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Comprehensive epidemiological study on COVID-19: Characteristics, diagnosis, and therapeutic approaches

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Abstract

COVID-19 is an infection initiated by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that was first reported in late December 2019 in Wuhan, China. Pneumonia caused by COVID-19 is highly contagious; the World Health Organization (WHO) declared this disease a global public health emergency due to the current outbreak. Even though the virus of COVID-19 has a resemblance to MERS-CoV and SARS-CoV, the infection is somewhat different. The first signs and symptoms of COVID-19 are not specific. It has a broad spectrum of clinical signs that remain to be determined. Various testing protocols have been published by the WHO for testing COVID-19. Person-to-person transmission is considered the primary route for the spreading of disease. Several efforts have been started all around the world to develop vaccines against the COVID-19 virus. Currently, various drugs and different diagnostic kits are being used to test for the COVID-19 infection. Based on earlier pieces of evidence, we systematically discuss the epidemiological study of SARS-CoV-2 with characteristics, symptoms, diagnosis and vaccine development, and preventive measures of the COVID-19 epidemic.

Introduction

A series of unexplained mysterious pneumonia illness was firstly reported in December 2019 in Hubei province Wuhan, China, which originated the concern of the proficient health department. On December 31, the Disease Control and Prevention Center (CDC) of China directed a swift response group to Wuhan. The viral infection may have spread through Wuhan, Hubei province's China seafood market, which was later closed by the local government on January 1. Simultaneously, an active search of the current case and crisis monitoring was required. The Chinese government informed the WHO about the prevailing situation on January 3 [1-4]. The main cause of infection was identified on January 7, 2020, named as a new coronavirus (2019-nCoV). After that, the genome of the concerned virus was sequenced, and a detection method was developed [5, 6]. The virus may originate naturally from an animal [7, 8]. The WHO named the infection initiated by SARS-CoV-2 as COVID-19. Even though the virus of COVID-19 has a resemblance to MERS-CoV and SARS-CoV, the disease is rather different [9]. Until 28th March 2020, the mortality rate per number of diagnosed cases was 4.6%, extending between 0.2-15% according to different age groups as well as other health problems.

History of coronaviruses

Coronaviruses represent a large family of viruses that are responsible for infections like cold to severe diseases like severe acute respiratory syndrome (SARS) and Middle East Respiratory Syndrome (MERS). They belong to the subfamily Orthocoronavirinae of the family Coronaviridae, order Nidovirales, and realm Riboviria. Most of the known coronaviruses are present in animals and do not infect humans [10]. They have enveloped viruses with positive-sense RNA that range in size from 40nm to 60nm in diameter. They are called coronaviruses due to the presence of spikes like projections on their surface that give them a crown-like appearance under an electron microscope [11]. OC43, NL63, HKU1, and 229E are commonly found coronaviruses in humans and cause mild respiratory infections. In 2002-2003, a new coronavirus of β genera originated in bats and transferred to humans through an intermediate host palm civet cats in China, known as severe acute respiratory syndrome coronavirus (SARS-CoV). That virus affected 8422 people with 916 deaths (mortality rate 11%), mostly in China [12]. In 2012, a new coronavirus known as Middle East respiratory syndrome coronavirus (MERS-CoV) originated from bats and crossed over to humans via an intermediate host, a dromedary camel in Saudi Arabia. This virus affected 2494 people, including 858 deaths (fatality rate 34%) [13]. COVID-19 is designated as third known zoonotic coronavirus disease after MERS and SARS [14]. The genetic material sequencing of SARS-CoV-2 confirmed its greater than 80% similarity with SARS-CoV as well as 50% identity with MERS-CoV [15]. Evidence showed that COVID-19 is a new bat-origin beta coronavirus, which showed high degree homology to the ACE2 receptor of various animal species, hence indicating animal species as probable animal models or intermediate hosts for SARS-CoV-2 infections [16].

Epidemiology of COVID-19

On December 31, the Disease Control and Prevention Center of China directed a swift response group to Wuhan. Possible causes were omitted one by one, including SARS-CoV, influenza, adenovirus, avian influenza, and MERS-CoV. The epidemiological enquiry, as shown in **Fig. 1**, indicates Coronaviruses **(**SARS-CoV-2) may emerge from primary host bats, which cause human infections after circulation. On January 20, the new coronavirus pneumonia was added into the management of infectious diseases of class B by the consent of the State Council, the National Health and Health Commission. After that, on January 23, the Epidemic Prevention and Control Headquarters of Wuhan city publicized that the city's subway, urban bus, and long-distance passenger transport operations were stopped temporarily. At the same time, the airport and train station networks were provisionally locked from Wuhan [17]. On 26th January 2020, there were 2033 confirmed cases of COVID-19 in China with 56 deaths [18]. At the same time, 90 other cases have been reported in other countries like Thailand, Malaysia, Sri Lanka, Japan, Korea, United States, Germany, India, Australia, France, UAE, Nepal, Taiwan, Vietnam, Cambodia, Singapore, Philippines, and Finland. At that time, a 2.2% case fatality rate was calculated [19]. The government of China put its maximum efforts and tried its best to stop the prevailing epidemic conditions. The formation and implementation of efficient control strategies were a critical issue due to the epidemiological characteristics of the COVID-19 transmission. On February 11, 2020, the analysis, as

well as the epidemiological characterization of all the patients of COVID-19, were performed [17]. Pneumonia that is caused by COVID-19 is a highly contagious disease; the WHO declared this disease a global public health emergency due to its current outbreak [6]. Even though the virus of COVID-19 has a resemblance to MERS-CoV and SARS-CoV, the disease is rather different [9]. It was concluded from some new cases that COVID-19 is less severe compared to MERS-CoV and SARS-CoV. But after that, the rapidly increasing number of cases as well as its mode of transmission from human-to-human indicated that the virus of COVID-19 is more infectious than MERS-CoV and SARS-CoV [20, 21]. According to WHO, on February 16, 2020, there were 51,174 confirmed patients in China, including 15, 384 severe patients and 1,666 death cases. Worldwide, there were 51,857 confirmed cases reported in 25 countries [22].

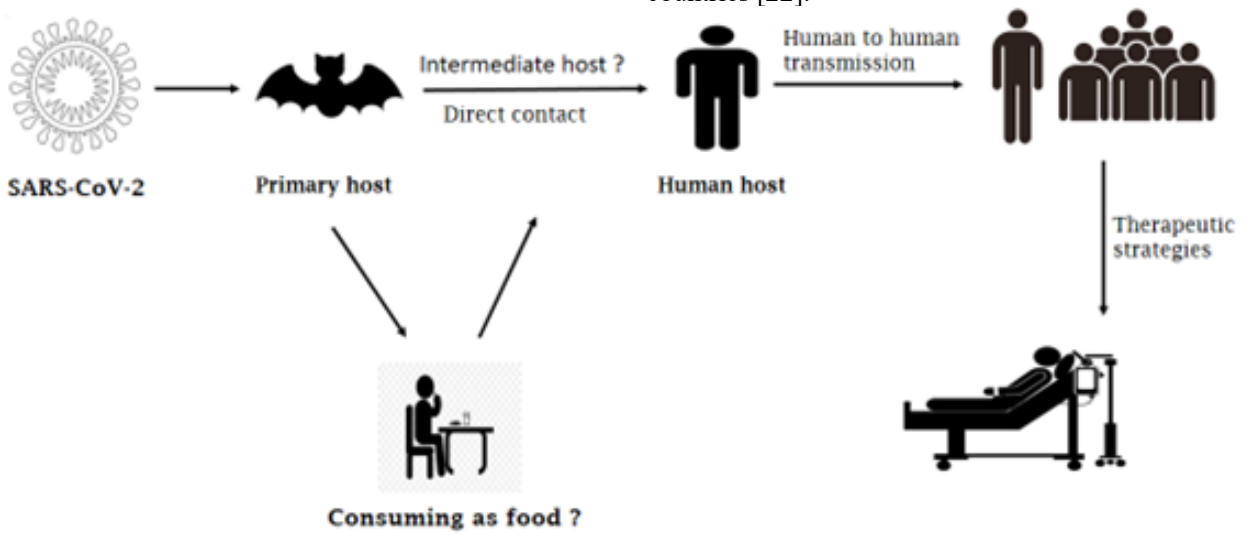

Fig. 1: Coronaviruses (SARS-CoV-2) emerging from primary host bats, which cause human infections after circulation, and COVID-19 may represent humans as an intermediate host.

Signs and symptoms

The basic signs and symptoms of COVID-19 are not specific. It has a large spectrum of clinical signs that remain to be determined [9, 23]. After getting a virus infection, generally, the symptoms enlisted in Fig. 2 appear between two to fourteen days, usually after five days of exposure [24, 25]. It depends upon the age of the infected patient as well as the status of the patient's immune system. Patients under 70 years old take less time to show symptoms as compared to young people [26]. It must be said that COVID-19 and earlier beta coronavirus have many similar symptoms like fever, dyspnea, dry cough, and bilateral ground-glass opacities [27]. Fever, shortness of breath, and cough are normal symptoms of COVID-19 infection [24]. Loss of smell, diarrhoea, muscle pain, sore throat, as well as sputum production, and abdominal pain are some more symptoms regarding COVID-19 [28]. In most cases, patients showed mild symptoms that may develop into pneumonia and failure of different vital organs [4, 29]. The most common signs and symptoms of COVID-19 include fever (85-90%), cough (65-70%), fatigue (35-40%), sputum production (30-35%), and shortness of breath (15-20%). The minor symptoms include myalgia/arthralgia (10-15%), headaches (10-15%), sore throat (10-15%), chills (10-12%), and pleuritic pain. The rarest symptoms are vomiting, nausea, nasal congestion (<10%), diarrhoea (<5%) [30], chest tightness, and palpitations [31].

Pathogenesis

Patients who are infected with coronavirus 2019 have several leukocytes, increased levels of plasma pro-inflammatory cytokines, and unusual respiratory outcomes. According to a COVID-19 infected patient report, after five days of fever, the patient showed a body temperature of 39.0°C, a cough, and stiff breathing sound in both lungs [32]. The infected patients showed leucopenia with leukocytes count 2.91 × 10^9 cells/L, from which 70% of leukocytes consists of neutrophils. At the same time, an abnormally elevated level (16.16mg/L) of C-reactive protein was also observed in infected patients of

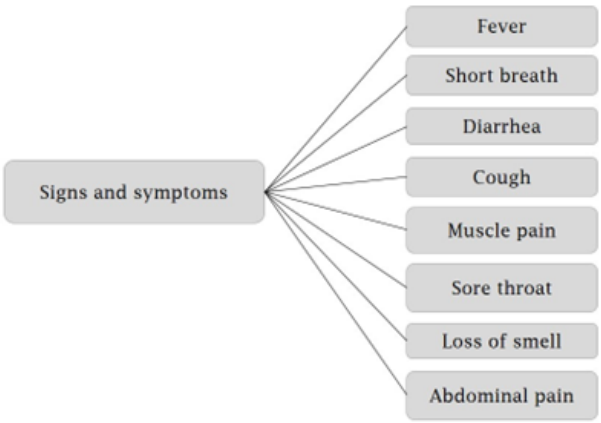

Fig. 2: The symptoms appear between two to fourteen days after getting a virus infection. Fever, shortness of breath, diarrhea, cough, muscle pain, sore throat, loss of smell, and abdominal pain are basic symptoms of COVID-19.

COVID-19. Elevated erythrocyte sedimentation ratio and D-dimer were also measured [32]. The radiological imaging results of COVID-19 pneumonia patients have indicated the prominent damage of pulmonary parenchyma as well as extensive consolidation and interstitial inflammation, which was already reported in patients infected with coronavirus [20, 33-35]. The chest CT scan showed some unusual features like acute respiratory distress syndrome, RNAaemia, acute cardiac injury, and incidence of grand glass opacities that may cause death [27].

Some of the patients who were infected with COVID-19 have not shown any respiratory distress or hypoxemia throughout recovery. Unilateral or ground-glass opacities (GGO) in the lower lobes and small subpleural are the initial stages of pneumonia caused by coronavirus 2019, which then progresses into the crazy-paving pattern and consequent consolidation. Later, for up to two weeks, the lesions were slowly immersed with residual GGO and subpleural parenchymal bands [36]. Lymphopenia is one of the most critical elements present in all people infected with COVID-19. It is considered to be closely associated with the severity of infection and mortality [37]. The COVID-19 infected patients showed significantly increased blood levels of chemokines and cytokines that included IL10, IL9, IL8, IL17, IL1-β, IL1RA, basic FGF2, GMCSF, GCSF, IP10, IFNγ, MCP1, MIP1α, MIP1β, TNFα, VEGFA, and PDGFB. Some patients in severe disease conditions showed increased levels of pro-inflammatory cytokines, including TNFα, MIP1α, MCP1, IP10, GCSF, IL2, IL7, and IL10, which are responsible for the severe condition of disease [20].

Diagnosis

Fast and precise recognition of COVID-19 is essential to stop epidemics in the community as well as hospitals [38]. Different testing protocols have been published by the WHO for testing COVID-19 [39]. The reverse transcription-polymerase chain reaction (RT-PCR) is considered the most significant method for diagnosis. In this respiratory test, samples are used that have been collected by using a nasopharyngeal swab; however, a sputum sample or nasal swab can also be used in RT-PCR [40]. Reverse transcription loop-mediated isothermal amplification (RT-LAMP) is another diagnostic test for COVID-19. The RT-LAMP and rRT-PCR have equal sensitivity and are very specific, used to diagnose MERS-CoV [41]. The RT-PCR takes several days (2-8 days) to give positive results [42]. Automated solutions can be used for the molecular diagnostics of a large number of samples and can compete with fluctuating demand [43].

Appearing of different symptoms, risk factors, as well as CT scan of the chest which display features of pneumonia, can also be used to diagnose COVID-19 [44-46]. As of March 2020, the American College of Radiology recommends that "CT should not be used to screen for or as a first-line test to diagnose COVID-19" [47]. There are some common gastrointestinal symptoms such as diarrhoea between COVID-19, SARS-CoV, and MERS-CoV. So, some urine and fecal sample tests are required to eradicate a possible alternative way of transmission, especially through patients and health care workers, etc. [48, 49].

Routes of transmission

Person-to-person transmission is considered the basic route for the spreading of the coronavirus 2019 infection [50]. The most important way by which the virus spreads is through close contact and through respiratory droplets that are produced when an infected patient sneezes or coughs [40]. The respiratory droplets can also be formed through breathing, but the virus is not typically airborne. COVID-19 can also be transmitted if a healthy person directly touches the contaminated surface and, after that, touched their face. It is considered as most contagious when symptoms appear; however, the infected person may become the source of spread to other people before the symptoms appear [51]. The research indicated the presence of the virus in faeces, so it can also be transmitted through faeces [52, 53].

The coronavirus 2019 can live on any external surface up to 72 hrs. [25]. According to a study that accompanied pregnant women during their third trimester who are confirmed patients of COVID-19, there was no indication of the transmission of infection from mother to child [6]. First of all, the spike protein present on the surface of the virus attached to the host receptor and resulted in the fusion of viral and host membranes. The binding of the virus spike caused the person-to-person transmission of SARS-CoV-2 with host angiotensin-converting enzyme 2 (ACE2) cellular receptor [16, 54]. A study showed that the sequence of the receptor-binding domain of COVID-19 spikes is similar to SARS-CoV. It significantly suggested that both viruses have the same mechanism to enter into the host cells, as shown in **Fig. 3** [16].

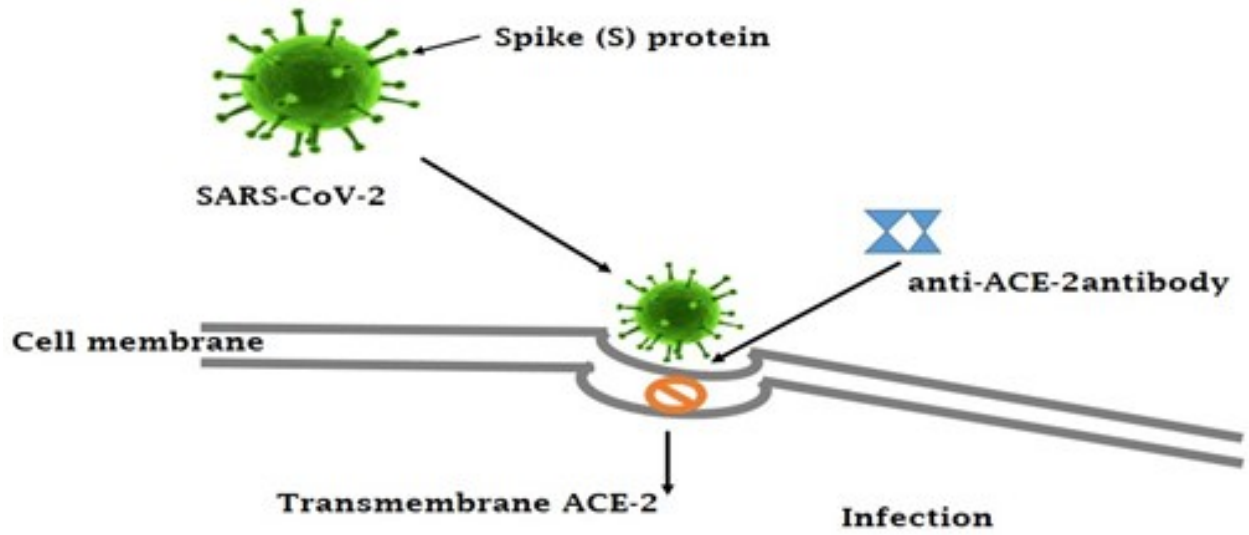

Fig. 3: The person-to-person transmission of SARS-CoV-2 occurs by the binding of virus spike (S-protein) with host angiotensin-converting enzyme 2 (ACE2) cellular receptor. A study showed that the sequence of the receptor-binding domain of COVID-19 spikes is similar to SARS.

Disease progression in Pakistan

After China, Iran reported a large number of cases of COVID-19 in Asia. Every year, a large number of people visit Iran from Pakistan for religious and cultural devotions. Pakistan closed its border with Iran on February 23, 2020, after COVID-19 epidemic conditions [55], but hundreds of Pakistanis came back through different means. On 26th February, the government of Pakistan reported the first two cases of COVID-19, one from Islamabad and the other from Karachi. Both of the patients have recently come from Iran. After that, two more cases were reported on February 29, 2020. On 9th March 2020, there were 16 confirmed patients of coronavirus 2019 in Pakistan, of which 13 patients were from Sindh. On 13th March, a new confirmed patient of COVID-19 was reported in Sindh who had no travel history. It was the first case of locally transmitted COVID-19. By 26th March 2020, there were 1179 confirmed patients of COVID-19 with nine deaths in Pakistan [55]. On May 18, 2020, there are 42125 confirmed cases of COVID-19, 903 deaths, and 11922 recoveries.

Treatment

Several reports have reported that the COVID-19 infection route is likely to be person-to-person transmission [56]. Currently, there is no evidence of specific treatment that is prescribed for patients with confirmed or suspected COVID-19 infection. Self-management is the best supportive care for any respiratory disease. Recently, there have been no specific vaccines or antiviral drugs for the control of SARS-CoV-2 in clinical practice; only symptomatic treatment strategies are recommended [44].

Antiviral agents

Currently, no vaccine or drug has been approved for the treatment of COVID-19. Some of the antiviral medicines, such as lopinavir/ritonavir and ribavirin, were applied during past experiences of the SARS and MERS outbreaks. In the past, ribavirin with lopinavir

(LPV) had better results as compared to the single use of ribavirin [57].

Lopinavir/ritonavir

Lopinavir (LPV) is a specific antiviral drug called Kaletra (market name) that inhibits the protease activity of the coronavirus in the *in vivo* and *in vitro* trails. An early study of 1052 SARS-CoV-2 patients showed that the use of lopinavir/ritonavir as an early treatment was associated with a decreased mortality rate from 11.3% to 2.3% [58]. Lopinavir (protease inhibitor) is an effective treatment for the SARS as well as MERS outbreaks, representing it is a probable treatment option for COVID-19 infestation [59].

Ribavirin

Ribavirin is a compound that has antiviral properties used to treat different viral diseases such as hepatitis C virus, hemorrhagic fever, and other syncytial viruses. Ribavirin was widely used in combination with steroids for the treatment of patients during the SARS outbreak in Hong Kong [60]. The ribavirin, as well as IFN, inhibit synergistically invitro SARS linked CoV replication [61]. The *Rhesus macaque* model represents promising results of ribavirin to treat MERS-CoV [62]. Besides, the SARS-CoV-2 RdRp model confirmed after sequence analysis, docking, and modelling that targeted ribavirin is responsible for the antiviral property against SARS-CoV-2 [63]. In clinical trials, the proper dosage of ribavirin should be used to overcome adverse effects.

Remdesivir

Remdesivir is an antiviral compound that is widely used for the treatment of the Ebola virus disease [64]. The remdesivir showed a wide range of antiviral activities against several RNA viruses, and it might participate in the RdRp model [65]. *In vitro* study, remdesivir and IFNb have a great potential antiviral activity like LPV and ritonavir [66] and remdesivir also showed antiviral activity against SARS-CoV-2 [67]. An *in vivo* study (mouse model) of SARS-CoV pathogenesis revealed that both therapeutic and prophylactic remdesivir improved pulmonary functions and reduced viral infections and severe lung pathology [68]. In the United States of America, the first COVID-19 patient was treated with remdesivir [69]. The overall results indicated that remdesivir showed more antiviral potential as compared to LPV/ritonavir-IFNb [70].

Nelfinavir

Nelfinavir is a specific HIV protease inhibitor, which represents a possible therapeutic for COVID-19 by the inhibition of SARS-CoV [71].

Arbidol

Arbidol is an antiviral compound that blocks the viral fusion of influenza viruses. It has been reported that arbidol, as well as its derivative named arbidolmesylate, have activity against SARS-CoV *in vitro* [72], and recommended for clinical trials [73].

Chloroquine

Chloroquine is an inexpensive and broad-spectrum antiviral agent, a nontoxic drug having biochemical properties to treat malaria by the inhibition of endosomal acidification, which is compulsory for viral-host cell fusion [74, 75]. Previous literature showed that Chloroquine has antiviral activity *in vitro* against Ebola, HIV, Hendra, Nipah, SARS, and MARS viruses [74, 76]. Chloroquine interfering with the ACE2 receptor that is an inhibitor of SARS-CoV infection [71] and glycosylation for the cellular receptor of SARS [77]. The *in vitro* studies revealed that Chloroquine is responsible for inhibiting SRAS-CoV [67] and control viral replication for clinical patients [73]. In China, COVID-19 patients were treated with Chloroquine and safe antiviral drugs against SARS-CoV-2 infection [78]. Based on these findings, experts advised that Chloroquine is a safe drug to use against SARS-CoV-2 infection (**Table 1**).

Table 1: List of antiviral agents used for COVID-19 treatment

Candidate	Market name	*EC50* COVID-19
Lopinavir (T-705)	Kaletra	61.88 µM [67]
Ribavirin	Virazole	109 µM [67]
Remdesivir (GS-5734)	Gilead	0.77 µM [67]
Nelfinavir	Viracept	---
Arbidol	Umifenovir	----
Chloroquine	Aralen	1.13 µM [67]

Corticosteroids

Corticosteroids were adequate for COVID-19 patients because they played a significant role in the suppression of lung inflammation [20]. Methylprednisolone dose depends upon the severity of the infectious disease, and after SARS-CoV-2 infection, corticosteroids were less administered [84]. Corticosteroids were used for the treatment of diabetes, avascular necrosis, and psychosis and the

management of SARS [85, 86]. COVID-19 patients did not extensively use corticosteroids because it may be harmful [87].

Antibodies

Receptor-binding-domain (RBD) in SARS-CoV-2 and SARS-CoV cross-reactivity was assessed by anti-SARS-CoV antibodies with the spike of COVID-19 protein. Therapeutic antibodies against the COVID-19 vaccine development are a necessary implication. Therefore, SARS-CoV- specific antibody CR3022 (Human monoclonal antibody) binds potently with COVID-19 RBD [88]. CR3022 used as a single dose and combinations with neutralizing antibody (NA) and specific antibodies against the Ebola virus is Mab114 and REGN-EB3; they reduce the mortality rate against Ebola virus infection [64]. Mab114 and REGN-EB3 are monoclonal antibodies having a single epitope for the treatment of COVID-19 patients. In clinical practice, it is not easy to apply a monoclonal antibody for the treatment of new pathogenic infections.

Convalescent plasma transfusion

Recently, after the COVID-19 outbreak, convalescent plasma has been extensively recommended [89]. Convalescent plasma was the safest and effective method for COVID-19 patients. Hence, convalescent plasma should be collected to ensure a high level of neutralizing antibody titter.

Traditional Chinese medicines and others

Chinese conventional drugs were the safest and effective against SARS-CoV-2 infection because it has the potential of anti-SARS-CoV-2 activity [90]. For the COVID-19 outbreak, ACE2 is the binding receptor of viral SARS-CoV-2 infection. Renin-angiotensin system (RAS) inhibitors, ACEI, and AT1R have prospective therapeutic effects. Systemic inflammatory drug IVIG has a therapeutic role for COVID-19 [91, 92].

Current status of COVID-19 vaccines

Vaccine development is a cost-effective, time-consuming, lengthy process that reduces mortality and morbidity [93]. The therapeutic and preventive vaccine will be an essential way to protect health issues globally [94, 95]. Since 2013, after the pandemic (Ebola virus) outbreak, no vaccine was available, and three years later, phase I trials of the rVSV (Ebola vaccine) vaccine were selected for clinical patients for its immunogenicity and safety in Europe and Africa [96]. The structural spikes of the S protein of coronavirus are a vital target; it binds host cells [97] and rapid development for the ongoing public health crisis [98].

mRNA vaccine

mRNA vaccines were the safest and quickest techniques against cancers and infectious diseases. These vaccines were encoding the mRNA antigens by the translation of the host cellular machinery [89, 99]. In silico is designed for the development of mRNA vaccines, and a cell culture system was used for the production of the conventional vaccine [99].

DNA vaccine

DNA vaccines are widely used for the treatment of immune responses by encoding the specific antigen (plasmid encoding) [100]. Recently, various DNA vaccines were used for the improvement and efficiency of vaccines by electroporation [101]. In China, the *in vivo* pharmaceutical company started pre-clinical trials of DNA vaccines (INO-4800) against COVID-19 [102].

Other vaccine approaches

Hyleukine-7 platform technology is used for the development of the COVID-19 vaccine (Genexine Inc.) [103] and enhances the immune response by IL-7 fusion with the hybridized IgD and IgG4 [104]. Antibody-dependent enhancement (ADE) is a specialized disease process in which viruses enter into host cells via a specific pathway Fc-receptor, and vaccines against zika and dengue fever also use the ADE process [105]. In the case of SARS-CoV-2 infection, ACE2 is a basic unit for the treatment of viral infections by the blockage of binding sites of S protein. RAS inhibitor is used for the development of the COVID-19 vaccine by targeting the ACEI and ATR1R. Some anti-inflammatory drugs were used to reduce cytokines by treating severe COVID-19 infections [91, 92].

Recombinant subunit vaccine

Subunit vaccines are cheap, safe, and have rare side effects by enhancing the immune system without

interfering with other viral infections [106]. Subunit-based vaccines induce T-cell immune response and create an elevated level of neutralizing antibodies in *vivo* [107, 108]. Subunit-based vaccines (Clover Biopharmaceuticals) arrange pre-clinical trials on SARS-CoV-2 [109].

Vaccine development

The vaccine is the best, safest route for COVID-19 infections. mRNA, epitopes, and S protein- RBD structure-based vaccine have been widely in progress and planned [110, 111]. For COVID-19 vaccine development, rhesus monkeys and human ACE2 transgenic mouse models have been recognized [112], and a few vaccines of SARS-CoV-2 have been under clinical trials [112, 113] (**Table 2**).

Differential diagnosis

The differential diagnosis includes all types of respiratory infections such as parainfluenza, influenza, adenovirus, RSV, atypical organisms (mycoplasma chlamydia), and bacterial infections. Therefore, travel history is fundamental for COVID-19.

Table 2: Viruses with their cellular receptor's

Viruses	Host	Cellular receptor	References
Alpha coronaviruses			
HCoV-229E	Human	APN	[79]
HCoV-NL63	Human	ACE2	[80]
Beta coronavirus			
SARS-CoV	Human	ACE2	[81]
MERS-CoV	Human	DPP4	[82]
MHV	Mouse	CEACAM	[83]

Prevention and control

Healthcare workers are at high risk for COVID-19 infection, and since 2002, the SARS outbreak has profoundly affected [114]. There are three parameters for controlling COVID-19 infection: prevention, control strategies, and logical methods [115]. National-level policies have been launched for urban and rural areas [18, 116]. Some health measures follow up on contacts, environmental disinfectants, and hygiene equipment that slow down the virus (COVID-19) transmission [115]. Symptomatic treatment and supportive care were suggested for COVID-19 infection [56]. Some preventive measures were preferred to reduce nosocomial infection, including isolation, self-care, disinfection, and protection of confirmed cases [116, 117]. The WHO provides a detailed guideline in the community on the use of masks, staying at home, and health care settings of COVID-19 infection [118]. Coronavirus 2019 is not age-specific and infects people of all ages. A recent study showed that people who are already suffering from some disease (like cancer, diabetes, cardiovascular disease, and chronic respiratory disease) and people more than 60 years old are at high risk of being infected with COVID-19. After around 40 years, the risk of disease severity increases with the increase of age. So the people who fall in this range should shelter themselves from COVID-19, not only to protect themselves but also others that could be more susceptible [119].

Future perspectives

Currently, Scientists have adapted extensive efforts to overcome this viral outbreak. Although the development of vaccines and therapeutic measures for COVID-19 is still in its initial stages. Scientists progress on the complete genome sequencing of SARS-CoV to start clinical trials with the COVID-19 vaccine [120]. Recent studies do not show that COVID-19 is spread through the Huanan seafood market. Bats serve as a natural reservoir for SARS-CoV-2, and coronaviruses jump from animals to humans, and person-to-person transmission is reported. COVID-19 is transmitted through the inhalation of viral particles through the respiratory tract, as reported. As COVID-19 continuously spreads around the globe, we need a rapid, reliable, more efficient, and less time-consuming diagnostic kit for the testing and diagnosis of COVID-19 patients on an urgent basis. RT-PCR is considered the most significant method for diagnosis of COVID-19 patients. Appearing of different symptoms, risk factors, as well as CT scan of the chest which display features of pneumonia, can also be used to diagnose COVID-19 [44-46]. Besides, long-term studies and enormous funds are required for clinical trials for vaccine development and therapeutic measures against infectious disease. For this purpose, the Coalition for Epidemic Preparedness Innovations (CEPI) was established in 2017 at Davis to cooperate between pharmaceutical companies and academics to provide financial support against infectious disease [121]. The coronavirus disease (COVID-19) outbreak disturbed the global economy, disrupting supply chains, decreased market demand, and losing public health infrastructure. The current study is valuable for future studies, health policies and vaccine approaches

against coronavirus disease (COVID-19) outbreak worldwide.

Conflict of interest

The authors declare no conflict of interest.

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