Epidemiological Characteristics of COVID-19; a Systemic Review and Meta-Analysis

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Running title: Epidemiological Characteristics of COVID-19

Word Count: 2718 words

Abstract

Background: Our understanding of the corona virus disease 2019 (COVID-19) continues to evolve. However, there are many unknowns about its epidemiology.

Purpose: To synthesize the number of deaths from confirmed COVID-19 cases, incubation period, as well as time from onset of COVID-19 symptoms to first medical visit, ICU admission, recovery and death of COVID-19.

Data Sources: MEDLINE, Embase, and Google Scholar from December 01, 2019 through to March 11, 2020 without language restrictions as well as bibliographies of relevant articles.

Study Selection: Quantitative studies that recruited people living with or died due to COVID-19.

Data Extraction: Two independent reviewers extracted the data. Conflicts were resolved through discussion with a senior author.

Data Synthesis: Out of 1675 non-duplicate studies identified, 57 were included. Pooled mean incubation period was 5.84 (99% CI: 4.83, 6.85) days. Pooled mean number of days from the onset of COVID-19 symptoms to first clinical visit was 4.82 (95% CI: 3.48, 6.15), ICU admission was 10.48 (95% CI: 9.80, 11.16), recovery was 17.76 (95% CI: 12.64, 22.87), and until death was 15.93 (95% CI: 13.07, 18.79). Pooled probability of COVID-19-related death was 0.02 (95% CI: 0.02, 0.03).

Limitations: Studies are observational and findings are mainly based on studies that recruited patient from clinics and hospitals and so may be biased toward more severe cases.

Conclusion:

We found that the incubation period and lag between the onset of symptoms and diagnosis of COVID-19 is longer than other respiratory viral infections including MERS and SARS;

52 however, the current policy of 14 days of mandatory quarantine for everyone might be too
53 conservative. Longer quarantine periods might be more justified for extreme cases.
54
55 **Funding:** None.
56
57 **Protocol registration:** Open Science Framework: https://osf.io/a3k94/
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Background

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was first identified in a few unusual pneumonia patients linked to the Wuhan seafood wholesale market in China in December 2019 (1). However, it soon grew out of China and the corona virus disease 2019 (COVID-19) was declared a pandemic on March 11, 2020 and is now found in 190 countries (2). While the epidemic seems to have slowed down in China due to the strict quarantine and preventative regulations, the number of COVI-19 patients (i.e., >370,000 as of March 23rd) and confirmed deaths (i.e., i.e., >16,000 as of March 23rd) are rapidly increasing (2); figures that greatly surpass that of other diseases in the family of coronaviruses with similar genomes to SARS-CoV-2 such as severe acute respiratory syndrome (SARS) and Middle East Respiratory Syndrome (MERS) (3) which emerged in 2003, 8,098 patients and 774 deaths across 29 countries, and 2012, leading to 2494 patients and 858 deaths across 27 countries, respectively (4-6). The healthcare systems in many countries, such as Italy, Iran, Spain, and France are overwhelmed and struggling with the soaring number of patients (7).

Although our understanding of COVID-19's epidemiology is evolving, it is assumed that SARS-CoV-2 is mainly transmitted via droplets and close contacts with people carrying the virus (2). However, recent reports have also proposed the possibility of the virus being contracted via various surfaces, gastrointestinal transmission (8), and potentially airborne (2, 9). Based on the existing evidence, elderly population, those with suppressed immune systems, and underlying metabolic, cardiovascular or respiratory diseases are at an increased risk for adverse outcomes; however, recent reports from outside China point to a considerable risk of severe outcomes among the general adult population (i.e., <65 years old) (10, 11).

As we continue to learn more about COVID-19 and its characteristics, there are many unknowns and confusions about its epidemiology such as hospitalization- and recovery-

related outcomes which are indeed of utmost importance when it comes to health system preparedness (12, 13). For example, mean number of days of incubation for COVID-19 varies greatly across the existing literature ranging from 2.5 (14) to 12.1 (15) days. Our knowledge of time from contracting the disease to recovery or death are even more limited. In this systematic review, we tried to identify the studies that recruited patients diagnosed with COVID-19 and calculate polled estimates for several epidemiological and clinical outcomes to help provide an overall picture of the characteristics of COVID-19. Findings of this study could help inform the ongoing public health and public policy practices across the world.

Methods

The details of inclusion criteria and analytical approach were designed a priori and are documented in Open Science Framework (https://osf.io/a3k94/).

Databases and Search Strategy

Following the Systematic Reviews and Meta-Analyses (PRISMA) checklist (16) and the Peer Review of Electronic Search Strategies (PRESS) guideline (17), we searched PubMed, Embase, and Google Scholar from December 01, 2019 through to March 11, 2020 for studies that measured and reported several characteristics of COVID-19 (e.g., incubation period, hospitalization, death). Search terms were combined using appropriate Boolean operators and included subject heading terms/keywords relevant to COVID-19 (e.g., novel coronavirus, sars-cov2, coronavirus disease). Please see **supplement 1** for a sample search strategy.

Inclusion criteria

Quantitative studies were included in the review if they reported incubation period or time from onset of the symptoms to first medical visit, intensive care unit (ICU) admission, recovery or death. Studies were also included if they reported number of deaths from patients with confirmed COVID-19 diagnosis. Studies were not excluded based on language, location, or measurement method. Given the nature of the study which used secondary data involving no interaction with humans, no ethics approval was required.

Study Selection

Two authors (SJ and NN) completed the abstract and full-text screening, independently. Citations that met our eligibility criteria or were unclear were screened at full-text by two

126 independent reviewers (SJ and NN) in duplicate. Disagreements over inclusion of studies were
127 resolved through discussion. Duplicate records were excluded.
128
129 *Data Extraction*
130 Data were extracted independently by the two authors (SJ and NN), and discrepancies were
131 resolved through discussion or by arbitration with a senior co-author (AM). Data were
132 extracted on study type (e.g., descriptive, case-series, mathematical modeling), publication
133 year, location, sample size, patients' age, gender, exposure history, X-ray and computed
134 tomography (18) scan findings, symptoms, and underlying conditions if reported. We also
135 extracted data on the main outcomes of interests including the number of deaths from
136 confirmed COVID-19 cases, incubation period, as well as time from onset of COVID-19
137 symptoms to first medical visit, to ICU admission, to recovery and to death.
138
139 *Statistical analysis*
140 For studies that did not provided enough data to be included in the meta-analysis, we
141 performed a qualitative data synthesis. Case-reports with a sample size of one were also
142 removed from the meta-analysis as they did not provide any dispersion estimate. Meta-
143 analysis was performed using STATA's (V.15.1) metan (for numerical variables) and metaprop
144 (for binary variables) commands. The 95% confidence intervals (CI) for binary variables were
145 computed using the exact binomial method. Heterogeneity between studies was assessed
146 using both the I^2 statistic with a cutoff of ≥ 50% and the Chi-square test with P-value <0.10 to
147 define a significant degree of heterogeneity (19). As all results turned to be significantly
148 heterogenous, we used random-effects model to calculate the pooled point estimate and 95%
149 CI for the mortality rate, mean time from onset of COVID-19 symptoms to first medical visit,

ICU admission, recovery and death. For mean incubation period, we estimated 99% CI. We also conducted a random-effects meta-regression using STATA's metareg command to identify the sources of heterogeneity and explore the effect of study-level covariates where data were available. A two-sided P-value <0.05 was considered as statistically significant effect.

Results

Participants and study characteristics

We found a total of 1675 non-duplicate studies, 57 of which were included in our qualitative synthesis and 43 were considered for meta-analysis (Figure 1). A description of the main characteristics of the included studies is provided in Table 1. The 57 studies included 27 cross-sectional, one case-control, one retrospective cohort, and 28 case series/case report studies with sample sizes of observational studies ranging greatly from one to 58182 for a study in the Hubei province (20). Inclusion criteria varied greatly across the studies but most participants were hospitalized patients living or traveling from various provinces in China. Median (range) age of the participants was 46.2 (17 days to 78.5 years) and about 60% were men. Most studies were conducted between January and February 2020. Clinical and epidemiological characteristics of the patients included in the study are presented in Table 2. Among studies that reported exposure history among their participants, most patients were directly or indirectly traced back to the city Wuhan (e.g., lived in Wuhan or had recently travelled to Wuhan) and the Huanan seafood market in Hubei province, China. Several cases of contracting COVID-19 through close contacts with family members were also reported across the studies. Frequent CT or X-ray findings included thickened texture of lungs, bilateral focal consolidation, lobar consolidation, ground glass opacity, and patchy consolidation, and

174 unilateral/bilateral pneumonia. Common symptoms reported across the studies include
175 fever, cough, shortness of breath, and fatigue/weakness. Only 15 studies reported some
176 information about the pre-existing conditions of the patients; most of whom had metabolic
177 and cardiovascular underlying conditions.

178

179 *Mean incubation period*

180 The estimated mean incubation period obtained from the included studies as well as resulting
181 pooled mean are presented in Fig. 2. Out of the 14 studies included in the meta-analysis, 12
182 were conducted in China. The findings of meta-analysis showed that the mean incubation
183 period was 5.84 (95% CI: 4.83, 6.85) days. Heterogeneity testing (I^2=94.7%) revealed notable
184 differences among the included studies in the meta-analysis. Multivariate meta-regression
185 results (**Table 2**) showed no significant differences in incubation period time by country (China
186 vs. others, Adjusted Beta = 1.70; P-value = 0.484), age (Adjusted Beta = -1.16; P-value = 0.239)
187 or percent of male (Adjusted Beta = -13.07; P-value = 0.09) participants.

188

189 *Mean time from onset of symptoms to first clinical visit*

190 The estimated mean number of days from the onset of COVID-19 symptoms to first clinical
191 visit was 4.82 (95% CI: 3.48, 6.15). As shown in Fig. 3, out of the 21 studies included in the
192 meta-analysis, only 6 were conducted outside China. Heterogeneity testing (I^2=98.0%)
193 revealed notable differences among the included studies in the meta-analysis. Multivariate
194 meta-regression results (**Supplement 2**) showed no significant differences in time from onset
195 of symptoms to first clinical visit by country (China vs. others, Adjusted Beta = 1.47; P-value =
196 0.456), age (Adjusted Beta = 0.91; P-value = 0.187) or percent of male (Adjusted Beta = -2.96;
197 P-value = 0.614) participants.

198

199 *Mean time from onset of symptoms to ICU admission*

200 The estimated mean number of days from the onset of COVID-19 symptoms to ICU admission
201 was 10.48 (95% CI: 9.80, 11.16), an estimate that was derived from one study in Singapore
202 and one in Wuhan, China (Fig. 4).

203

204 *Mean time from onset of symptoms to recovery*

205 The estimated mean number of days from the onset of symptoms to recovery was reported
206 in 6 studies and the resulting pooled mean was 17.76 (95% CI: 12.64, 22.87). Only one of the
207 studies was conducted in China and the rest were completed in France, South Korea, UK, and
208 Japan (Fig. 5). Heterogeneity testing (I^2=99.0%) revealed notable differences among the
209 included studies in the meta-analysis. Multivariate meta-regression results (**Supplement 2**)
210 showed no significant differences in time from onset of symptoms to recovery by country
211 (China vs. others, Adjusted Beta = 8.40; P-value = 0.522), age (Adjusted Beta = -3.02; P-value
212 = 0.602) or percent of male (Adjusted Beta = 35.56; P-value = 0.537) participants.

213

214 *Mean time from onset of symptoms to death*

215 The estimated mean number of days from the onset of symptoms to death was reported in
216 three studies with a pooled mean of 15.93 (95% CI: 13.07, 18.79). All of the studies were
217 conducted in China (Fig. 6).

218

219 *Death probability*

220 The estimated probability of COVID-19-related death was reported in 22 studies a pooled
221 probability of 0.02 (95% CI: 0.02, 0.03) (Fig. 7). Heterogeneity testing (I^2=97.6%) revealed

222 notable differences among the included studies in the meta-analysis. Multivariate meta-
223 regression results (**Supplement 2**) showed a significant difference in death probability by age
224 (Adjusted Beta = 0.058; P-value = 0.016).
225
226 **Discussion**
227 We conducted a systematic review and meta-analysis to provide an overview of the
228 epidemiological characteristics of COVID-19. Our findings suggested that the COVID-19 has an
229 incubation time of more than five days (5.84 days) and a lag of less than five days (4.82 days)
230 from onset of symptoms to first clinical visit. On average, the symptoms lasted more than
231 twenty days (17.76 days) before recovery was achieved and the mortality risk among
232 confirmed cases was 2%, which significantly increased by age. Similar to previous studies (21),
233 fever, dry cough, shortness of breath, and fatigue were common symptoms among the
234 patients in the included studies. As expected, history of direct or indirect exposure to Wuhan
235 was frequent and the most common radiologic findings were bilateral consolidation and
236 pneumonia (22, 23).
237 We found that the average incubation period of COVID-19 infection to be less than 6 days
238 which is broadly consistent with previously reported estimates (24-27). The right tail of the
239 incubation period for COVID-19 even for 99% CI was less than seven days (6.85). This finding
240 is of particular interest as uncertainties continue to exist about the incubation period of
241 COVID-19. For example, while both WHO and United States' CDC suggest an incubation period
242 of 2-14 days, single outlier cases as long as 19 (15), 24 (28) or 27 days (29) have been reported;
243 estimates that are most likely reflecting a double exposure. Our meta-analytic findings are of
244 particular importance for quarantine-related policies and planning and suggest that the
245 current 14-day quarantine period might be rather conservative. Indeed, we found that except

246 for one small study from China in Anyang city on a cluster of six patients (Bai 2020 (15)), all
247 other studies reported incubation periods less than 11 days; therefore, a shorter period of 14
248 days would most likely suffice and it is expected that almost all infected people will show
249 symptoms within 11 days of initial exposure. Nonetheless, decisions to modify or keep the
250 existing policies need to weigh the costs of extending active quarantine against the potential
251 or costs of missing a symptomatic case.
252 COVID-19 seems to have a longer incubation period than that of other acute respiratory viral
253 infections (30) such as human coronavirus (3.2 days), influenza A (1.43-1.64 days (31)),
254 parainfluenza (2.6 days), respiratory syncytial virus (4.4 days), and rhinovirus (1.4 days).
255 Furthermore, the median incubation period for SARS has been reported estimated as 4.0 days
256 in 2009 (30), which is considerably lower than what we observed for COVID-19. The longer
257 incubation period of the COVID-19 may be one of the major factors that helps explain its rapid
258 spread in comparison previous respiratory infection viruses. Another factor that contributes
259 to spread of COVID-19 is the lag between the onset of symptoms and first clinical visit and the
260 high number of asymptomatic cases of COVID-19. Our results indicated on average it is less
261 than five days (4.82 days), and particularly increases by age (1.94 days increase per each 10
262 years increase in age). This finding suggests that MERS and SARS progress rapidly to sever
263 symptoms and respiratory failures (32) than most cases infected by COVID-19 (33).
264 In compare to MERS-COV with a mortality rate of 35.67% (34) and SARS with a mortality rate
265 of 11% (35), we found that COVID-19 has a much lower mortality rate (2%) which significantly
266 increase by age (48% increase for every 1% increase in male participants). Although this
267 estimate is comparable with previous studies (36, 37), it is important to recognize the
268 limitations of calculating mortality rates of COVID-19 while the epidemic is still growing. As
269 most cases of CVOID-19 remain asymptomatic and may recover without seeking medical care,

it is likely that the true rate of death among people infected with COVID-19 could be even lower. On the other hand, the estimated mortality rates reported in most studies need to be interpreted with caution as they are often based on the cumulative number of deaths relative to the number of confirmed cases, while patients who die on a given day have been infected at a much earlier date and this would bias the denominator of the mortality rate (38).

We acknowledge four main limitations of our systematic review. First, our findings are mainly based on studies that recruited patient from clinics and hospitals and so may be biased toward more severe cases. Second, many studies did not report the study outcomes by subgroups such as age or gender and so we could report group-specific outcomes. Third, we used the mean and the standard error of the incubation period assuming a normal distribution which may have led to underestimate the right tail of the distribution. Lastly, given the urgency of topic and the heterogeneity of the studies included in the review, we did not conduct risk of bias and quality assessment of the studies. Inevitably, given the novelty of COVID-19 and the observational nature of all of the available evidence, they are most likely at a high risk of bias and the quality of existing evidence is low. Nonetheless, our systematic review of literature provides an update on epidemiological characteristics of COVID-19 which can be helpful for decision making on prevention measures as well as modeling and cost-analysis purposes.

Conclusions

Our findings of the overall epidemiological characteristics of COVID-19 have important insight for healthcare systems' prevention and planning efforts. The incubation period (i.e., <11 days in most studies) and the lag between the onset of symptoms and diagnosis (i.e., <5 days) are longer for COVID-19 compared to other respiratory viral infections including MERS and SARS.

294 Nonetheless, current policies of 14 days of mandatory quarantine for everyone, might be too
295 conservative and longer quarantine periods might be more justified for extreme cases. As
296 effective vaccination or treatment for COVID-19 are yet to be developed, practicing the
297 fundamentals of public health and prevention efforts such as social distancing and personal
298 hygiene are critical and need to be emphasized and enforced further to reduce the
299 transmission risk of COVID-19 to vulnerable populations.

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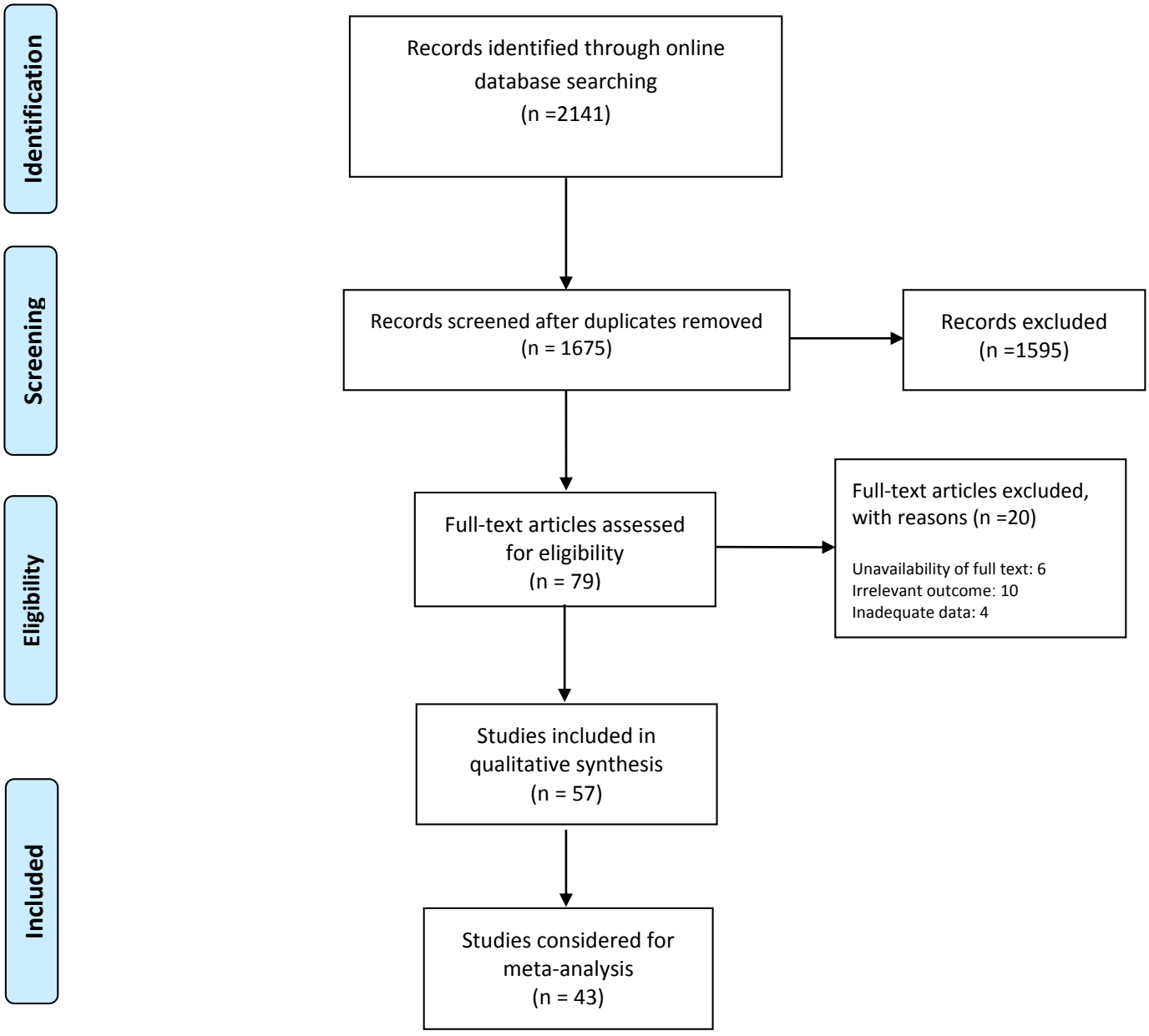

Figure 1. PRISMA flowchart of screened and included studies

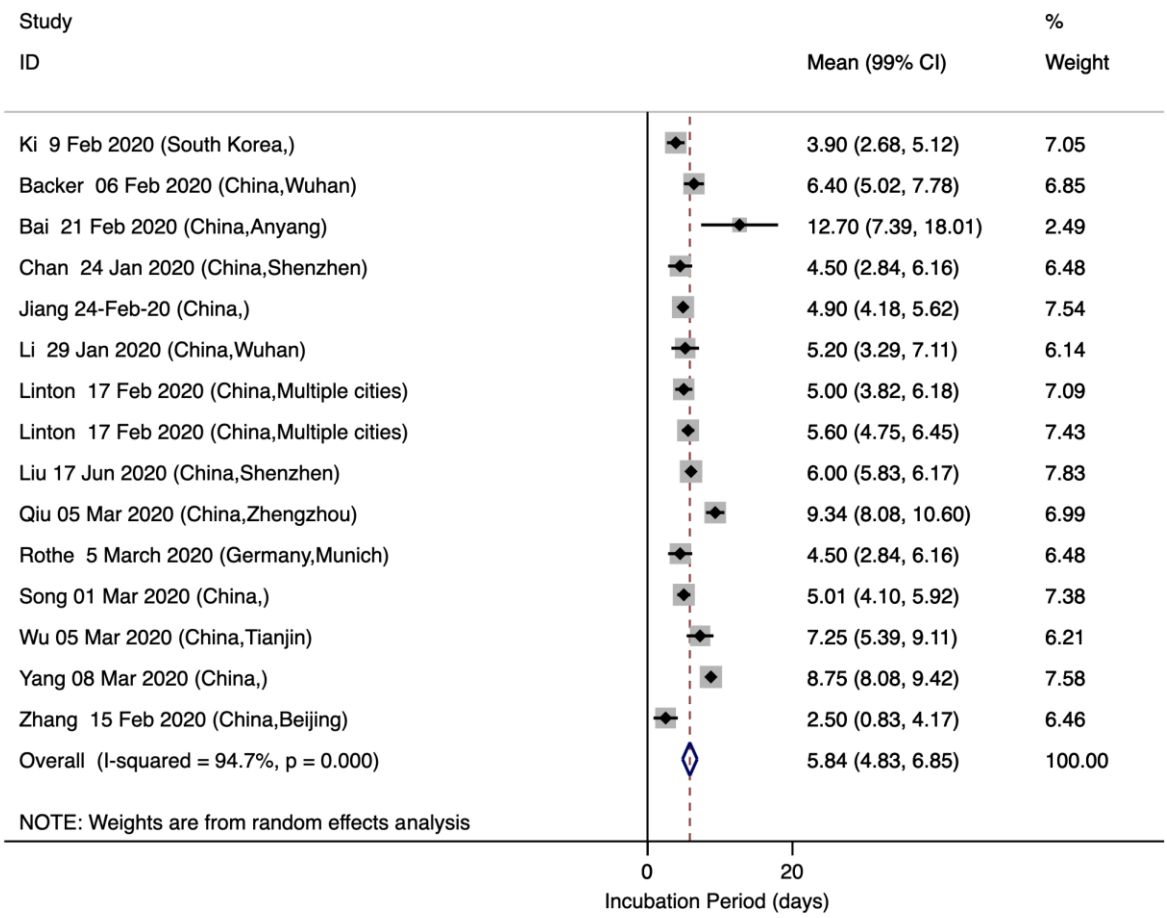

Figure 2. Incubation period of COVID-19 infection

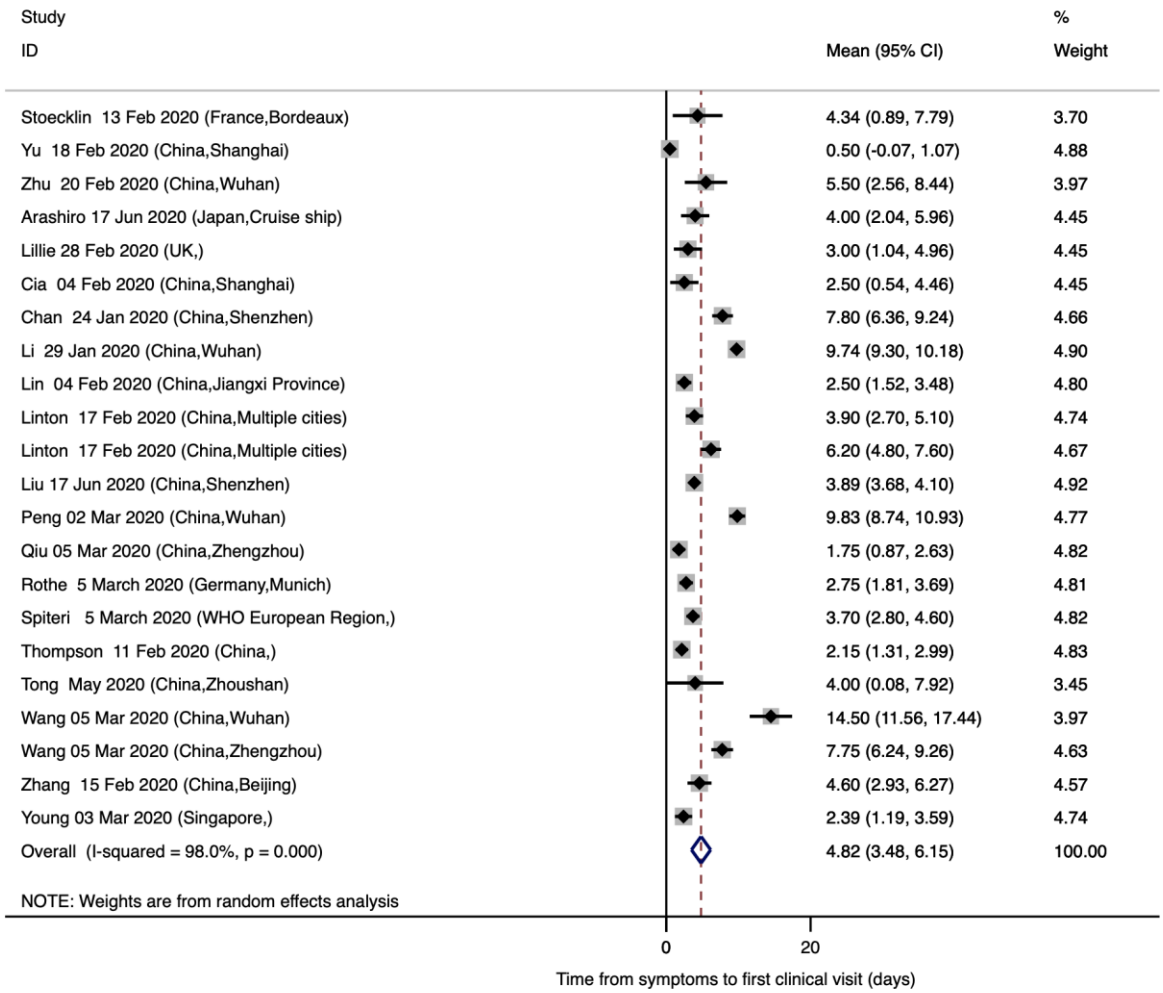

Figure 3. Time from onset of symptoms to first clinical visit for COVID-19 infection

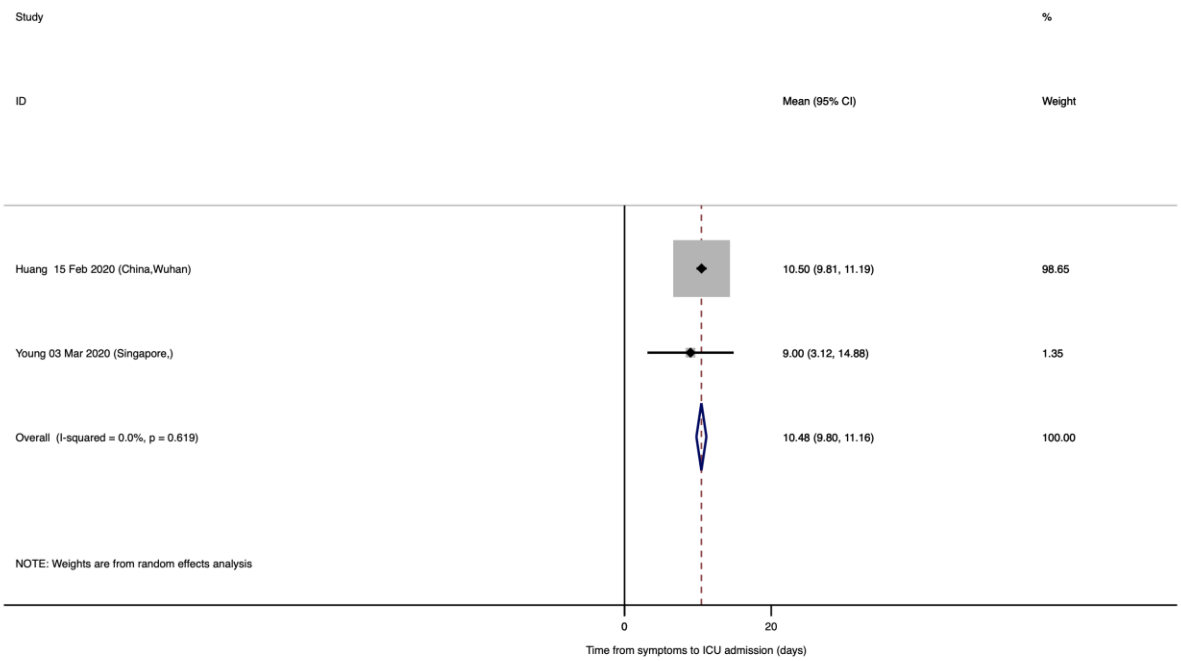

Figure 4. Time from onset of symptoms to ICU admission for COVID-19 infection

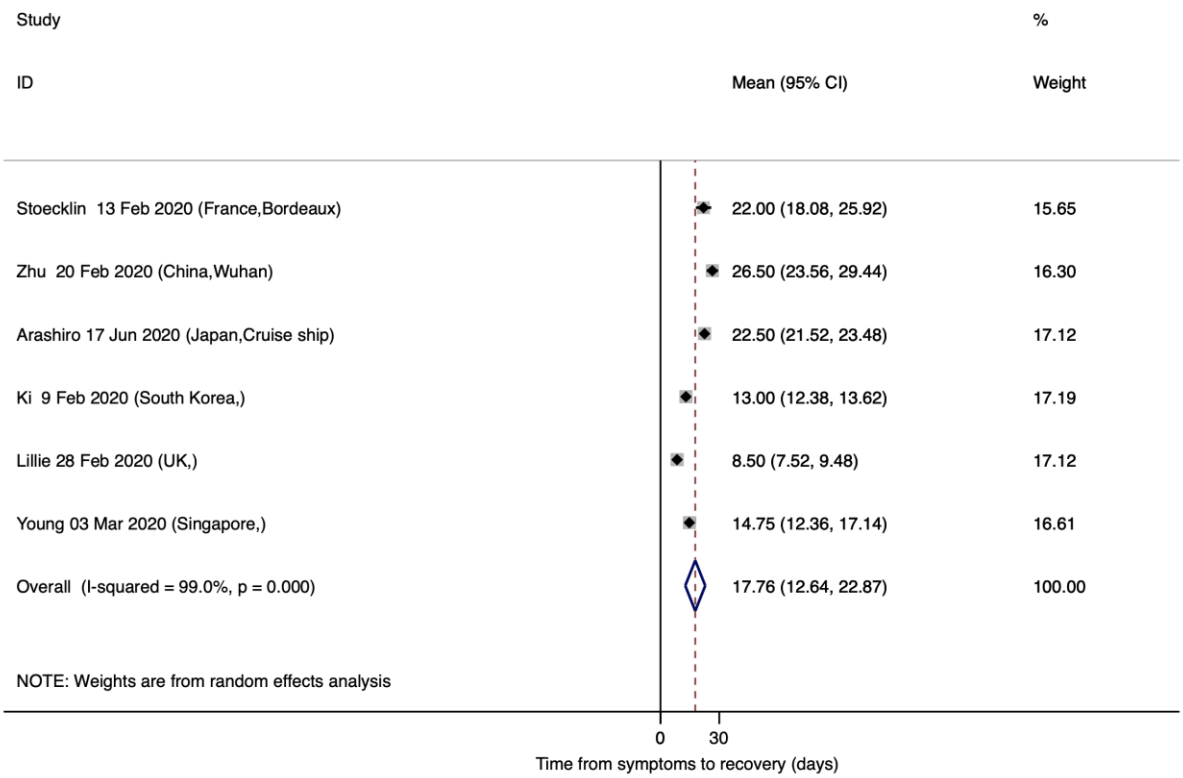

Figure 5. Time from onset of symptoms to recovery for COVID-19 infection

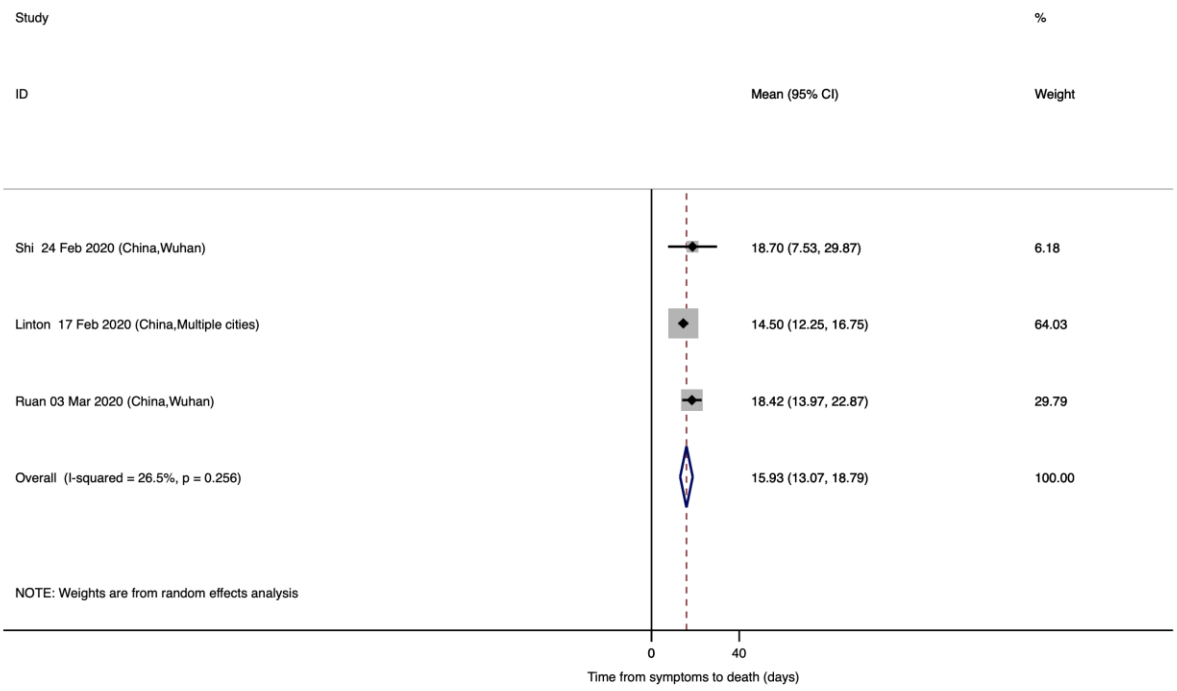

Figure 6. Time from onset of symptoms to death for COVID-19 infection

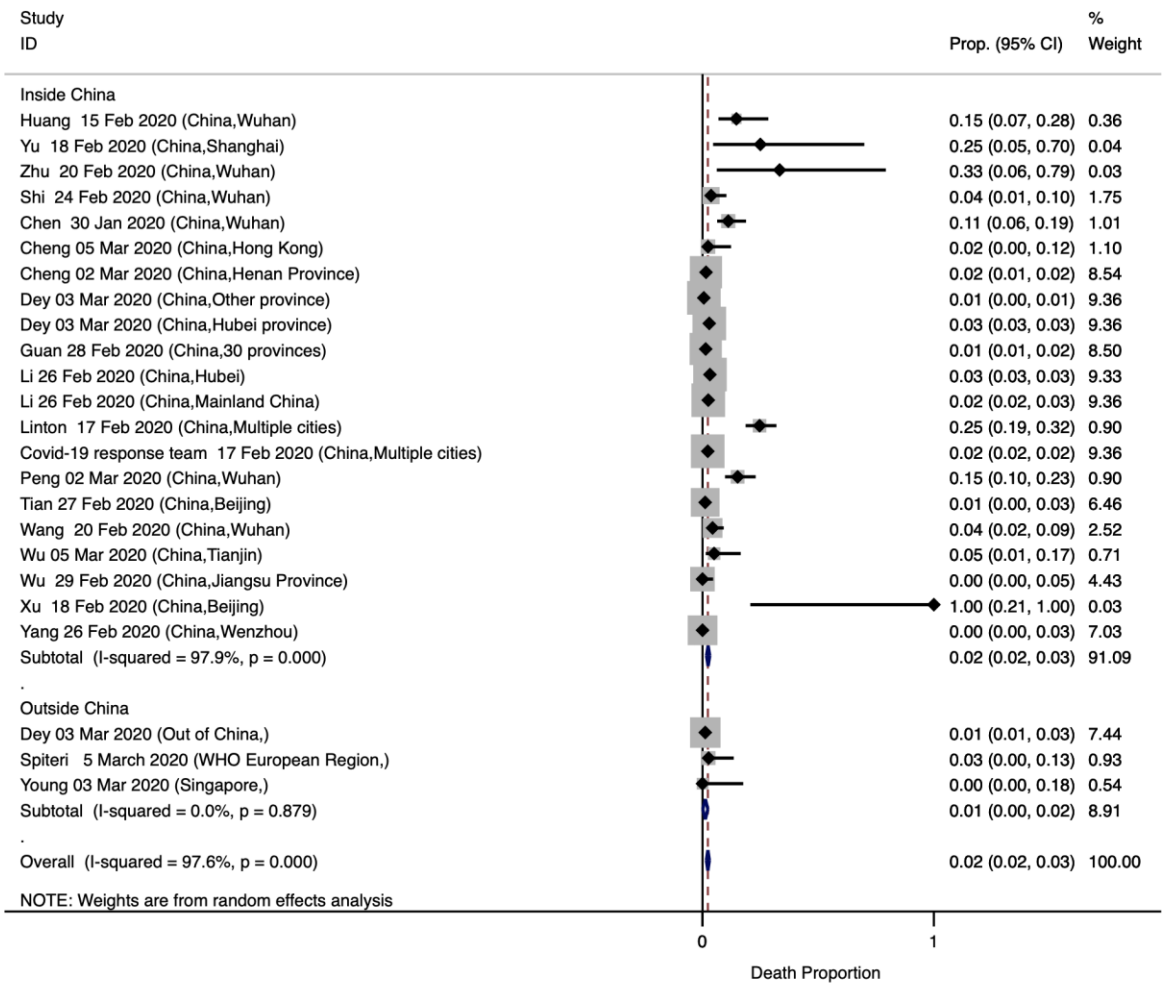

Figure 7. Probability of death among patients diagnosed with COVID-19 infection

Table 1. Characteristics of the included studies in the systematic review

First Author	**Publication Date (DD-MM-YY)**	**Study Setting/Location**	**Study Type**	**Sample size**	**Age; Mean/Range**	**Male Proportion**
Chan (39)	24-Jan-20	China, Shenzhen	Case series	6	46.17	0.50
Li (24)	29-Jan-20	China, Wuhan	Cross-sectional	425	55.5	0.56
Chen (1)	30-Jan-20	China, Wuhan	Cross-sectional	99	55.5	0.68
Holshue (40)	31-Jan-20	USA, Washington	Case-report[a]	1	35	1.00
Wu (41)	3-Feb-20	China, Wuhan	Case-report	1	41	1.00
Kim (42)	3-Feb-20	Korea, Incheon	Case-report	1	35	0.00
Cai (43)	4-Feb-20	China, Shanghai	Case-report[b]	2	7	0.67
Lin (44)	4-Feb-20	China, Jiangxi province	Case-report	2	37	1.00
Backer (26)	6-Feb-20	China, Wuhan	Cross-sectional	88	2 to 72	0.65
Ki (45)	9-Feb-20	South Korea	Cross-sectional	28	42.1	0.54
Jiang (46)	24-Feb-20	China	Cross-sectional	50	NR	NR
Chen (47)	11-Feb-20	China, Wuhan	Case-report	1	1	1.00
Thompson (48)	11-Feb-20	China	Cross-sectional	47	47	0.63
Zhang (49)	11-Feb-20	China, Xiaogan	Case-report	1	0.25 (3 months)	0.00
Duan (50)	12-Feb-20	China, Wuhan	Case-report	1	46	0.00
Stoecklin (51)	13-Feb-20	France, Bordeaux	Case-report	3	36.3	0.67
Huang (52)	15-Feb-20	China, Wuhan	Cross-sectional	41	49.34	0.73
Zhang (14)	15-Feb-20	China, Beijing	Case series	9	35.3	0.56
Lim (53)	17-Feb-20	Korea, Goyang	Case-report	1	54	1.00
Linton (54)	17-Feb-20	China, multiple cities	Cross-sectional	276	30–59 (>50%)	0.58
COVID-19 Response Team (36)	17-Feb-20	China, multiple cities	Cross-sectional	44672	30-69 (77.8%)	0.51
Zeng (55)	17-Feb-20	China, Wuhan	Case-report	1	0.046 (17 days)	1.00
Yu (56)	18-Feb-20	China, Shanghai	Case-report	4	74.25	0.50
Xu (57)	18-Feb-20	China, Beijing	Case-report	1	50	1.00
Fang (58)	19-Feb-20	China, Chengdu	Case-report	1	47	1.00
Wang (59)	20-Feb-20	China, Wuhan	Cross-sectional	138	55.3	0.54
Zhu (60)	20-Feb-20	China, Wuhan	Case-report	3	47.33	0.67
Bai (15)	21-Feb-20	China, Anyang	Case series	6	34.75	0.17
Hao (61)	21-Feb-20	China, Shaanxi	Case-report	1	58	1.00
Shi (62)	24-Feb-20	China, Wuhan	Cross-sectional	81	49.5	0.52

Cheng (63)	26-Feb-20	Taiwan, Taoyuan	Case-report	1	55	0.00
Li (64)	26-Feb-20	China, Mainland China	Cross-sectional	44653	NR	NR
	26-Feb-20	China, Hubei	Cross-sectional	33366	NR	NR
Yang (65)	26-Feb-20	China, Wenzhou	Cohort	149	45.11	0.54
Shrestha (66)	27-Feb-20	Nepal, Kathmandu	Case-report	1	32	1.00
Tian (67)	27-Feb-20	China, Beijing	Cross-sectional	262	47.5	0.48
Guan (68)	28-Feb-20	China, 30 provinces	Cross-sectional	1099	46.7	0.58
Lillie (69)	28-Feb-20	UK	Case-report	2	36.5	0.50
Wu (70)	29-Feb-20	China, Jiangsu province	Cross-sectional	80	46.1	0.49
Song (71)	1-Mar-20	China	Cross-sectional	11791	NR	NR
Cheng (72)	2-Mar-20	China, Henan province	Cross-sectional	1079	46.6	0.53
Peng (73)	2-Mar-20	China, Wuhan	Cross-sectional	112	61.3	0.47
Dey (20)	3-Mar-20	China, Hubei province	Cross-sectional	58182	NR	NR
		China, Other provinces	Cross-sectional	12264	NR	NR
		Outside of China	Cross-sectional	425	NR	NR
Ruan (74)	3-Mar-20	China, Wuhan	Case control	66	45-75 (>50%)	NR
Young (75)	3-Mar-20	Singapore	Cross-sectional	18	49.5	0.50
Chen (76)	5-Mar-20	China, Guangdong	Case-report	1	46	0.00
Cheng (77)	5-Mar-20	China, Hong Kong	Cross-sectional	42	57.8	0.48
Qiu (78)	5-Mar-20	China, Zhengzhou	Case series	8	25.9	0.50
Rothe (79)	5-Mar-20	Germany, Munich	Case series	5	NR	NR
Spiteri (80)	5-Mar-20	WHO European Region	Cross-sectional	38	41.75	0.66
Wang (81)	5-Mar-20	China, Wuhan	Case-report	2	78.5	0.50
Wang (82)	5-Mar-20	China, Zhengzhou	Cross-sectional	18	41	0.56
Wu (83)	5-Mar-20	China, Tianjin	Cross-sectional	40	44.0	0.33
Yang (84)	5-Mar-20	China	Cross-sectional	325	8 months to 90 years	0.49
Lauer (27)	10-Mar-20	China, outside Hubei province	Cross-sectional	181	44.67	0.60
		Outside mainland China	Cross-sectional	108	NR	NR
Tong (85)	17-May-20[c]	China, Zhoushan	Case-report	3	33	1.00
Arashiro (86)	17-Jun-20[c]	Japan, Cruise ship	Case-report	2	31	0.50

Liu (87)	17-Jun-20[c]	China, Shenzhen	Cross-sectional	365	46.2	0.50

[a] Studies with a sample size less than or equal to 4 patients were labeled as case-reports (88); [b] A 7-year-old-boy and his parents; [c] Studies are in press and will be published in future issues of the respective journal

Table 2. Medical and epidemiological characteristics of studies included in the review

First Author	Exposure history	X-ray/CT findings	Symptoms	Underlying conditions	Incubation period[a]	Time to first clinical visit[b]	Time to ICU admission	Time to recovery	Time to death	Death
Chan (39)	Family cluster; History of travel to Wuhan; No contact with animals; Huanan seafood wholesale market in Wuhan.	14.3% Ground-glass lung opacities; 85.7% Pulmonary infiltrates and multifocal patchy ground-glass opacities, especially around the peripheral parts of the lungs	71.4% Fever; 57.1% Cough; 42.9% Generalized weakness; 14.3% Nasal congestion; 14.3% Sneezing; 14.3% Rhinorrhea; 14.3% Sore throat; 14.3% Pleuritic chest pain; 28.6% Diarrhea	28.6% Hypertension; 14.3% Benign intracranial tumor; 14.3% Chronic sinusitis; 14.3% Diabetes:	4.5 (0.64)	7.8 (0.74)	NR	NR	NR	NR
Li (24)	11.8% Huanan Seafood Wholesale Market; 4.0% Other wet market but not Huanan Seafood Wholesale Market; 15.3% Contact with another person with respiratory symptoms; 49.9% No exposure to either market or person with respiratory symptoms.	NR	NR	NR	5.2 (0.74)	9.7 (0.22)	NR	NR	NR	NR
Chen (1)	49% Huanan seafood market	25% Unilateral pneumonia; 74% Bilateral pneumonia; 14% Multiple mottling and ground-glass opacity.	83% Fever; 82% Cough; 31% Shortness of breath; 11% Muscle pain; 9% Confusion; 8% Headache; 5% Sore throat; 4% Rhinorrhea; 2% Chest pain; 2% Diarrhea; 1% Nausea and vomiting; 90% More than one sign or symptom; 15% Fever, cough, and shortness of breath.	51% Chronic medical illness; 40% Cardiovascular and cerebrovascular diseases; 11% Digestive system disease; 13% Endocrine system disease; 1% Malignant tumor; 1% Nervous system disease; 1% Respiratory system disease.	NR	NR	NR	NR	NR	11

Holshue (40)	History of travel to Wuhan	Illness day 4: No thoracic abnormalities; Illness day 9: Increasing left basilar opacity.	Cough; Fever; Nausea and vomiting	Hypertriglyceridemia	NR	3 (0.0)	NR	15 (0.0)	NR	NR
Wu (41)	Worked at a local indoor seafood market	X-ray: Illness day 6: Abnormal with air-space shadowing such as ground-glass opacities, focal consolidation and patchy consolidation in both lungs. Illness day 11: Bilateral diffuse patchy and fuzzy shadow. CT: Illness day 6: Bilateral focal consolidation; Lobar consolidation and patchy consolidation, especially in the lower lung.	Fever; Cough; Sputum production; Dizzy; Weakness; Chest tightness; Dyspnea	No	NR	6 (0.0)	9 (0.0)	NR	NR	NR
Kim (42)	Living in Wuhan	Initial X-ray: No infiltrations; Illness day 8: Chest infiltrates in the right lower lung field; CT: Illness day 4: Multiple ground-glass opacities in both subpleural spaces.	Fever; Chill; Myalgia; Nasal Congestion; Cough; Sputum; Pleuritic chest discomfort; Watery Diarrhea.	Obese (body mass index, 33.4 kg/m2)	NR	1 (0.0)	NR	13 (0.0)	NR	NR
Cai (43)	History of travel to Wuhan; Familial contacts.	X-ray in child: Thickened texture of both lungs; Blurred right inner lung zone and left posterior region of the heart; Without obvious patch shadows.	Fever; Cough; Nasal secretions. Mother of the child: Asymptomatic.	NR	NR	2.5 (1.0)	NR	7 (0.0)	NR	NR
Lin (44)	History of travel to Wuhan; Close contact.	CT: Patient 1: Multiple regions of patchy consolidation and ground-glass opacities with indistinct border in both lungs; Distributed lesions along the bronchial bundles or within the subpleural lung regions. Patient 2: Focal consolidation along broncho-vascular bundles in right lower lung lobe; Ground-glass opacities in subpleural regions of left lower lung lobe.	Fever; Cough; Throat discomfort.	No	NR	2.5 (0.5)	NR	NR	NR	NR
Backer (26)	NR	NR	NR	NR	6.4 (0.54)	NR	NR	NR	NR	NR

Ki (45)	34.6% Arrived from Wuhan; 46.2% Close contact; 3.9% History of travel to Japan; 3.9% History of travel to Thailand; 7.7% Attended a conference in Singapore.	NR	Mostly fever; Sore throat; Cough; Chill; Fatigue; Muscle pain.	NR	3.9 (0.47)	NR	NR	13 (0.31)	NR	NR
Jiang (46)	NR	NR	NR	NR	4.9 (0.28)	NR	NR	NR	NR	NR
Chen (47)	Exposed to infection during the consultation	X-ray: Illness day 2: Large blurred images of right upper and lower right lungs; Illness day 7: Partial absorption of right lower lobe pneumonia, right upper lobe atelectasis; CT: Illness day 2: Enhanced texture of lungs; Large consolidating shadows in right lung; Ground glass shadows.	Intermittent diarrhea; Vomiting; Fever; Shortness of breath; Poor mental response; Lethargy; Poor appetite	NR	NR	1 (0.0)	6 (0.0)	17 (0.0)	NR	NR
Thompson (48)	NR	NR	NR	NR	NR	2.15 (0.43)	NR	NR	NR	NR
Zhang (49)	Unknown	X-ray: Illness day 1: thickened texture of lungs; a small patch-like shadow in the lower right lung field; CT: Illness day 6: Enlarged lung texture.	Fever; Cough; Foaming	NR	NR	0 (0.0)	NR	14 (0.0)	NR	NR
Duan (50)	NR	CT: Bilateral and peripheral ground-glass opacities in the superior segments of both lower lobes; Without sparing of subpleural regions.	Fever	NR	NR	7 (0.0)	NR	20 (0.0)	NR	NR
Stoecklin (51)	Arrived from Wuhan	NR	100% Fever; 33.4% Headaches; 100% Cough; 66.7% Fatigue; 33.4% Conjunctivitis; 66.7% Chills.	NR	NR	4.34 (1.8)	10 (0.0)	22 (2.0)	NR	NR

Huang (52)	66% Direct exposure to Huanan seafood market	98% Bilateral involvement; CT in ICU patients on admission: Bilateral multiple lobular; Subsegmental areas of consolidation.	98% Fever; 76% Cough; 44% Myalgia or Fatigue; 28% Sputum production; 8% Headache; 5% Hemoptysis; 3% Diarrhea; 55% Dyspnea.	20% Diabetes; 5% Hypertension; 15% Cardiovascular disease; 2% Chronic obstructive pulmonary disease; 2% Malignancy; 2% Chronic liver disease.	NR	7 (0.15)	10.5 (0.35)	NR	NR	6
Zhang (14)	66.7% History of travel to Wuhan; 11.1% History of travel to Xiaogan, Hubei;11.1% Clinician at 3 hospitals in Beijing; 11.1% Familial transmission.	X-ray: 22.2% A little exudation of lung; CT: 77.8% Multiple ground glass shadows in the lungs; 33.4% Accompanied by consolidation on the basis of ground glass shadows.	88.9% Fever; 55.6% Cough; 44.5% Sore throat; 44.5 % Fatigue; 11.1% Nasal congestion; 11.1% Tonsil enlargement; 11.1% Rhinorrhea.	11.12% Diabetes	2.5 (0.65)	4.6 (0.85)	NR	NR	NR	NR
Lim (53)	Living in Wuhan	CT: Small consolidation in right upper lobe and ground-glass opacities in both lower lobes	Fever; Dry cough; Loose stool; Chilling; Myalgia; Muscle pain.	No	NR	3 (0.0)	NR	19 (0.0)	NR	NR
Linton (54)	Direct or indirect exposure to Wuhan and Hubei Province	NR	NR	NR	5.6 (0.33)	6.2 (0.71)	NR	NR	14.5 (1.14)	39
COVID-19 Response Team (36)	68.6% living or going to Wuhan or in close contact with Wuhan patients	NR	NR	NR	NR	NR	NR	NR	NR	1023
Zeng (55)	Family transmission	X-ray: A little right upper lung opacities CT: No increase in hilar shadows; Enhanced texture of both lungs, and even distribution	Sneezing; Intermittent vomiting; Decreased mental reaction; Milk intake	No	NR	7 (0.0)	NR	13 (0.0)	NR	NR

Yu (56)	Arrived from Wuhan; Family transmission.	CT: Patient 1: Interstitial hyperplasia with infection in both of lungs; Chronic bronchitis; Emphysema, Pulmonary bullae of lingual segment of the left lung; Pulmonary hypertension in both lungs; Increased heart shadow; Calcification of the aorta and aortic wall. Patient 2: 2 Ground-glass opacities on the inferior lobe of the right lung.	100% Fever; 25% Poor appetite; 25% Dry cough; 25% Chills.	Patient 1: Hypertension, Heart disease; Chronic obstructive pulmonary disease	NR	0.5 (2.9)	1 (0.0)	NR	5 (0.0)	1
Xu (57)	History of travel to Wuhan	X-ray: Illness day 8: Multiple patchy shadows in both lungs Illness day 12: Progressive infiltrate; Diffuse gridding shadow in both lungs.	Fever; Chills; Cough; Fatigue; Shortness of breath	NR	NR	7 (0.0)	NR	NR	14 (0.0)	1
Fang (58)	Family transmission	CT: Ground-glass opacities; Consolidation; or Both in bilateral lungs; 'Halo sign' in the basal segment of the lower lobe of the right lung.	Cough; Sputum production; Sore throat; Throbbing headache.	NR	NR	3 (0.0)	NR	NR	NR	NR
Wang (59)	8.7% were exposed to Huanan Seafood Wholesale Market	CT: 100% Bilateral involvement	98.6% Fever; 69.6% Fatigue; 59.4% Dry cough; 39.9% Anorexia; 34.8% Myalgia; 31.2% Dyspnea; 26.8% Expectoration; 17.4% Pharyngalgia; 10.1% Diarrhea; 10.1% Nausea; 9.4% Dizziness; 6.5% Headache; 3.6% Vomiting; 2.2% Abdominal pain.	31.2% Hypertension; 14.5% Cardiovascular disease; 10.1% Diabetes; 7.2% Malignancy; 5.1% Cerebrovascular disease; 2.9% COPD; 2.9% Chronic kidney disease; 2.9% Chronic liver disease; 1.4% HIV infection.	NR	NR	NR	NR	NR	6

Zhu (60)	Frequently exposed to Huanan Seafood Wholesale Market	CT: Illness day 8: Bilateral fluffy opacities; Illness day 11: Bilateral fluffy opacities in both images, with increased in density, profusion, and confluence	Fever; Cough; Chest discomfort.	NR	NR	5.5 (1.5)	NR	26.5 (1.5)	14 (0.0)	1
Bai (15)	An asymptomatic carrier arrived from Wuhan; Family transmission.	CT: Multifocal ground-glass opacities; Subsegmental areas of consolidation and fibrosis.	16% Asymptomatic; Fever; Respiratory symptoms; Sore throat.	NR	12.17 (2.06)	NR	NR	NR	NR	NR
Hao (61)	Arrived from Wuhan	CT: At admission: Multiple patchy; Cloud-like high-density shadows in the dorsal segment of the right lower lobe. 4 days after admission: Large ground glass-like high-density shadows on the dorsal segment of the right lung; Patchy cloud-like high-density shadows and consolidation shadows on the left lung.	Fever; Sore throat; Fatigue.	NR	4 (0.0)	1 (0.0)	NR	NR	NR	NR
Shi (62)	38% Direct exposure to Huanan seafood market; 19% Healthcare workers having close contact with patients; 9% Familial transmission; 35% Without any obvious history of exposure.	All patients wiht abnormal CT imaging features; All lung segments can be involved, and 27% predilection for the right lower lobe; mean number of segments involved: 10.5	73% Fever; 42% Dyspnea; 22% Chest tightness; 59% Cough; 19% Sputum; 26% Rhinorrhea; 1% Anorexia; 9% Weakness; 5% Vomiting; 6% Headache; 2% Dizziness; 4% Diarrhea.	11% Chronic pulmonary disease; 12% Diabetes; 15% Hypertension; 4% Chronic renal failure; 10% Cardiovascular disease; 7% Cerebrovascular disease; 5% Malignancy; 9% Hepatitis or Liver cirrhosis.	NR	NR	NR	23.2 (0.67)	18.7 (5.7)	3
Cheng (63)	Arrived from Wuhan	X-ray: Progression of prominent bilateral perihilar infiltration; Patchy opacities at bilateral lungs; CT: Persistent multifocal ground glass opacities with or	Sore throat, Dry cough, Fatigue, Fever	Hypothyroidism	NR	9 (0.0)	NR	28 (0.0)	NR	NR

		without superimposed reticulation; Mild fibrotic change at bilateral lungs, including peripheral subpleural regions of both lower lobes; Small irregular opacities.								
Li (64)	NR	NR	NR	NR	NR	NR	NR	NR	NR	1113
	NR	NR	NR	NR	NR	NR	NR	NR	NR	1068
Yang (65)	53.7% Stayed in Wuhan; 3.4% Stay in Hubei province except Wuhan; 32.9% Contact with people from Hubei province; 10.1% No relation with Hubei province.	CT: 3 Involved pulmonary lobes; 6 Involved segments in each patient; Segment 6 and 10 most involved; 2.1% Segments presented ground glass opacities; 26.8% Segments presented mixed opacity; 7.2% Segments presented consolidation; More localized lesions in the periphery rather than the center of the lung; More patchy lesions than oval lesions.	76.5% Fever; 58.4% Cough; 32.2% Expectoration; 1.3% Dyspnea; 3.4% Muscle pain; 8.7% Headache; 14.1% Sore throat; 3.4% Snotty; 3.4% Chest pain; 10.7% Chest tightness; 14.1% Chill; 7.4% Diarrhea; 1.3% Nausea and Vomiting.	18.8% Cardio-cerebrovascular disease; 5.4% Digestive system disease; 6.1% Endocrine diseases; 1.3% Malignant tumor; 0.7% Respiratory system diseases; 2.7% Others.	NR	6.8 (5.0) Median (IQR)	NR	NR	NR	0
Shrestha (66)	Arrived from Wuhan	NR	Fever	NR	NR	10 (0.0)	NR	14 (0.0)	NR	NR
Tian (67)	40.5% Arrived from; 49.2% Contact with a symptomatic case in the previous 14 days; 67.2% Cluster case.	NR	82.1% Fever; 45.8% Cough; 26.3% Fatigue; 6.9% Dyspnea; 6.5% Headache.	NR	6.7 (5.2) Median (IQR)	4.5 (3.7) Median (IQR)	NR	NR	NR	3
Guan (68)	43.9% Living in Wuhan; 1.9% Contact with wildlife; 31.3% Arrived from Wuhan; 72.3% Contact with Wuhan residents.	X-ray: 20.1% Ground-glass opacity; 28.1% Local patchy shadowing; 36.5% Bilateral patchy shadowing; 4.4% Interstitial abnormalities. CT: 56.4% Ground-glass opacity; 41.9% Local patchy shadowing; 51.8% Bilateral patchy shadowing; 14.7% Interstitial abnormalities.	88.7% Fever; 0.8% Conjunctival Congestion; 4.8% Nasal congestion; 13.6% Headache; 67.8%% Cough; 13.9% Sore throat; 33.7% Sputum production; 38.1% Fatigue; 0.9% Hemoptysis; 18.7% Shortness of breath; 5.0% Nausea or Vomiting; 3.8% Diarrhea; 14.9% Myalgia or Arthralgia; 11.5% Chills.	1.1% Chronic obstructive pulmonary disease; 7.4% Diabetes; 15.0% Hypertension; 2.5% Coronary heart disease; 1.4% Cerebrovascular disease; 2.1% Hepatitis B	4 (0.02)	NR	NR	NR	NR	15

				infection, 0.9% Cancer, 0.7% Chronic renal disease, 0.2% Immunodeficiency						
Lillie (69)	Arrived from Wuhan; Close household contact.	NR	Fever, Malaise, Dry Cough, Sinus congestion, Sore throat, Sinus congestion	NR	NR	3 (1.0)	NR	8.5 (0.5)	NR	NR
Wu (70)	100% Arrived from Wuhan	45.0% Bilateral pneumonia; 23.7% Unilateral pneumonia; 31.2% No abnormal density shadow.	78.7% Fever; 63.7% Cough; 37.5% Shortness of breath; 22.5% Muscle pain; 16.2% Headache and mental disorder symptoms; 13.7% Sore throat; 6.1% Rhinorrhea; 3.7% Chest pain; 1.2% Diarrhea; 1.2% Nausea and vomiting; 82.5% More than one sign or symptom.	31.2% Cardiovascular and cerebrovascular diseases; 6.2% Endocrine system diseases; 3.7% Digestive system disease; 1.2% Respiratory system diseases; 1.2% Malignant tumor; 1.2% Nervous system diseases; 1.25% Chronic kidney disease; 1.2% Chronic liver disease.	NR	NR	NR	NR	NR	0
Song (71)	NR	NR	NR	NR	5.01 (0.35)	NR	NR	NR	NR	NR

Cheng (72)	48% Short stay in Wuhan; 35.4% Arrived from Wuhan; 35.4% Close contact; 16.9% No clear case contact history.	NR	91.4% Fever; 7.3% Fatigue; 18.2% Cough; 3.1% Sputum; 1.2% Chills; 3.5% Rhinorrhea; 1.3% Nasal Congestion; 4.0% Dry throat; Sore throat; 3.5% Headache; 1% Chest pain; 3% Shortness of breath; 3.5% Digestive symptoms.	NR	NR	NR	NR	NR	NR	19
Peng (73)	NR	NR	90.2 Fever; 67.9% Cough; 63.4% Fatigue or myalgia; 33.9% Chest pain and tightness; 13.4% Diarrhea; 11.6% Difficulty breathing; 8.9% Stuffy nose; 8.9% Other.	20.5% Diabetes; 82.1% Hypertension; 55.4% Coronary heart disease; 35.7% Heart failure.	NR	9.84 (0.56)	NR	NR	NR	17
Dey (20)	NR	NR	NR	NR	NR	NR	NR	NR	NR	1696
	NR	NR	NR	NR	NR	NR	NR	NR	NR	69
	NR	NR	NR	NR	NR	NR	NR	NR	NR	5
Ruan (74)	Residents of Wuhan	NR	NR	NR	NR	NR	NR	NR	18.42 (2.27)	
Young (75)	100% History of travel to Wuhan; 5.6 %Huanan seafood market; 17% Contact with healthcare facility in China; 50% Contact with known case of COVID-19	33% abnormal chest radiograph finding or lung crepitations; bilateral diffuse airspace opacities; 67% no pulmonary opacities.	72% Fever; 83% Cough; 6% Diarrhea; 12.5% Rhinorrhea; %61 Sore throat; 11% Shortness of breath.	NR	NR	2.39 (0.61)	9 (3)	14.75 (1.22)	NR	0
Chen (76)	History of travel to Wuhan	CT: Multiple patchy ground glass opacities in bilateral subpleural areas.	Fever; Sore throat; Cough; Chest distress.	NR	NR	7 (0.0)	NR	23 (0.0)	NR	NR
Cheng (77)	33.4% History of travel to mainland China; 4.8% Wet or seafood market; 66.7% Familial transmission.	NR	NR	NR	NR	NR	NR	NR	NR	1

Qiu (78)	Arrived from Wuhan; Familial transmission.	NR	75% Fever; 37.5% Cough; 12.5% Nasal congestion; 25% Rhinorrhea; 25% Sneezing; 12.5% Sore throat; 12.5% Tears; 12.5% Diarrhea; 12.5% Chills; 12.5% Headache; 12.5% Pharyngeal discomfort; 12.5% Rapid heartbeat.	NR	9.34 (0.49)	1.75 (0.45)	NR	NR	NR	NR
Rothe (79)	Close contact in workplace	NR	Fever; Sore throat, Myalgia, Chills	NR	4.5 (0.65)	2.75 (0.48)	NR	NR	NR	NR
Spiteri (80)	40% Arrived from China; 60% Infected in Europe.	NR	6.4% Asymptomatic; 64.5% Fever; 45.2% Cough; 25.8% Weakness; 16.3% Headaches; 6.4% Sore throat; 6.4% Rhinorrhea; 6.4% Shortness of breath.	NR	NR	3.7 (0.46)	NR	NR	NR	4
Wang (81)	NR	CT: Multiple ground glass Shadow	Intermittent fever, Intermittent cough, Chest tightness, Shortness of breath, Muscle pain	in one patient: coronary heart disease	NR	14.5 (1.5)	NR	NR	NR	NR
Wang (82)	72.2% history of visiting Wuhan; Familial transmission.	CT: Ground glass opacities with consolidations	94.4% Fever; 55.6% Cough; 22.2% Shortness of breath; 5.6% Hemoptysis; 11.1% Muscle pain; 5.6% Headache; 5.6% Sore throat; 16.7% Diarrhea; 5.6% Nausea and vomiting.	16.7% Cardiovascular disease; 27.8% Hypertension; 16.7% Diabetes; 11.1% Stroke; 5.6% Malignant tumor.	NR	7.75 (0.77)	NR	NR	NR	NR

Wu (83)	Close contact in a department store	NR	95.0% Fever; 35.0% Cough; 27.5% Fatigue; 25.0% Muscle soreness; 15% Diarrhea; 12.5% Rhinorrhea; 10% Nasal congestion; 7.5% Headache; Sneezing, Sputum; Nausea; Abdominal pain; 5% Dry mouth; Pharyngeal discomfort; Chest tightness; Asthma; Dizziness; Vomiting.	NR	7.25 (0.72)	NR	NR	NR	NR	2
Yang (84)	79% Family transmission; 10% Meals; 6% In a mall or supermarket; 3% Cases of work; 2% Cases of transportation	NR	NR	NR	8.75 (0.26)	NR	NR	NR	NR	NR
Lauer (27)	46.4% Resident of Hubei province; 42.5% History of travel to Wuhan; 11.0% Unknown.	NR	NR	NR	5.15 (0.33)	NR	NR	NR	NR	NR
	NR	NR	NR	NR	5.7 (0.66)	NR	NR	NR	NR	NR
Tong (85)	Close contact with a visitor from Wuhan; Familial transmission.	NR	Fever, Cough, Skin tingling, Myalgia.	NR	NR	4 (2.0)	NR	NR	NR	NR
Arashiro (86)	Close contact	Not clinically significant	Throat dryness and soreness; Throat redness; A slight cough; Fever.	NR	NR	4.0 (0.99)	NR	22.5 (0.5)	NR	NR
Liu (87)	43% Close contact; 51% Arrived from Hubei province; 6% Unknown.	NR	NR	NR	6.0 (0.70)	3.89 (0.11)	NR	NR	NR	NR

[a] Mean (se) day unless specified otherwise; [b] Time refers to time from onset of symptoms