

# Coronavirus disease 2019: a bibliometric analysis and review

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**Abstract. – OBJECTIVE:** On December 8, 2019, many cases of pneumonia with unknown etiology were first reported in Wuhan, China, subsequently identified as a novel coronavirus infection aroused worldwide concern. As the outbreak is ongoing, more and more researchers focused interest on the COVID-19. Therefore, we retrospectively analyzed the publications about COVID-19 to summarize the research hotspots and make a review, to provide reference for researchers in the world.

**MATERIALS AND METHODS:** We conducted a search in PubMed using the keywords “COVID-19” from inception to March 1, 2020. Identified and analyzed the data included title, corresponding author, language, publication time, publication type, research focus.

**RESULTS:** 183 publications published from 2020 January 14 to 2020 February 29 were included in the study. The first corresponding authors of the publications were from 20 different countries. Among them, 78 (42.6%) from the hospital, 64 (35%) from the university and 39 (21.3%) from the research institution. All the publications were published in 80 different journals. *Journal of Medical Virology* published most of them (n=25). 60 (32.8%) were original research, 29 (15.8%) were review, 20 (10.9%) were short communications. 68 (37.2%) epidemiology, 49 (26.8%) virology and 26 (14.2%) clinical features.

**CONCLUSIONS:** According to our review, China has provided a large number of research data for various research fields, during the outbreak of COVID-19. Most of the findings play an important role in preventing and controlling the epidemic around the world. With research on the COVID-19 still booming, new vaccine and effective medicine for COVID-19 will be expected to come out in the near future with the joint efforts of researchers worldwide.

## Key Words:

Corona virus disease 2019, COVID-19, Novel coronavirus pneumonia, NCP, Review.

## Introduction

The corona virus which was known as SARS-CoV-2 and caused a serious respiratory disease, named as COVID-19 infection<sup>1,2</sup>, had been in-

fecting by more than 101927 people around the world and being spread in 94 countries by March 07, 2020<sup>3</sup>. The continuing outbreak of COVID-19 had raised serious concerns of more and more researchers. At least 54 papers written in English on COVID-19 had been published in journals by Jan 30, 2020 as reported by *Nature*, which had gained the attention of *Scientific Citation Index (SCI)*<sup>4</sup>. Therefore, Ministry of Science and Technology of the People’s Republic of China encouraged researchers to focus on epidemic prevention and paper publication in mainland China. Using the terms of “2019-nCoV” and “COVID-19”, we searched the electronic databases of PubMed and found that 183 publications from 20 different countries including 164 publications in English and 19 in Chinese had been published by March 1, 2020. Urgent questions that need to be addressed promptly include what have these publications studied, what were the research focuses of these publications, where did these publications come from, where had these publications been published, what were the types of the publications, who had written these publications and the publishing time of these publications. To answer these questions, summarize the research hotspots and review, we had implemented a retrospective analysis of the publications on COVID-19, in this manner to provide a reference to the researches all around the world.

## Materials and Methods

### Searching Strategy

Two investigators had carried out independent search in the electronic databases of PubMed using the following keywords and Boolean operators: (((((((((pneumonia) OR 2019-nCoV) OR COVID-19) OR Corona Virus Disease 2019) OR Novel Coronavirus Pneumonia) OR NCP) OR 2019 novel coronavirus) OR SARS-CoV-2) OR 2019 Novel Coronavirus Diseases OR novel coronavirus) AND Wuhan in all

fields. The time frame for publication searching was set from inception to March 1, 2020 with no limitations on languages or document types and results were listed in descending order according to their publication time in the PubMed databases. Double-extraction method was used, with which two reviewers had extracted data and evaluated the study eligibility independently. The title and abstract for acceptable papers were screened respectively and in the case that the title and abstract hit the inclusion criteria, full publication will be included for retrieving and evaluation. The study contains the researches on COVID-19 and those which include COVID-19 in their main part. However, publications on pneumonia not related to COVID-19 or focusing on other types of coronavirus were excluded. Document retrieval was completed within March 1, 2020, thus to avoid any biases occurred due to possible daily updates in the database. In addition, all disagreements were settled through discussions under the verification of third-party reviewer.

#### **Data Extraction**

All eligible document data on COVID-19 were extracted in the format of Microsoft Excel 2019 by two reviewers independently. Data were extracted directly from the entire text of the publications, including title, corresponding author, author affiliation, author nationality, the city of author, language, publication time, publication type, research focus, content of research, journal title, journal impact factor and quartile in category. For each publication, the information of the first corresponding author will be used for the record of corresponding author, author affiliation, author nationality and the city of author. In addition, the publication time was defined as the time when the publication is first available online and the publication type was defined as original research, review, short communication, case report, guideline, consensus and other type based on searching results and subsequent check. Journal impact factors were queried from 2018 *Incites Journal Citation Reports*.

## **Results**

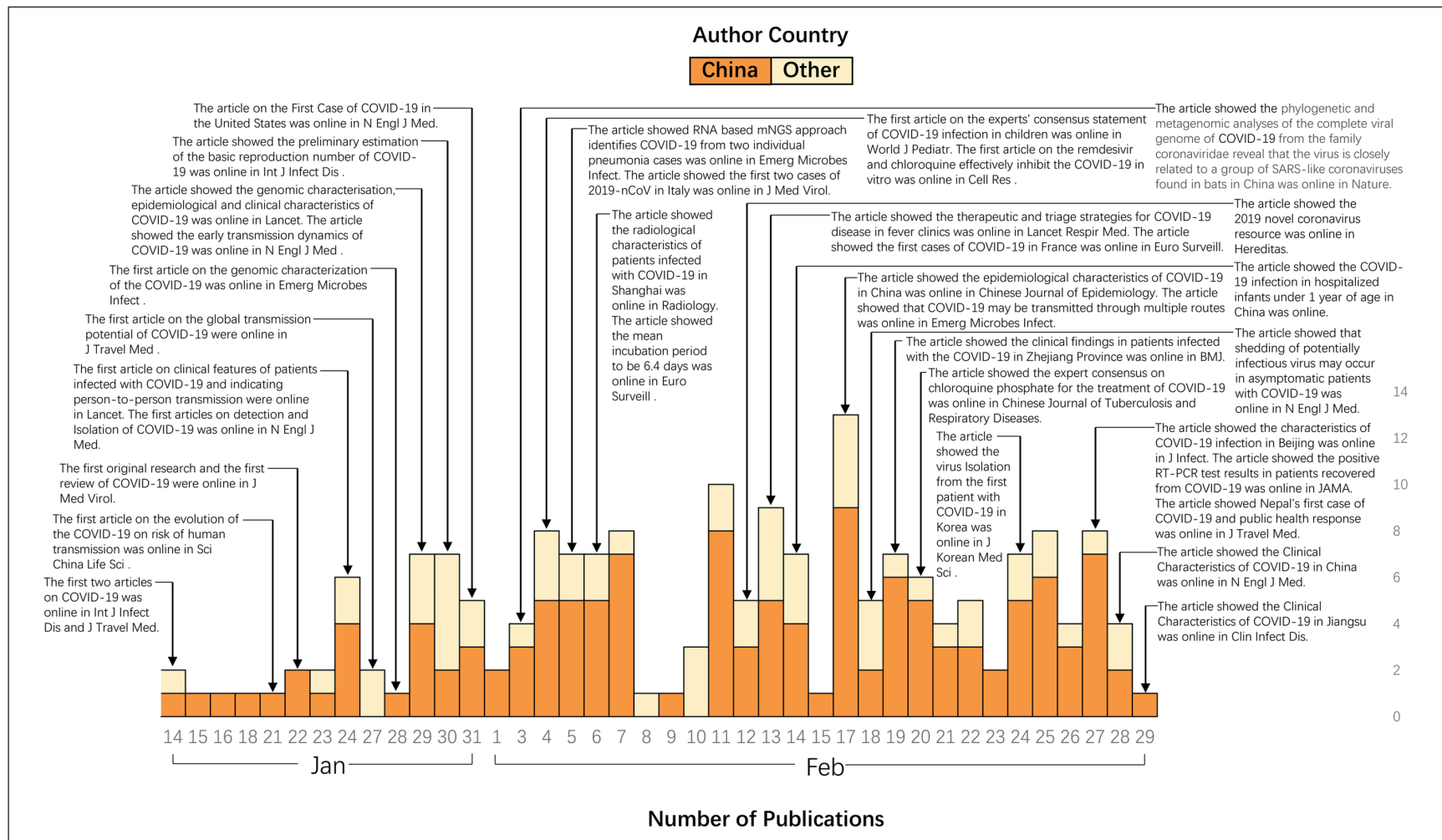
#### **Characteristics of Publications**

As the result, 511 publications in total were retrieved from PubMed in the first round of

search and 220 publications were identified after reviewing the study titles and abstracts. Eligibility was assessed for these 220 publications throughout the entire text and 183 were enrolled after removing duplicates and irrelevant records. All publications with inclusion criteria were published online from January 14, 2020 to February 29, 2020 (Figure 1). The first corresponding authors of the 183 publications were from 20 different countries (Figure 2); most of them were from China (123, 67.2%) with 61, 6, 31 and 1 publications published in Q1, Q2, Q3 and Q4 *Journal of Journal Citation Reports (JCR)* respectively and cumulative impact factor of 1383.477; second only to China, the authors from the United States (18, 9.8%) had published 13, 2 and 1 publications in Q1, Q2 and Q3 *Journal of JCR* respectively with cumulative impact factor of 233.808; Japan (5, 2.7%) had published 4 and 1 publications in Q1 and Q4 *Journal of JCR* with cumulative impact factor of 23.756; Among all 185 publications, 96, 15, 40 and 3 publications were published in Q1, Q2, Q3 and Q4 *Journal* respectively with cumulative impact factor 1853.249. For more information, please refer to Table I. In general, 123 publications were published with first corresponding author from China, of which 104 were written in English and 19 were in Chinese. (**Supplementary Table I**).

#### **Corresponding Author Information**

Among all first corresponding authors of the above 183 publications, 78 (42.6%) authors were from the hospitals, Tongji Hospital has the most publications (n=8), which was followed by Zhongnan Hospital of Wuhan University (n=7) and Wuhan Union Hospital (n=6), etc.; 64 (35%) authors were from universities, University of Hong Kong and Fudan University were tied for the first place in terms of publications (n=5), which were followed by Hokkaido University (n=4) and Chinese University of Hong Kong (n=3), etc.; 39 (21.3%) authors were from research institutions, Chinese Center for Disease Control and Prevention has the most publications (n=4), which was followed by Hubei Engineering Research Center of Viral Vector (n=3) and Wuhan Institute of Virology (n=2), etc.; 2 (1.1%) authors' names were still unknown. For the information of hospital, university and research institution with more than one publication, please refer to **Supplementary Table II**.



**Figure 1.** Papers published on important time nodes.

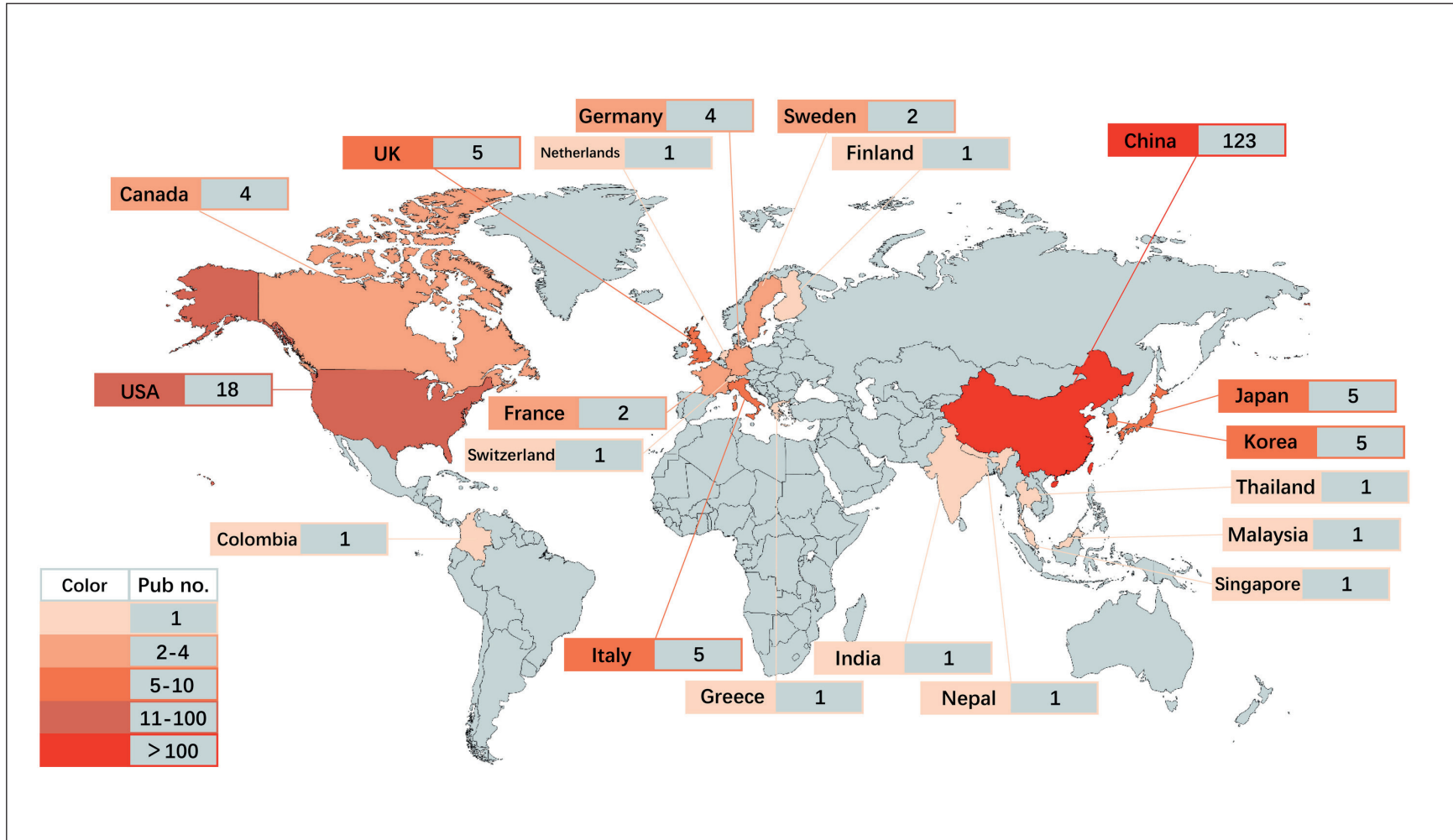


Figure 2. Distribution of publications.

**Table I.** Characteristics of publications.

Author Country	Number of Publications	Language English	Chinese	Quartile in Category				Cumulative Impact Factor
				Q1	Q2	Q3	Q4	
China	123	104	19	61	6	31	1	1383.477
USA	18	18		13	2	1		233.808
Japan	5	5		4			1	23.756
Korea	5	5			3	1		7.197
UK	5	5		3	1			16.989
Italy	5	5			1	4		10.298
Germany	4	4		2	1	1		82.319
Canada	4	4		3			1	37.089
France	2	2		2				11.531
Sweden	2	2		2				8.31
Switzerland	1	1		1				7.421
Netherlands	1	1		1				7.421
Singapore	1	1		1				4.694
Finland	1	1		1				4.379
Nepal	1	1		1				4.155
Thailand	1	1			1			3.405
Greece	1	1				1		2.611
India	1	1		1				2.34
Malaysia	1	1				1		2.049
Colombia	1	1						
<b>Total</b>	<b>183</b>	<b>164</b>	<b>19</b>	<b>96</b>	<b>15</b>	<b>40</b>	<b>3</b>	<b>1853.249</b>

### Journal of Publication

All the above 183 publications were published in 80 journals respectively, *Journal of Medical Virology* has the most publications (n=25), which is followed by *Chinese Journal of Tuberculosis and Respiratory Diseases* (n=9), *Journal of Travel Medicine* (n=8), *Journal of Clinical Medicine* (n=8), *Lancet* (n=7), *Radiology* (n=6), *JAMA* (n=5), *New England Journal of Medicine* (n=5), *Eurosurveillance* (n=5) and *Emerge Microbes Infect* (n=5). For the information of other journals with more than one publication as well as their quartile in category journals in JCR and impact factors, please refer to [Supplementary Table III](#).

### Publication Type and Research Focus

Among all the above 183 publications, 60 (32.8%) publications were original research, 29 (15.8%) were review, 20 (10.9%) were short communications, 15 (8.2%) were commentary, 13 (7.1%) were letters, 11 (6.0%) were case reports, 10 (5.5%) were editorial, 6 (3.3%) were opinion, 5 (2.7%) were guideline and consensus, 5 (2.7%) were correspondence and 3 (1.6%) were perspective, weekly report and brief report/news (Figure 3).

183 publications in total were classified into different research focuses: 68 publications (37.2%) were based on epidemiology, 49 (26.8%) were based on virology, 26 (14.2%) were based on clinical features, 19 (10.4%) were based on diagnosis and treatment, 14 (7.7%) were based on radiography and 7 (3.8%) were based on laboratory examinations (Figure 3). For more details, please refer to [Supplementary Table IV](#).

### Discussion

Scientific research plays an important role in epidemic prevention and control, which deserves to be fully mobilized, deployed and strengthened comprehensively to update our knowledge about the relationship among disease, humanity and history. In addition, scientific and technological methodology and approaches should be the top priority in our constant fighting against viruses and getting us fully prepared for epidemic prevention and control. Many scientific researches have been done for COVID-19 prevention and control, which lay the solid foundation for virus identification, vaccine development, prevention



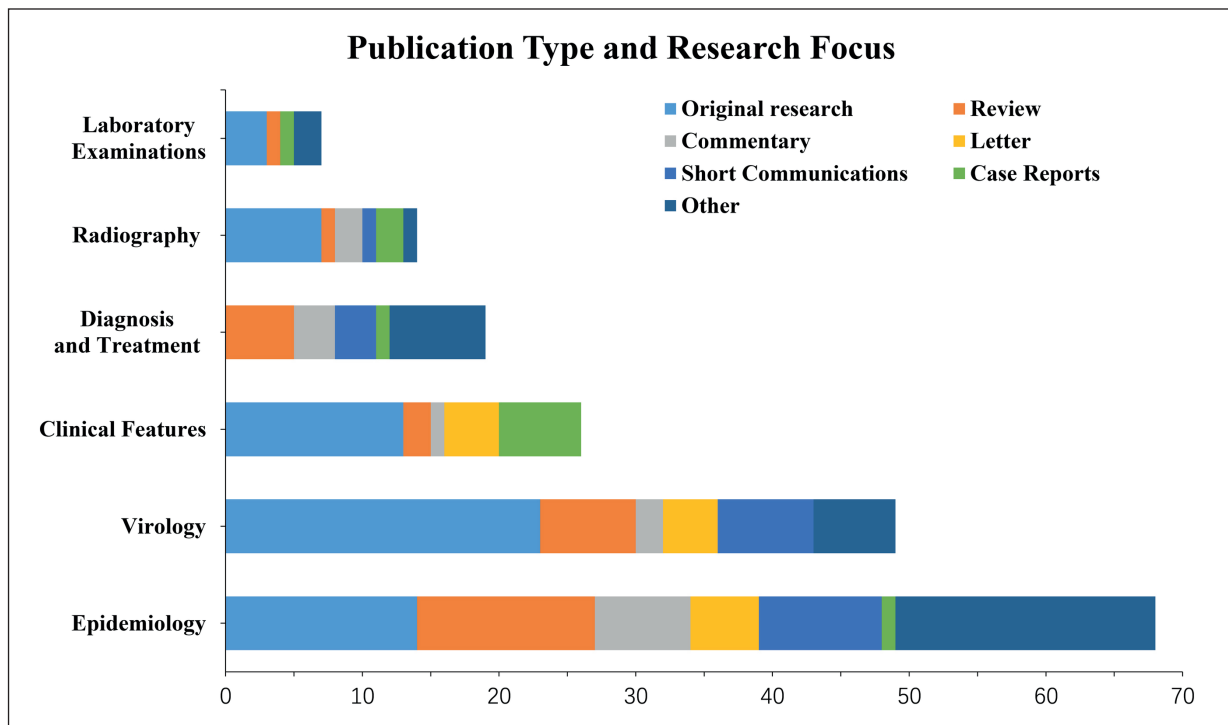


Figure 3. Publication type and Research Focus.

and control measures formulation and R&D of specific drugs. In this regard, this review summarizes the scientific research publications after the epidemic outbreak and aims to provide reference and thinking for the direction of scientific research on COVID-19 in the future.

China has contributed a large number of research data to the fields of research during the outbreak of COVID-19 as per our review. Fighting epidemic in the most seriously infected area, medical staffs in Wuhan not only fulfilled their responsibilities but also provided first-hand and most valuable research data to researchers all over the world. The nature of the epidemic is being gradually portrayed by more and more clinical, epidemiological and Virology publications on COVID-19.

The first publication focusing on the virology of COVID-19 was published in the journal of *Science China-Life Sciences* on Jan 21, 2020<sup>5</sup>. Subsequently, 49 virology-related publications in total were online. Most of the researches were based on original researches (23, 46.9%) and the research contents mainly include structural characteristic, virus detection, isolation of virus strains, receptor recognition, phylogenetic analysis of genetic sequences, potential intermediate animal host,

molecular evolutionary analysis, cross-species transmission analyses, genetic variability and development of vaccine. Early research findings demonstrates that COVID-19 is a novel lineage B betacoronavirus closely related to bat SARS-related coronaviruses<sup>6</sup>. The viral genome (GenBank accession MN908947) has the highest similarity (89%) to a SARS-related member of the Sarbecoviruses (MG772933), a subgenus within the betacoronavirus genus<sup>5</sup>. Phylogenetic analysis shows that COVID-19 belongs to genus betacoronavirus, which includes coronavirus (SARS-CoV, bat SARS-like CoV, etc.) found in human, bat and other wild animals<sup>7</sup>. COVID-19 is closely related to bat-SL-CoVZC45 and bat-SL-CoVZXC21, two bat-derived severe acute respiratory syndrome (SARS) - like coronaviruses collected in Zhoushan, eastern China in 2018 (the identity is 88%)<sup>8</sup>. Seen from the epidemiological and survey results, most of the initial cases of COVID-19 and the disease caused by SARS-CoV-2 are epidemiologically linked to the exposures in Wuhan Huanan Seafood Market where wild animals were traded. In addition, 27 out of 41 patients who were first confirmed were reported to be in contact with the market<sup>1,9</sup>. Although phylogenetic analysis shows that bats may be the original host of the vi-

rus, the animals sold in Wuhan Huanan Seafood Market may represent an intermediate host which promotes the emergence of the virus in human body<sup>6</sup>. However, based on available epidemiological evidence, although most patients experience history exposure to Wuhan Huanan Seafood Market, the virus has not been found in animals sold in the market. Therefore, it is too early to draw the conclusion on the existence of zoonotic transmission in the market<sup>10</sup>. As for virus vaccine development, a study shows that the spike glycoprotein of COVID-19 contains 13 MHC-I and 3 MHC-II epitopes, which makes an ideal candidate for the formulation of multi-epitope peptide vaccine. Though its importance and effectiveness have been verified, a number of *in vitro* and *in vivo* experiments on these epitopes are still needed to be implemented before formulating the COVID-19 vaccine<sup>11</sup>.

The first epidemiological publication on COVID-19 was published by Isaac I. Bogoch et al<sup>12</sup> on January 14 in the journal of *Travel Medicine*. Subsequently, 68 related publications were online, of which only 14 publications were based on original researches. The samples vary their sizes from 3 to 72314 by covering China and more than 10 countries across the world<sup>5,13-17</sup>. The main research contents include epidemic process as well as prevention and control strategies and measures. The epidemic process consists of source of infection, route of transmission, herd susceptibility and influencing factors. See from previous studies, it is found that conventional routes for the transmission of SARS-CoV, MERS-CoV and highly pathogenic influenza including respiratory droplets and direct contact are also available for COVID-19<sup>18,19</sup>. However, early cases have also shown that although COVID-19 may not be as severe as SARS-CoV and MERS-CoV, the sharp increase in terms of cases and increasing evidence of human to human transmission suggest that the virus is more infectious than SARS-CoV and MERS-CoV with  $R_0$  varied from 2.0 to 4.0<sup>1,6,20,21</sup>. Another research shows that virus is detected in anal swabs and blood of patients with COVID-19 infection, in this case, infected patients may spread the pathogen via fecal-oral or humor, which deserves our attention<sup>22</sup>. With the development of the epidemic situation, the emergence of asymptomatic patients has become the focus of research. Without quarantine and medical observation, the asymptomatic patients may not seek medical care or see a doctor, therefore they could not be found in the special period.

Although asymptomatic patients may exist in a small group of people, they can still spread the virus to others in close contact with inadvertently. Therefore, the detection and control of non-pneumonia and asymptomatic cases become more important for the prevention of the transmission of COVID-19<sup>23,24</sup>. To prevent and control this highly infectious disease as soon as possible, in the event of a confirmed case of COVID-19, the rest of family members or people in close contact with the infected should be placed under close observation and tested to rule out the possibility of infection even if they have no symptoms yet<sup>25</sup>.

As for the control strategies and measures, the studies show that the epidemic surveillance, quarantine of the source of infection, traffic control for population movement restriction as well as community prevention and control strengthening are important for epidemic control, they are the scientific basis for the development of epidemic prevention and control strategies<sup>26</sup>. Several important aspects in terms of epidemiology, virology, diagnosis and clinical characteristics were stated and analyzed in some studies, unfortunately the key issues were inconclusive, e.g., the source, the potential for infection, the mode of transmission and in particular, no specific drug or vaccine was developed<sup>27,28</sup>. It is believed that more information about the pathogenesis of the virus has to be learnt and specific vaccines and treatments have to be developed as soon as possible. The only effective measures available for the time being include infection source control, early diagnosis, isolation and supportive care, tracking reports of World Health Organization and comprehensive data sharing. It is necessary to classify and provide guidance to different regions based on the prevalence and characteristics of the virus, thus to develop prevention and control strategies<sup>29</sup>. According to the current situation, the emergency management strategies for COVID-19 consist of blocking transmission, isolation, respiratory and eye protection as well as hand hygiene<sup>30-32</sup>. In response to the epidemic, a lot of public emergency intervention measures have been taken, including the use of susceptible-exposed-infectious-recovered model to estimate the basic reproduction number at the early stage of the epidemic, analysis of the transmission intensity of COVID-19 infection and strengthening of the management of blood donation and transfusion to avoid blood safety crisis<sup>33</sup>. The entrances of residential communities, dormitories and public places are restricted and residents entering the communities

are tested for body temperature and related symptoms. In addition, appropriate restrictions on traffic for COVID-19 infection are applied and online mental health services to relieve people's tensions and resolve possible psychological and health problems etc. are provided<sup>34</sup>.

The first publication reporting clinical features of 41 patients confirmed to be infected with COVID-19 in Wuhan was published in *Lancet* on Jan 24, 2020<sup>1</sup>. After that, 26 publications related to clinical features in total were online. Half of the publications are based on original researches and the publication with the largest sample size of 1099 for COVID-19 infection in China was published online in *New England Journal of Medicine* on Feb. 28, 2020<sup>35</sup>. Subsequently, many publications on clinical features of patients infected with COVID-19 in or outside Wuhan have been published in succession and the clinical features of patients with COVID-19 infection have become increasingly clear. According to the research, people of all ages were susceptible to COVID-19 and there is no statistical proportional difference between men and women. The most common clinical features were fever, cough, fatigue and sputum production. On chest CT, ground-glass opacity and bilateral patchy shadowing were the most common manifestations. On admission, most of the patients had lymphocytopenia, thrombocytopenia, leukopenia and elevated levels of C-reactive protein<sup>24, 35-38</sup>. Few patients with COVID-19 infection had prominent upper respiratory tract signs and symptoms (e.g., rhinorrhoea, sneezing, or sore throat). These non-specific signs and symptoms of mild illness early in the clinical course of COVID-19 infection may be indistinguishable clinically from many other common infectious diseases, particularly during the winter respiratory virus season. However, some other patients with pneumonia may develop rapidly into acute respiratory distress syndrome (ARDS), acute respiratory failure and other serious complications<sup>1,36</sup>.

As for laboratory examinations, the first publication focusing on COVID-19 infection was published online in the journal of *Medical Virology* on Jan 21, 2020<sup>39</sup>. Subsequently, 7 related publications in total were online and most of the researches focus on rapid virus detection. Currently, RNA-based molecular detection requires high-end laboratory facilities with demanding biosafety level and technical complexity, besides, it is costly. Unfortunately, patient screening is distributed in both large medical centers and small

community hospitals; in that case, it is difficult to achieve large-scale screening. In contrast, serological testing can be easily performed in the clinical laboratory of any hospital, therefore it may have a wider application than molecular testing<sup>39</sup>. A study shows that a rapid COVID-19 IgG-IgM combination antibody test using lateral flow immunoassay techniques have been developed. Test result is available in less than 15 minutes, thus to determine whether a recent COVID-19 infection has occurred. It features simplicity, saving of additional equipment as well as high sensitivity and specificity. This rapid detection has great potential for rapid screening of COVID-19 infection and may arouse great interest for wider clinical application after a short-term test in Chinese hospitals<sup>40</sup>. According to the new coronavirus detection guidelines, the design and production of viral nucleic acid detection kit can meet the needs for pathological paraffin sample detection. Using the established fluorescence quantitative PCR system, pathological paraffin samples is available for nucleic acid detection of novel coronavirus<sup>41</sup>.

Chest CT examination plays an important role in the initial diagnosis of COVID-19<sup>42</sup>. A study finds chest CT imaging to be highly sensitive for diagnosis of COVID-19 and even in asymptomatic patients; COVID-19 pneumonia presents anomalies in CT imaging, which have typical imaging features that manifest rapidly development from focal unilateral to diffuse bilateral ground-glass opacification and develop or merge with consolidation within 1-3 weeks; the anomalies may grow into fibrosis in the later stages of the disease<sup>43-46</sup>. Some researches have shown that imaging of patients with COVID-19 infection changes rapidly because the manifestations of COVID-19 pneumonia were diverse<sup>47</sup>. For patients with a positive CT result, a quick nucleic acid test is recommended. In addition, data suggest the potential clinical utilization of PET /CT in the differential diagnosis of complex cases of COVID-19, although pets are generally not recommended for infectious disease testing<sup>48</sup>.

COVID-19 features rapid transmission, atypical clinical symptoms and susceptibility to both lungs, which may lead to missed diagnosis and misdiagnosis and bring difficulty to detection and assessment at early stage. Fever, cough, myalgia, weakness, dyspnea and imaging may be helpful for early detection of COVID-19. At the same time, the rate of disease progression, fever, CT manifestations, hypoxia degree, age, basic diseases and laboratory indicators can also be used



to evaluate the severity of the novel coronavirus pneumonia<sup>49</sup>. Real time RT-PCR is widely used in virological diagnosis. In public health emergencies, a proficient diagnostic laboratory can rely on this powerful technology to establish new diagnostic tests in its daily services before pre-formulated assays become available<sup>50</sup>.

Antiviral drugs commonly used in clinical practice, including neuraminidase inhibitors (oseltamivir, paramivir, zanamivir, etc.), ganciclovir, acyclovir and ribavirin are not effective for COVID-19. Drugs which may be effective for COVID-19 include: remdesivir, lopinavir / ritonavir, lopinavir / ritonavir combined with interferon- $\beta$ , convalescent plasma and monoclonal antibodies. However, the efficacy and safety of these drugs for COVID-19 pneumonia patients need to be assessed by further clinical trials<sup>51</sup>. Another research shows that remdesivir and chloroquine are highly effective in the control of COVID-19 infection. These compounds have been used in human patients with a safety track record and shown to be effective against various ailments, therefore, the next step may be the evaluation to be implemented in patients infected with COVID-19<sup>52</sup>.

## Conclusions

Virology, epidemiology, clinical features, laboratory examination, radiography, diagnosis and treatment are the research hotspots of COVID-19; these research findings play an important role in the prevention and control of the epidemic spreading all around the world. With research on COVID-19 still booming, new vaccine and effective medicine for COVID-19 can be anticipated in the near future.

## Conflict of Interests

The Authors declare that they have no conflict of interests.

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