27 | Singapore      | Singapore                  | Jin Yin-tan Hospital                             | 3 Feb 2020–8 Feb 2020                     | 17   | 42.3 (12.1)         | 41.2%    | NA         |
| Wang et al.28 | China          | Wuhan city                 | Zhongnan Hospital                                | 1 Jan 2020–28 Jan 2020                    | 138  | 55.3 (19.5)         | 54.3%    | 19.6%      |
| Young et al.29| Singapore      | Singapore                  | Four hospitals                                   | 23 Jan 2020–3 Feb 2020                    | 18   | NA                  | 50.0%    | 0.0%       |
| Chen et al.30 | China          | Wuhan city                 | Zhongnan Hospital                                | 20 Jan 2020–31 Jan 2020                   | 9    | 32.0 (12.2)         | NA       | 0.0%       |
| Huang et al.31| Taiwan         | Taichung                    | Taichung Veterans General Hospital               | NA                                         | 2    | 73.5 (0.5)          | 0.0%     | NA         |
| Cheng et al.32| Taiwan         | Taoyuan                    | Taoyuan General Hospital                        | 20 Jan 2020                               | 1    | 55.0 (NA)           | 0.0%     | NA         |
| Holshue et al.33| US             | Washington                  | Not reported                                    | 20 Jan 2020                               | 1    | 35.0 (NA)           | 100.0%   | NA         |
| Wei et al.34  | China          | Beijing city, Hainan, Guangdong, Anhui, Shanghai, Zhejiang, and Guizhou province | Not reported                                  | 8 Dec 2019–6 Feb 2020                     | 9    | 0.5 (0.8)           | 22.2%    | 0.0%       |
| Bernard-Stoecklin et al.35| France | Bordeaux and Paris          | Not reported                                    | 10 Jan 2020–24 Jan 2020                   | 3    | 36.3 (10.1)         | 66.7%    | NA         |
| Shi et al.36  | China          | Wuhan city                 | Jin Yin-tan hospital and Union Hospital of Tongji Medical College | 20 Dec 2019–23 Jan 2020                   | 81   | 49.5 (11.0)         | 51.9%    | 3.7%       |
| Zhu et al.37  | China          | Wuhan city                 | Jin Yin-tan Hospital                             | 27 Dec 2019                               | 3    | 47.3 (14.6)         | 66.7%    | 100.0%     |
| Ghinai et al.38| US             | Illinois State             | Not reported                                    | 20 Jan 2020–24 Jan 2020                   | 2    | NA                  | 50.0%    | NA         |
| Zhou et al.39 | China          | Wuhan city                 | Jin Yin-tan Hospital and Wuhan Pulmonary Hospital | 29 Dec 2019–31 Jan 2020                   | 191  | 56.3 (15.7)         | 62.3%    | 62.3%      |
| Yang et al.40 | China          | Wuhan city                 | Wuhan Jin Yin-tan                               | 24 Dec 2019–26 Jan 2020                   | 52   | 59.7 (13.3)         | 67.3%    | 100.0%     |
| Kim et al.41  | South Korea    | Seoul                      | Incheon Medical Center, Seoul National University Hospital, and Seoul National University Bundang Hospital | 21 Feb 2020                               | 1    | 35.0 (NA)           | 0.0%     | NA         |
| Okada et al.42| Thailand       | Nonthaburi                  | Ramrasanadura Infectious Disease Institute Hospital | 8 Jan 2020–13 Jan 2020                     | 2    | NA                  | 0.0%     | 0.0%       |
| Arashiro et al.43| Japan       | Diamond Princess cruise ship | Ramrasanadura Infectious Disease Institute Hospital | 9 Feb 2020                                | 2    | 31.0 (14.2)         | 50.0%    | 0.0%       |
| Lillie et al.44| UK             | Newcastle and Hull         | Castle Hill Hospital                            | 30 Jan 2020                               | 2    | 36.5 (19.1)         | 50.0%    | NA         |
| Tian et al.45 | China          | Wuhan city                 | Zhongnan Hospital                               | NA                                        | 2    | 78.5 (19.5)         | 50.0%    | NA         |
| Continued     |                |                             |                                                    |                                           |      |                     |          |            |
| Study          | Region/country | State/city                      | Hospital                                      | Period of confirmed cases | N | Mean age (SD) (year) | Male (%) | Severe (%) |
|---------------|----------------|---------------------------------|-----------------------------------------------|---------------------------|---|----------------------|----------|------------|
| Haveri et al. | Finland        | Rovaniemi                       | Lapland Central Hospital                      | 29 Jan 2020               | 1 | NA                   | 0.0%     | NA         |
| Nicastri et al.| Italy          | Rome                            | Lazzaro Spallanzani National Institute for Infectious Diseases | 6 Feb 2020               | 1 | NA                   | 100.0%   | NA         |
| Cuong et al.  | Vietnam        | Hanoi                           | Thanh Hoa General Hospital                    | 24 Jan 2020–21 Feb 2020  | 38 | 41.7 (NA)            | 65.8%    | NA         |
| Spiteri et al.| European region| Germany, France, Italy, Spain, Finland, Sweden, Belgium, Russia | Not reported | 26 Jan 2020–28 Jan 2020 | 4 | NA                   | NA       | 0.0%       |
| Rothe et al.  | Germany        | Munich                          | Not reported                                  | 4 Feb 2020–30 Jan 2020   | 7 | 31.1 (12.2)          | 42.9%    | NA         |
| Bai et al.    | China          | Anyang city                     | Fifth People's Hospital of Anyang             | 26 Jan 2020–28 Jan 2020  | 5 | NA                   | 0.0%     | 40.0%      |
| Yu et al.     | China          | Shanghai city                   | Not reported                                  | 22 Jan 2020–23 Jan 2020  | 4 | 76.5 (25.1)          | 50.0%    | NA         |
| Li et al.     | China          | Zhejiang Province               | Not reported                                  | 6 Feb 2020–9 Feb 2020    | 4 | 44.8 (27.4)          | 25.0%    | NA         |
| Tang et al.   | China          | Zhejiang Province               | Not reported                                  | 1 Feb 2020               | 1 | 10.0 (NA)            | 100.0%   | NA         |
| Kam et al.    | Singapore      | Singapore                       | KK Women's and Children's Hospital            | 3 Feb 2020               | 1 | 0.5 (NA)             | 100.0%   | NA         |
| Zhou et al.   | China          | Wuhan city                      | Tongji Hospital                               | 16 Jan 2020–30 Jan 2020  | 62 | 52.8 (12.2)         | 62.9%    | NA         |
| Zhao et al.   | China          | Hunan Province                  | Four hospitals                                | NA                       | 101| 44.4 (12.3)         | 55.4%    | 13.9%      |
| Cheng et al.  | China          | Shanghai city                   | Ruijin Hospital                               | 19 Jan 2020–6 Feb 2020   | 11| 50.4 (15.5)         | 72.7%    | NA         |
| Chung et al.  | China          | Guangdong, Jiangxi, and Shandong Provinces | Three hospitals | 18 Jan 2020–27 Jan 2020 | 21| 51.0 (14.0)         | 61.9%    | NA         |
| Liu et al.    | China          | Hubei province                  | Nine hospital                                 | 30 Dec 2019–24 Jan 2020  | 137| 55.0 (16.0)        | 44.5%    | NA         |
| Chang et al.  | China          | Beijing city                    | Three hospitals                               | 16 Jan 2020–29 Jan 2020  | 13| 38.7 (11.6)         | 76.9%    | NA         |
| COVID-19 National Incident Room Surveillance Team| Australia | National-wide | Not reported | 20 Jan 2020–14 Mar 2020 | 295| 45.9 (17.4)        | 50.8%    | NA         |
| Pan et al.    | China          | Wuhan city                      | Union Hospital                                | 12 Jan 2020–6 Feb 2020   | 21| 40.0 (9.0)          | 28.6%    | 0.0%       |
| Wang et al.   | China          | Wuhan city                      | Tongji Hospital                               | 2 Feb 2020               | 1 | 0.0 (NA)            | 0.0%     | NA         |
| Bastola et al.| Nepal          | Kathmandu                       | Sukraraj Tropical and Infectious Disease Hospital | 14 Jan 2020              | 1 | 32.0 (NA)           | 0.0%     | NA         |
| Qiu et al.    | China          | Zhejiang Province               | Three hospitals                               | 17 Jan 2020–1 Mar 2020   | 36| 8.3 (3.5)           | 63.9%    | 0.0%       |
| Zhang et al.  | China          | Wuhan city                      | No. 7 Hospital of Wuhan                      | 16 Jan 2020–3 Feb 2020   | 140| 0.0 (0.0)          | 50.7%    | 41.4%      |
| Ye et al.     | China          | Wuhan city                      | Zhongnan Hospital                             | 8 Jan 2020–10 Feb 2020   | 5 | 32.4 (5.7)         | 40.0%    | NA         |
| Liu et al.    | China          | Shenzhen                        | Shenzhen Third People's Hospital              | 21 Jan 2020              | 12| 52.8 (18.6)        | 66.7%    | 41.7%      |
| Chen et al.   | China          | Wuhan city                      | Tongji Hospital                               | 13 Jan 2020–12 Feb 2020  | 274| 58.7 (19.4)        | 62.4%    | 71.5%      |
| Guan et al.   | China          | 31 province/autonomous regions/provincial municipalities | 575 hospitals | 11 Dec 2019–31 Jan 2020 | 1590| 48.9 (16.3)       | 56.9%    | 16.0%      |
| Wong et al.   | China          | Hong Kong                       | Queen Mary Hospital, Pamela Youde Nethersole Eastern Hospital, Queen Elizabeth Hospital, and Rutonjee Hospital | 1 Jan 2020–5 Mar 2020 | 64| 56.0 (19.0)        | 40.6%    | NA         |
| Xu et al.     | China          | Changzhou                       | Third Hospital of Changzhou                  | 23 Jan 2020–18 Feb 2020  | 51| 42.3 (20.8)        | 49.0%    | 0.0%       |
| Shen et al.   | China          | Shenzhen                        | Shenzhen Third People's Hospital              | 20 Jan 2020–25 Mar 2020  | 5 | 54.0 (15.2)        | 60.0%    | 100.0%     |
| Kimball et al.| US             | Washington State                | Not reported                                  | 13 Mar 2020              | 23| 80.7 (8.4)         | 30.4%    | NA         |

Continued
Table 1. Summary of 90 reviewed studies. COVID-19 Coronavirus Disease 2019, US The United States, UK The United Kingdom, SD standard deviation, NA not available.

| Study                    | Region/country       | State/city              | Hospital                                              | Period of confirmed cases | N   | Mean age (SD) (year) | Male (%) | Severe (%) |
|--------------------------|----------------------|-------------------------|-------------------------------------------------------|---------------------------|-----|----------------------|----------|------------|
| Centers for Disease Control and Prevention77 | US                   | 49 states, district of Columbia, and 3 US territories | Not reported                | 12 Feb 2020–16 Mar 2020  | 4226 | NA                   | NA       | NA         |
| Wu et al.78              | China                | Jiangsu Province        | Three hospitals                                       | 22 Jan 2020–14 Feb 2020  | 80  | 46.1 (15.4)          | 48.8%    | 3.8%       |
| Yang et al.79            | China                | Wenzhou city            | Three hospitals                                       | 17 Jan 2020–10 Feb 2020  | 149 | 45.1 (13.4)          | 54.4%    | NA         |
| Zhu et al.80             | China                | Wuhan city              | Tongji Hospital                                       | 4 Dec 2019                | 1   | 52.0 (NA)            | 100.0%   | NA         |
| Zhu et al.81             | China                | Hefei                   | Affiliated Hospital of University of Science and Technology of China | 24 Jan 2020–20 Feb 2020  | 32  | 44.3 (13.2)          | 46.9%    | NA         |
| Wu et al.82              | China                | Wuhan city              | Jinyintan Hospital                                    | 25 Dec 219–26 Jan 2020   | 201 | 51.3 (12.7)          | 63.7%    | 41.8%      |
| Wang et al.83            | China                | Shanghai                | Shanghai Public Health Clinical Center                  | 21 Jan 2020–24 Jan 2020  | 4   | 44.3 (22.3)          | 75.0%    | 25.0%      |
| Wang et al.84            | China                | Shenzhen                | Shenzhen Third People's Hospital                       | 11 Jan 2020–29 Feb 2020  | 55  | 39.9 (21.6)          | 40.0%    | 3.6%       |
| Wan et al.85             | China                | Chongqing               | Chongqing University Three Gorges Hospital            | 23 Jan 2020–8 Feb 2020   | 135 | 46.0 (14.2)          | 53.3%    | 29.6%      |
| Tian et al.86            | China                | Beijing                 | 57 Hospitals                                           | 20 Jan 2020–10 Feb 2020  | 262 | 45.9 (20.8)          | 48.5%    | 17.6%      |
| Sun et al.87             | China                | Wuhan city              | Wuhan Children’s Hospital                             | 24 Jan 2020–24 Feb 2020  | 8   | 6.8 (6.5)            | 75.0%    | 100.0%     |
| Song et al.88            | China                | Shanghai                | Shanghai Public Health Clinical Center                  | 20 Jan 2020–27 Jan 2020  | 51  | 49.0 (16.0)          | 49.0%    | NA         |
| Hu et al.89              | China                | Nanjing, Jiangsu Province | Second Hospital of Nanjing                           | 28 Jan 2020–9 Feb 2020   | 24  | 38.9 (22.6)          | 33.3%    | 0.0%       |
| Qu et al.90              | China                | Huizhou                 | Huizhou Municipal Central Hospital                    | Jan 2020–Feb 2020        | 30  | 50.5 (22.6)          | 53.3%    | 10.0%      |
| Qian et al.91            | China                | Zhejiang                | Five hospitals                                        | 20 Jan 2020–11 Feb 2020  | 91  | 47.8 (15.4)          | 40.7%    | 9.9%       |
| Mo et al.92              | China                | Wuhan city              | Zhongnan Hospital                                     | 1 Jan 2020–5 Feb 2020    | 155 | 54.0 (18.0)          | 55.5%    | 59.4%      |
| Liu et al.93             | China                | Wuhan city              | Three hospitals                                       | 30 Dec 2019–15 Jan 2020  | 78  | 42.7 (18.1)          | 50.0%    | 10.3%      |
| Liu et al.94             | China                | Hainan                  | Hainan General Hospital                               | 1 Jan 2020–15 Feb 2020   | 56  | 52.1 (14.7)          | 55.4%    | NA         |
| Liu et al.95             | China                | Hangzhou                | Xixi hospital                                         | 22 Jan 2020–11 Feb 2020  | 10  | 43.0 (10.4)          | 40.0%    | NA         |
| Liu et al.127            | China                | Wuhan City              | Union Hospital                                        | 20 Jan 2020–10 Feb 2020  | 15  | 32.0 (5.0)           | 0.0%     | 0.0%       |
| Guillen et al.97         | Spain                | Not reported            | Not reported                                          | 28 Feb 2020              | 1   | 50.0 (NA)            | 100.0%   | NA         |
| Dong et al.98            | China                | Wuhan City              | Zhongnan Hospital of Wuhan University, Wuhan No.7 Hospital and Wuhan Children’s Hospital | NA                      | 11  | 36.6 (21.5)          | 45.5%    | 9.1%       |
| Fan et al.99             | China                | Not reported            | Not reported                                          | 24 Jan 2020–26 Jan 2020  | 1   | 31.5 (3.5)           | 0.0%     | NA         |
| Chen et al.100           | China                | Wuhan City              | Renmin hospital of Wuhan University                   | 30 Jan 2020–23 Feb 2020  | 17  | 29.4 (2.9)           | 0.0%     | NA         |
| Chen et al.101           | China                | Wuhan City              | Zhongnan Hospital of Wuhan University                 | 2 Jan 2020               | 2   | NA                   | 0.0%     | NA         |
| Chen et al.102           | China                | Shanghai                | Shanghai Public Health Clinical Center                | 20 Jan 2020–6 Feb 2020   | 249 | 50.3 (20.9)          | 50.6%    | 10.0%      |
| Ding et al.103           | China                | Wuhan City              | Tongji Hospital                                       | NA                      | 5   | 50.2 (9.8)           | 40.0%    | NA         |
| Kong et al.104           | Korea                | Not reported            | Not reported                                          | 20 Jan 2020–14 Feb 2020  | 28  | 42.6 (NA)            | 53.6%    | NA         |
| Li et al.105             | China                | Zhengzhou City          | Not reported                                          | 5 Feb 2020               | 2   | 4.0 (0.0)            | 50.0%    | NA         |
| Ai et al.106             | China                | Shanghai                | Not reported                                          | 20 Jan 2020              | 1   | 56.0 (NA)            | 0.0%     | NA         |

**Table 1.** Summary of 90 reviewed studies. COVID-19 Coronavirus Disease 2019, US The United States, UK The United Kingdom, SD standard deviation, NA not available.

*p* values < 0.001), indicating a high heterogeneity exists across studies. Figure 3 shows the pooled proportion of symptoms of patients presented at hospital.

For laboratory parameters, white blood cell (pooled mean: $5.31 \times 10^9$/L, 95% CI $5.03–5.58 \times 10^9$/L), neutrophil (pooled mean: $3.60 \times 10^9$/L, 95% CI $3.31–3.89 \times 10^9$/L), lymphocyte (pooled mean: $1.11 \times 10^9$/L, 95% CI
radiological findings of SARS-CoV-2 pneumonia were non-specific. Despite chest radiograph
elevated inflammatory markers such as CRP are some of the most common haematological and biochemical
Laboratory investigations among COVID-19 patients did not reveal specific characteristics—lymphopenia and
Radiology imaging often plays an important role in evaluating patients with acute respiratory distress; how-
The prevalence of radiological outcomes and non-pharmacological treatments were presented in Fig. 6. Radiology
Discussion
This meta-analysis reveals the condition of global medical community responding to COVID-19 in the early
early phase. During the past 4 months, a new major epidemic focus of COVID-19, some without traceable origin,
has been identified. Following its first identification in Wuhan, China, the virus has been rapidly spreading to
Europe, North America, Asia, and the Middle East, in addition to African and Latin American countries. Three
months since Wuhan CDC admitted that there was a cluster of unknown pneumonia cases related to Huanan
Seafood Market and a new coronavirus was identified as the cause of the pneumonia108, as on 1 April, 2020, there
have been 858,371 persons confirmed infected with COVID-19, affecting 202 countries and territories around
Discussion
This meta-analysis reveals the condition of global medical community responding to COVID-19 in the early
phase. During the past 4 months, a new major epidemic focus of COVID-19, some without traceable origin,
has been identified. Following its first identification in Wuhan, China, the virus has been rapidly spreading to
Europe, North America, Asia, and the Middle East, in addition to African and Latin American countries. Three
months since Wuhan CDC admitted that there was a cluster of unknown pneumonia cases related to Huanan
Seafood Market and a new coronavirus was identified as the cause of the pneumonia108, as on 1 April, 2020, there
have been 858,371 persons confirmed infected with COVID-19, affecting 202 countries and territories around
the world. Although this rapid review is limited by the domination of reports from patients in China, and the
patient population is of relative male dominance reflecting the gender imbalance of the Chinese population109,
it provides essential information.
In this review, the pooled mean age was 45.8 years. Similar to the MERS-CoV pandemic108, middle-aged
adults were the at-risk group for COVID-19 infections in the initial phase, which was different from the H1N1
influenza pandemic where children and adolescents were more frequently affected111. Biological differences
may affect the clinical presentations of infections; however, in this review, studies examining the asymptomatic
COVID-19 infections or reporting any previous infections were not included. It is suggested that another system-
atic review should be conducted to compare the age-specific incidence rates between the pre-pandemic and
post-pandemic periods, so as to understand the pattern and spread of the disease, and tailor specific strategies
in infection control.
Both sexes exhibited clinical presentations similar in symptomatology and frequency to those noted in other
severe acute respiratory infections, namely influenza A H1N1112 and SARS113,114. These generally included fever,
new onset or exacerbation of cough, breathing difficulty, sore throat and muscle pain. Among critically ill patients
usually presented with dyspnoea and chest tightness12,29,39,72,141 (4.6%) of them with persistent or progressive
hypoxia resulted in the requirement of intubation and mechanical ventilation115, while 194 (6.4%) of them
required non-invasive ventilation, yielding a total of 11% of patients requiring ventilatory support, which was
similar to SARS116.
The major comorbidities identified in this review included hypertension, cardiovascular diseases and diabetes
mellitus. Meanwhile, the percentages of patients with chronic renal diseases and cancer were relatively low. These
chronic conditions influencing the severity of COVID-19 had also been noted to have similar effects in other
respiratory illnesses such as SARS, MERS-CoV and influenza117,118. Higher mortality had been observed among
older patients and those with comorbidities.
Early diagnosis of COVID-19 was based on recognition of epidemiological linkages; the presence of typi-
cal clinical, laboratory, and radiographic features; and the exclusion of other respiratory pathogens. The case
definition had initially been narrow, but was gradually broadened to allow for the detection of more cases, as
milder cases and those without epidemiological links to Wuhan or other known cases had been identified119,120.
Laboratory investigations among COVID-19 patients did not reveal specific characteristics—lymphopenia and
elevated inflammatory markers such as CRP are some of the most common haematological and biochemical
abnormalities, which had also been noticed in SARS121. None of these features were specific to COVID-19. There-
fore, diagnosis should be confirmed by SARS-CoV-2 specific microbiological and serological studies, although
initial management will continue to be based on a clinical and epidemiological assessment of the likelihood of
a COVID-19 infection.
Radiology imaging often plays an important role in evaluating patients with acute respiratory distress; how-
ever, in this review, radiological findings of SARS-CoV-2 pneumonia were non-specific. Despite chest radiograph
Figure 2. Random-effects meta-analytic estimates for comorbidities. (A) Diabetes mellitus, (B) Hypertension, (C) Cardiovascular disease, (D) Chronic obstructive pulmonary disease, (E) Chronic kidney disease, (F) Cancer.
usually revealed bilateral involvement and Computed Tomography usually showed bilateral multiple ground-glass opacities or consolidation, there were also patients with normal chest radiograph, implying that chest radiograph might not have high specificity to rule out pneumonia in COVID-19.

Limited clinical data were available for asymptomatic COVID-19 infected persons. Nevertheless, asymptomatic infection could be unknowingly contagious\textsuperscript{122}. From some of the official figures, 6.4\% of 150 non-travel-related COVID-19 infections in Singapore\textsuperscript{123}, 39.9\% cases from the Diamond Princess cruise ship in Japan\textsuperscript{124}, and up to 78\% cases in China as extracted on April 1st, 2020, were found to be asymptomatic\textsuperscript{122}. 76\% (68/90) studies based on hospital setting which provided care and disease management to symptomatic patients had limited number of asymptomatic cases of COVID-19 infection. This review calls for further studies about clinical data of asymptomatic cases. Asymptomatic infection intensifies the challenges of isolation measures. More global reports are crucially needed to give a better picture of the spectrum of presentations among all COVID-19 infected persons. Also, public health policies including social and physical distancing, monitoring and surveillance, as well as contact tracing, are necessary to reduce the spread of COVID-19.

Concerning potential treatment regime, 62.4\% of patients received antivirals or interferons (including oseltamivir, lopinavir-ritonavir, interferon alfa), while 63.9\% received antibiotics (such as moxifloxacin, and ceftriaxone). In this review, around one-third of patients were given steroid, suggestive as an adjunct to IFN, or sepsis management. Interferon and antiviral agents such as ribavirin, and lopinavir-ritonavir were used during SARS, and the initial uncontrolled reports then noted resolution of fever and improvement in oxygenation and radiographic appearance\textsuperscript{113,125,138}, without further evidence on its effectiveness. At the time of manuscript preparation, there has been no clear evidence guiding the use of antivirals\textsuperscript{127}. Further research is needed to inform clinicians of the appropriate use of antivirals for specific groups of infected patients.

Limitations of this meta-analysis should be considered. First, a high statistical heterogeneity was found, which could be related to the highly varied sample sizes (9 to 4226 patients) and study designs. Second, variations of follow-up period may miss the event leading to heterogeneity. In fact, some patients were still hospitalized in the included studies. Third, since only a few studies had compared the comorbidities of severe and non-severe patients, sensitivity analysis and subgroup analysis were not conducted. Fourthly, the frequency and severity of signs and symptoms reported in included studies, primarily based on hospitalized COVID-19 patients were over-estimated. Moreover, different cutoffs for abnormal laboratory findings were applied across countries, and counties within the same countries. Lastly, this meta-analysis reviewed only a limited number of reports written in English, with a predominant patient population from China. This review is expected to inform clinicians of the epidemiology of COVID-19 at this early stage. A recent report estimated the number of confirmed cases in
Figure 4. Random-effects meta-analytic estimates for laboratory parameters. (A) White blood cell, (B) Lymphocyte, (C) Neutrophil, (D) C-reactive protein, (E) D-dimer, (F) Lactate dehydrogenase.
Figure 5. Random-effects meta-analytic estimates for pharmacological treatments and intensive unit care at hospital. (A) Antiviral or interferon drugs, (B) Lopinavir/Ritonavir, (C) Interferon alpha (IFN-α), (D) Antibiotic drugs, (E) Corticosteroid, (F) Admission to Intensive care unit.
Figure 6. Random-effects meta-analytic estimates for radiological findings and non-pharmacological treatments at hospital. (A) Bilateral involvement, (B) Pneumonia, (C) Oxygen therapy, (D) Non-invasive ventilation, (E) Extracorporeal membrane oxygenation (ECMO), (F) Dialysis.
China could reach as high as 232,000 (95% CI 161,000, 359,000) with the case definition adopted in 5th Edition. In this connection, further evidence on the epidemiology is in imminent need.

Received: 4 May 2020; Accepted: 25 September 2020
Published online: 13 November 2020

References

1. Oliveira N. Shrimp vendor identified as possible coronavirus ‘patient zero,’ leaked document says. 27 March 2020. New York Daily News. 2020.
2. World Health Organization. Basic protective measures against the new coronavirus (2020). https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public. Accessed 7 Oct 2020.
3. Google Trend. When will coronavirus end (2020). https://trends.google.com/trends/explore?date=today%203-m&q=when%20will%20coronavirus%20end. Accessed 10 Oct 2020.
4. Worldometer. COVID-19 Coronavirus Pandemic (2020). https://www.worldometers.info/coronavirus/. Accessed 13 Oct 2020.
5. Li, Q.
6. Chen, J. Pathogenicity and transmissibility of 2019-nCoV-A quick overview and comparison with other emerging viruses.
7. World Health Organization. Database of publications on coronavirus disease (COVID-19) (2020). https://www.who.int/emergencies/diseases/novel-coronavirus-2019/global-research-on-novel-coronavirus-2019-ncov. Accessed 30 Mar 2020.
8. Kucharski, A. J. et al. Impact of national containment measures on decelerating the increase in daily new cases of COVID-19 in 54 countries and 4 epicenters of the pandemic: a comparative observational study. J. Med. Internet Res. 22(7), e19904 (2020).
9. Centers for Disease Control and Prevention. Coronavirus Disease 2019 (COVID-19), Symptoms of Coronavirus (2020).
10. Wang, X., Wang, W., Liu, J. & Tong, T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMJ Med. Res. Methodol. 14(1), 135 (2014).
11. Nyaga, V. N., Arbyn, M. & Aerts, M. Metaprop: a Stata command to perform meta-analysis of binomial data.
12. Harris, R. J.
13. Cao, J.
14. Wan, X., Wang, W., Liu, J. & Tong, T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMJ Med. Res. Methodol. 14(1), 135 (2014).
15. Zhu, N.
16. Shi, H.
17. Bernard Stoecklin, S.
18. Young, B. E.
19. You, B. E.
20. Huang, W. H.
21. Huang, C.
22. Zhao, S. et al. The association between domestic train transportation and novel coronavirus (2019-nCoV) outbreak in China from 2019 to 2020: a data-driven correlational report. Travel Med. Infect. Dis. 33, 101568 (2020).
40. Yang, X. et al. Clinical and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir. Med. 8(5), 475–481 (2020).

41. Kim, J. Y. et al. The first case of 2019 novel coronavirus pneumonia imported into Korea from Wuhan, China: implication for infection prevention and control measures. J. Korean Med. Sci. 35(6), e61 (2020).

42. Okada, P. et al. Early transmission patterns of coronavirus disease 2019 (COVID-19) in travellers from Wuhan to Thailand, January 2020. Euro Surveill. 25(6), 6–10 (2020).

43. Arashiro, T., Furukawa, K. & Nakamura, A. COVID-19 in 2 persons with mild upper respiratory tract symptoms on a cruise ship, Japan. Emerg. Infect. Dis. 26(6), 1345–1348 (2020).

44. Lillie, P. J. et al. Novel coronavirus disease (Covid-19): the first two patients in the UK with person to person transmission. J. Infect. 80(5), 578–606 (2020).

45. Tian, S. et al. Pulmonary pathology of early-phase 2019 novel coronavirus (COVID-19) pneumonia in two patients with lung cancer. J. Thorac. Oncol. 15(5), 700–704 (2020).

46. Haveri, A. et al. Serological and molecular findings during SARS-CoV-2 infection: the first case study in Finland, January to February 2020. Euro Surveill. 25(11), 16–21 (2020).

47. Nicastro, E. et al. Coronavirus disease (COVID-19) in a paucisymptomatic patient: epidemiological and clinical challenge in settings with limited community transmission, Italy, February 2020. Euro Surveill. 25(11) (2020).

48. Van Cuong, L. et al. The first Vietnamese case of COVID-19 acquired from China. Lancet Infect Dis. 20(4), 408–409 (2020).

49. Spiteri, G. et al. First cases of coronavirus disease 2019 (COVID-19) in the WHO European Region, 24 January to 21 February 2020. Euro Surveill. 25(9), 2–7 (2020).

50. Rothe, C. et al. Transmission of 2019-nCoV infection from an asymptomatic contact in Germany. N. Engl. J. Med. 382(10), 970–971 (2020).

51. Tong, Z. D. et al. Potential presymptomatic transmission of SARS-CoV-2, Zhejiang Province, China. 2020. Emerg. Infect. Dis. 26(3), 1052–1054 (2020).

52. Bai, Y. et al. Presumed asymptomatic carrier transmission of COVID-19. JAMA 323(14), 1406–1407 (2020).

53. Yu, P., Zhu, J., Zhang, Z. & Han, Y. A familial cluster of infection associated with the 2019 novel coronavirus indicating possible person-to-person transmission during the incubation period. J. Infect. Dis. 221(11), 1757–1761 (2020).

54. Li, P. et al. Transmission of COVID-19 in the terminal stages of the incubation period: a familial cluster. Int. J. Infect. Dis. 96, 452–453 (2020).

55. Tang, A. et al. Detection of novel coronavirus by RT-PCR in stool specimen from asymptomatic child, China. Emerg. Infect. Dis. 26(6), 1337–1339 (2020).

56. Kam, K. Q. et al. A well infant with coronavirus disease 2019 with high viral load. Clin. Infect. Dis. 71(15), 847–849 (2020).

57. Zhou, S., Wang, Y., Zha, T. & Xia, L. CT Features of Coronavirus Disease 2019 (COVID-19) Pneumonia in 62 Patients in Wuhan, China. AJR Am J Roentgenol. 214(6), 1287–1294 (2020).

58. Zhao, W., Zhong, Z., Xie, X., Yu, Q. & Liu, J. Relation between chest CT findings and clinical conditions of coronavirus disease (COVID-19) pneumonia: a multicenter study. AJR Am. J. Roentgenol. 214(5), 1072–1077 (2020).

59. Cheng, Z. et al. Clinical features and chest CT manifestations of coronavirus disease 2019 (COVID-19) in a single-center study in Shanghai, China. AJR Am. J. Roentgenol. 215(1), 121–126 (2020).

60. Chung, M. et al. CT imaging features of 2019 novel coronavirus (2019-nCoV). Radiology 295(1), 202–207 (2020).

61. Liu, K. et al. Clinical characteristics of novel coronavirus cases in tertiary hospitals in Hubei Province. Chin Med J (Engl). 133(9), 1025–1031 (2020).

62. Chang, L. M. et al. Epidemiologic and clinical characteristics of novel coronavirus infections involving 13 patients outside Wuhan, China. JAMA 323(11), 1092–1093 (2020).

63. Team CNIBRS-COVID-19, Australia: Epidemiology Report 7 (Reporting week ending 19:00 AEDT 14 March 2020). Commun. Dis. Intell. 44 (2018).

64. Pan, F. et al. Time course of lung changes at chest CT during recovery from coronavirus disease 2019 (COVID-19). Radiology 295(3), 715–721 (2020).

65. Wang, S. et al. A case report of neonatal coronavirus disease 2019 (COVID-19) in China. Clin. Infect. Dis. 71(15), 853–857 (2020).

66. Bastola, A. et al. The first 2019 novel coronavirus case in Nepal. Lancet Infect. Dis. 20(3), 279–280 (2020).

67. Qiu, H. et al. Clinical and epidemiological features of 36 children with coronavirus disease 2019 (COVID-19) in Zhejiang, China: an observational cohort study. Lancet Infect. Dis. 20(6), 689–696 (2020).

68. Zhang, J. J. et al. Clinical characteristics of 140 patients infected with SARS-CoV-2 in Wuhan, China. Allergy 75(7), 1730–1741 (2020).

69. Ye, X. et al. Clinical characteristics of severe acute respiratory syndrome coronavirus 2 reactivation. J. Infect. 80(5), e14–e17 (2020).

70. Liu, Y. et al. Clinical and biochemical indexes from 2019-nCoV infected patients linked to viral loads and lung injury. Sci. China Life Sci. 63(3), 364–374 (2020).

71. Chen, T. et al. Clinical characteristics of 113 deceased patients with coronavirus disease 2019: retrospective study. BMJ 368, m1091 (2020).

72. Guan, W. J. et al. Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. Eur Respir J. 55(5), 2000347 (2020).

73. Wong, H. Y. F. et al. Frequency and Distribution of Chest Radiographic Findings in Patients Positive for COVID-19. Radiology 296(2), E72–E78 (2020).

74. Xu, T. et al. Clinical features and dynamics of viral load in imported and non-imported patients with COVID-19. Int J Infect Dis. 94, 68–71 (2020).

75. Shen, C. et al. Treatment of 5 critical patients with COVID-19 with convalescent plasma. JAMA 323(16), 1582–1589 (2020).

76. Kimball, A. et al. Asymptomatic and presymptomatic SARS-CoV-2 infections in residents of a long-term care skilled nursing facility—King County, Washington, March 2020. Morb. Mortal. Wkly. Rep. 69(13), 377–381 (2020).

77. Team CC-R. Severe outcomes among patients with coronavirus disease 2019 (COVID-19)—United States, February 12–March 16, 2020. Morb. Mortal. Wkly. Rep. 69(12), 334–346 (2020).

78. Wu, J. et al. Clinical characteristics of imported cases of coronavirus disease 2019 (COVID-19) in Jiangsu Province: a multicenter descriptive study. Clin. Infect. Dis. 71(15), 706–712 (2020).

79. Yang, W. et al. Clinical characteristics and imaging manifestations of the 2019 novel coronavirus disease (COVID-19): a multicenter study in Wenzhou city, Zhejiang, China. J. Infect. 80(4), 388–393 (2020).

80. Zhu, L. et al. Successful recovery of COVID-19 pneumonia in a renal transplant recipient with long-term immunosuppression. Am. J. Transplant. 20(7), 1859–1863 (2020).

81. Zhu, W. et al. Initial clinical features of suspected coronavirus disease in two emergency departments outside of Hubei, China. J. Med. Virol. 92, 1525–1532 (2019).

82. Wu, C. et al. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. JAMA Intern. Med. 180(7), 934–943 (2020).

83. Wang, Z., Chen, X., Lu, Y., Chen, F. & Zhang, W. Clinical characteristics and therapeutic procedure for four cases with 2019 novel coronavirus pneumonia receiving combined Chinese and Western medicine treatment. Biosci. Trends 14(1), 64–68 (2020).
84. Wang, Y. et al. Clinical outcomes in 55 patients with severe acute respiratory syndrome coronavirus 2 who were asymptomatic at hospital admission in Shenzhen, China. J. Infect. Dis. 221(11), 1770–1774 (2020).
85. Wan, S. et al. Clinical features and treatment of COVID-19 patients in northeast Chongqing. J. Med. Virol. 92(7), 797–806 (2020).
86. Tian, S. et al. Characteristics of COVID-19 infection in Beijing. J. Infect. 80(4), 401–406 (2020).
87. Sun, D. et al. Clinical features of severe pediatric patients with coronavirus disease 2019 in Wuhan: a single center’s observational study. World J. Pediatr. 16(3), 251–259 (2020).
88. Song, F. et al. Emerging 2019 novel coronavirus (2019-nCoV) pneumonia. Radiology 295(1), 210–217 (2020).
89. Xu, Z. et al. Clinical characteristics of 24 asymptomatic infections with COVID-19 screened among close contacts in Nanjing, China. Sci. China Life Sci. 63(5), 706–711 (2020).
90. Qu, R. et al. Platelet-to-lymphocyte ratio is associated with prognosis in patients with coronavirus disease-19. J. Med. Virol. 92, 1533–1541 (2020).
91. Qian, G. Q. et al. Epidemiologic and clinical characteristics of 91 hospitalized patients with COVID-19 in Zhejiang, China: a retrospective, multi-centre case series. QJM 113(7), 474–481 (2020).
92. Mo, P. et al. Clinical characteristics of refractory COVID-19 pneumonia in Wuhan, China. Clin. Infect. Dis. (2020).
93. Liu, W. et al. Analysis of factors associated with disease outcomes in hospitalized patients with 2019 novel coronavirus disease. Chin Med. J. (Engl) 133(9), 1032–1038 (2020).
94. Liu, K., Chen, Y., Lin, R. & Han, K. Clinical features of COVID-19 in elderly patients: A comparison with young and middle-aged patients. J. Infect. 80(6), e14–e18 (2020).
95. Liu, E. et al. Patients of COVID-19 may benefit from sustained Lopinavir-combined regimen and the increase of Eosinophil may predict the outcome of COVID-19 progression. Int. J. Infect. Dis. 95, 183–191 (2020).
96. Liu, D. et al. Pregnancy and perinatal outcomes of women with coronavirus disease (COVID-19) pneumonia: a preliminary analysis. AJR Am. J. Roentgenol. 215(1), 127–132 (2020).
97. Gulleen, E. et al. Case report of COVID-19 in a kidney transplant recipient: does immunosuppression alter the clinical presentation?. Am. J. Transplant. 20(7), 1875–1878 (2020).
98. Dong, X. et al. Eleven faces of coronavirus disease 2019. Allergy 75(7), 1699–1709 (2020).
99. Fan, C. et al. Perinatal transmission of COVID-19 associated SARS-CoV-2: should we worry? Clin. Infect. Dis. (2020).
100. Chen, R. et al. Safety and efficacy of different anesthetic regimens for parturients with COVID-19 undergoing Cesarean delivery: a case series of 17 patients. Can. J. Anaesth. 67(6), 653–663 (2020).
101. Chen, L. et al. RNA based mNGS approach identifies a novel human coronavirus from two individual pneumonia cases in 2019 Wuhan outbreak. Emerg. Microbes Infect. 9(1), 313–319 (2020).
102. Chen, J. et al. Clinical progression of patients with COVID-19 in Shanghai, China. J. Infect. 80(5), e1–e6 (2020).
103. Ding, Q., Liu, P., Fan, Y., Xia, Y. & Liu, M. The clinical characteristics of pneumonia patients infected with 2019 novel coronavirus and influenza virus in Wuhan, China. J. Med. Virol. 92, 1549–1555 (2020).
104. Covid-19 National Emergency Response Center E & Case Management Team KCFDC, Prevention. Early epidemiological and clinical characteristics of 28 cases of coronavirus disease in South Korea. Osong Public Health Res. Perspect. 11(1), 8–14 (2020).
105. Li, Y., Guo, F., Cao, Y., Li, L. & Guo, Y. Insight into COVID-2019 for pediatricians. Pediatr. Pulmonol. 55(5), E1–E4 (2020).
106. Ai, J. W., Zhang, Y., Zhang, H. C., Xu, T. & Zhang, W. H. Era of molecular diagnosis for pathogen identification of unexplained pneumonia, lessons to be learned. Emerg Microbes Infect. 9(1), 597–600 (2020).
107. Stang, A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur. J. Epidemiol. 25(9), 603–605 (2010).
108. Khan, N. New virus discovered by Chinese scientists investigating pneumonia outbreak. World J. (2020).
109. 国家统计局 (National Bureau of Statistics). 2019年国民经济运行总体平稳主要预期目标较好实现 (In 2019, the overall stable development of the national economic operation is expected to achieve the main goals (2020). http://www.stats.gov.cn/tjjs/zxfb/202001/t20200117_1723383.html. Accessed 30 Mar 2020.
110. Park, J. E., Jung, S., Kim, A. & Park, J. E. MERS transmission and risk factors: a systematic review. BMC Public Health 18(1), 574 (2018).
111. Van Kerkhove, M. D. et al. Risk factors for severe outcomes following 2009 influenza A (H1N1) infection: a global pooled analysis. PLoS Med. 8(7), e1001053 (2011).
112. Wang, C. et al. Epidemiological and clinical characteristics of the outbreak of 2009 pandemic influenza A (H1N1) at a middle school in Luoyang, China. Public Health 126(4), 289–294 (2012).
113. Lee, N. et al. A major outbreak of severe acute respiratory syndrome in Hong Kong. N. Engl. J. Med. 348(20), 1986–1994 (2003).
114. Booth, C. M. et al. Clinical features and short-term outcomes of 144 patients with SARS in the greater Toronto area. JAMA 289(21), 2801–2809 (2003).
115. Fowler, R. A. et al. Critically ill patients with severe acute respiratory syndrome. JAMA 290(3), 367–373 (2003).
116. Christian, M. D., Poutman, S. M., Loutfy, M. R., Muller, P. M. & Low, D. E. Severe acute respiratory syndrome. Clin Infect Dis. 38(10), 1420–1427 (2004).
117. Mertz, D. et al. Populations at risk for severe or complicated influenza illness: systematic review and meta-analysis. BMJ 3(347), f5061 (2013).
118. Badawi, A. & Ryyo, S. G. Prevalence of comorbidities in the Middle East respiratory syndrome coronavirus (MERS-CoV): a systematic review and meta-analysis. Int. J. Infect. Dis. 49, 129–133 (2016).
119. Tsang, T. K. et al. Effect of changing case definitions for COVID-19 on the epidemiologic curve and transmission parameters in mainland China: a modelling study. Lancet Public Health. 5(5), e289–e296 (2020).
120. 国家卫生健康委员会 (Office of National Health Comission). 新型冠状病毒肺炎诊疗方案(试行第七版) (Clinical Guide-line for Novel Coronavirus Pneumonia—Interim 7th Edition) (2020).
121. File, T. M. Jr. & Tsang, K. W. Severe acute respiratory syndrome: pertinent clinical characteristics and therapy. Treat. Respir. Med. 4(2), 95–106 (2005).
122. Day, M. Covid-19: four fifths of cases are asymptomatic, China figures indicate. BMJ 3(369), m1375 (2020).
123. Wei, W. E. et al. Presymptomatic transmission of SARS-CoV-2—Singapore, January 23–March 16, 2020. Morb. Mortal. Wkly. Rep. 69(14), 411–415 (2020).
124. Mizumoto, K., Kagaya, K., Zarebski, A. & Chowell, G. Estimating the asymptomatic proportion of coronavirus disease 2019 (COVID-19) cases on board the Diamond Princess cruise ship, Yokohama, Japan, 2020. Euro Surveill. 25(10), 2000180 (2020).
125. Poutman, S. M. et al. Identification of severe acute respiratory syndrome in Canada. N. Engl. J. Med. 348(20), 1995–2005 (2003).
126. Tsang, K. W. et al. A cluster of cases of severe acute respiratory syndrome in Hong Kong. N. Engl. J. Med. 348(20), 1977–1985 (2003).
127. Cao, B. et al. A trial of Lopinavir–Ritonavir in adults hospitalized with severe covid-19. N. Engl. J. Med. 382(19), 1787–1799 (2020).
Acknowledgements
None.

Author contributions
C.W., J.W. and A.W. contributed equally to all aspects of study design, conduct, data interpretation, and the writing of the manuscript. C.W., E.T. and C.H.A. contributed to eligibility screening, data extraction from eligible studies, and data analysis and interpretation.

Funding
There was no funding source for this study.

Competing interests
The authors declare no competing interests.

Additional information
Supplementary information is available for this paper at https://doi.org/10.1038/s41598-020-74988-9.

Correspondence and requests for materials should be addressed to A.K.W.

Reprints and permissions information is available at www.nature.com/reprints.

Publisher’s note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

© The Author(s) 2020