Risk Mitigation Measures for Coronavirus Disease 2019

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ABSTRACT : Since December 2019, Coronavirus disease 2019 (COVID-19) broke out in China and soon spread worldwide. The once-in-a-century pandemic brought unexpected effect on both economy and health globally. Up to August 12, 2020, more than 20 million cases have been diagnosed across nearly 200 countries. In some countries such as the United States and India, confirmed cases are still increasing substantially. However, China, as the most severe one in the early stage of the outbreak, has curbed epidemic and saved lives rapidly. The intention of this review is to discuss effective risk mitigation measures, with the main focus on those applied in China, aiming to provide actionable and achievable guidance for the fight against Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) in the world. We analyzed, evaluated and summarized the crucial strategies, including risk communication, quarantine and isolation, vaccine and antiviral administration. The above risk mitigation measures have proven to be effective in fighting against the epidemic in China. In light of specific conditions, we believe these effective risk mitigation measures can be well applied in other countries. In this paper, we will analyze the solution to control the worldwide pandemic and even the epidemic occurring in the future.

1. Introduction
The Coronavirus pandemic 2019 (COVID-19) is an ongoing momentous public health issue around the world. In December 2019, its first outbreak emerged in Wuhan, China [1]. Multiple cases of unexplained pneumonia with a history of exposure to the seafood market in Wuhan have been found in local hospitals [1]. On 30th January 2020, the WHO declared COVID-19 to be a Public Health Emergency of International Concern (PHEIC) [2]. Then, COVID-19 was declared to be a pandemic by WHO on March 11, 2020. Up to August 12, 2020, more than 20 million cases have been diagnosed globally [3]. Currently, the U.S. has the largest number of confirmed cases (5,141,879), followed by Brazil (3,109,630) and India (2,329,638) [3]. Now, with the escalating severity and range of COVID-19, there are still many countries stuck in this problem. Hence, it is of great significance to research the effective risk mitigation strategies, so as to help more countries to take powerful actions.

As a public health event caused by a severe infectious disease, prevention, control and governance of COVID-19 considerably depend on the public health system [4]. Public health is the science of protecting and promoting the health of people and their communities via organized efforts of society.
This is normally achieved by promoting healthy lifestyles, researching disease and injury prevention, as well as detecting and responding to infectious diseases [5]. For a long time, public health has been proven to be of great significance to help protect the general public from communicable diseases and pandemics.

For the current most imperative public health issue, through basic concepts, implementing process, effectiveness analysis, we thoroughly discuss the instrumental risk mitigation measures, especially those acquired remarkable effects in China, and the importance of public health initiatives. It is aimed to provide actionable and achievable guidance for controlling the COVID-19 pandemic, as well as for preventing and containing the possible one in the future.

1.1 COVID-19

COVID-19 is caused by a new coronavirus named "SARS-CoV-2" [6]. The virus bears a high resemblance to the coronavirus that causes SARS, and the new type of coronavirus belongs to the β genus of coronaviruses with an envelope. The particles are round or oval, often pleomorphic, with a diameter of 60 to 140 nm. Its genetic characteristics are significantly different from SARSr-CoV [7].(See Fig.1) Spread through respiratory droplets and contact are the main routes of transmission. In addition, current research shows that 2019-nCoV may also be transmitted through the fecal-oral route [8]. People infected with the virus have varying degrees of symptoms, some only have a fever or a slight cough while others develop pneumonia, more severe complications, or even die [1]. Judging from the status of the currently admitted cases, most patients have a good prognosis and a few patients are in critical condition. The prognosis of the elderly and those with chronic underlying diseases is poor. Symptoms in children are relatively mild [1].

Fig 1. Schematic diagram of SARS-CoV-2 and SARS-CoV genome (Excerpt from Yan Lu [7])

2. Risk Mitigation Measures

Risk mitigation is an interdisciplinary decision-making process based on information from risk and exposure assessment [9]. Multiple authorities are involved in the implementation and expansion of many key aspects of preparedness and response, playing complementary, interrelated and, in some situations, overlapping roles [10].

Different risk mitigation measures will be taken respecting different stages of pandemic (see table 1). In the pre-pandemic period, there is some common preparedness like stockpile building, continuity planning, etc. During the spark period, timely measures such as risk communication, contact tracing, quarantine and isolation are of great significance to initially contain further spreading. When it is out of control--in the spread period, there are many imperative response activities like vaccine and antivirals administration to mitigate the pandemic [10].

Table 1. Examples of Pandemic Preparedness and Response Activities, by Time Period [10]

| Time period                  | Examples of risk mitigation measures                              |
|------------------------------|------------------------------------------------------------------|
| Pre-pandemic period          | Stockpile Building                                               |
| (before a pandemic starts)   | Continuity Planning                                              |
|                              | Public health workforce training                                  |
|                              | Simulation exercises                                             |
| Spark period                 | Initial outbreak detection                                       |
| (as a pandemic starts)       | Laboratory confirmation                                          |
|                              | Risk communication and community engagement                      |
2.1 Risk communication

2.1.1 Definition of risk communication. The USA National Academy of Sciences has defined risk communication as “an interactive process of exchanging information and opinions between individuals, groups and institutions” [11]. This process involves multiple messages about the nature of risk and related information. It not only directly conveys information related to threats, but also expresses concerns, opinions and corresponding responses to risk events, publishes regulations, measures for risk management of countries or institutions. It is also worth noting that although risk communication emphasizes the role of government, it is not only from the government to the people but also a mutual information communication between the government, the media and the people.

According to the theory of risk communication, relevant government departments should provide information pertinent to the public to persuade people to do certain things or not, and strive to influence the public’s preferences and behaviors, to achieve the expected policy goals, so it has become one of the governance tools for public health emergencies [12]. Furthermore, in the prevention and control of epidemic, appropriate, correct, and efficient risk communication is capable to promote government to make correct decisions, put these decisions into plans and action timely. For the public, it is also conducive to calming emotions and maintaining social stability. However, in terms of how countries respond to the COVID-19, the importance of risk communication has seemingly been ignored to varying degrees. At present, in order to minimize the impact of the epidemic on the economy and society, it is an urgent task to draw experience from some successful cases for experience.

2.1.2 Status of risk communication during COVID-19 in China. Public health emergencies widely involve economic and social development, and pandemic have profoundly affected the survival and development of many industries. The preparation and response to risk communication and community participation not only put forward higher requirements for coordination among government departments, but also means more challenges to external cooperation and coordination. China adjusted the strategy during the pandemic of COVID-19 to communicate with public. In this review, we will reveal the process and measures taken by China government since January.

China's application of risk communication to control the epidemic has not been smooth as now. After experiencing failure and causing the spread of the disease, the government gradually figured out the appropriate method. In early January, COVID-19 has not yet attracted the attention of the government, conflicting public policies were issued such as "10,000 Family Banquets" to encourage group gathering activities, which conveyed misleading messages to the public and significantly added risk of spread and social instability. Soon, the policies to promote gathering activities and not report the number of infected people in time were challenged by people. Subsequently, the government changed and released different types of dynamic information of epidemic through official websites, television, and other channels to encourage the public to take various protective measures.

Multi-media, multi-channel, multi-angle risk communication accounts for the reason why China made it so successfully in this field. The individual's receiving of risk information and the judgment and research of risk will affect the decision-making of their health behaviors. The Chinese government first released authoritative information and implemented it step by step at the grassroots level, which
contributes to strong public protection awareness. As of January 26, 2020, 30 provinces across the country have initiated a first-level response to major emergencies. The top-down coordination in Henan Province is particularly prominent [13]. After that, the epidemic prevention information is bombarded through various media channels as to make people of different ages and classes fully acquire relevant information: text messages, TV, newspapers, and municipal accounts [14]. Also, the government started to cooperate with influential professionals or platforms to publish relevant information. Although public information officials are mainly responsible for closely contact with the media during crisis, it is a better choice to have disease control experts walk to the camera and talk to reporters at this time, because subject experts make the information more credible. Zhong Nanshan, a famous academic, called on the public to "Stay at home, wash hands frequently, and wear masks". As a well-known medical knowledge-sharing platform, DXY started to provide an epidemic map with People's Daily [15]. Encouraged, some individuals or non-governmental organizations also began to organize spontaneously or as volunteers to help carry out publicity work.

While government is applying risk communication through various channels, the focus of content is different at different stages [16]. From January to March, during the outbreak of the epidemic, the main contents are epidemiological knowledge and essential protection points. At this time, when anxiety and panic are spreading among the public, it focused on interpreting the meaning behind the data, avoiding increasing the public fear, and digging up positive signals to convey positive emotions. When the time comes to April and May, while the pandemic situation in China is approaching stable for a long period of time, and people's anxiety has also eased. The news provided is to help readers to see the scientific knowledge behind the data more rationally. The government often broadcasts the latest progress of vaccine research, people's actions against global epidemics according to people's needs on CCDC weekly or other channels. Till today, although there are occasional small outbreaks in different cities, the epidemic in China has obviously been well controlled. The content of media dissemination is to broadcast the situation in overseas countries as well as some high-risk areas. The communication content accurately meets people's needs, and frequent changes of them can better help people prepare mentally and physically.

A series of risk communication measures that have been taken have a positive impact on public behaviour. After more than a month, as of May 29, the epidemic map provided by DXY and People’s Daily has generated more than 4 billion views [13]. A research shows that the vast majority of the public has taken effective protective measures, not going out or significantly reducing the number of outings, and do a noticeable job of personal protection (See Table 2). This has effectively prevented the spread of the epidemic to a certain extent [12]. The research team of Professor Wei Lu of Zhejiang University found that the overall online public opinion information can reflect the overall situation of the epidemic to a certain extent through the analysis of the network information in January 2020. In a city with a population of tens of millions, if the probability of protection awareness is above 0.5 and the epidemic attention (proportion of population with epidemic awareness) is above 0.9; or the probability of self-protection awareness is above 0.75 and the epidemic attention is above 0.7, the epidemic will most likely be suppressed [17].

| Behaviors after acquiring the information | Percentage |
|------------------------------------------|------------|
| Avoid from going outside                 | 92.22%     |
| Wear masks when going out                | 84.04%     |
| Increase hand washing                    | 93.44%     |
| Store protective equipment               | 66.94%     |
| Store food                               | 39.55%     |

2.1.3 Suggestions on improving. In the process of China's fight against the epidemic, risk communication is an indispensable part. Many of its practices are worth learning, but nothing is perfect. China’s early
failures have also given a lot of experience, and the lack of information circulation between various departments is also a major drawback. Here are some suggestions for improving.

Firstly, government ought to accurately grasp the timing of risk communication and disclose information by strengthen department cooperation and establish a unified information-publishing platform. Communication theory believes that "whoever sends the signal first will be able to take the lead and win more audiences" [18]. As the core area of COVID-19, Wuhan City, after discovering the first case, failed to pay attention in time and still reported it as "limited transmission", which led to the spread of the epidemic nationwide. Therefore, the response of relevant departments in emergency risk communication needs to be more rapid, accurate and active. Also, it is necessary to strengthen communication and cooperation between relevant departments, fully integrate information resources, and achieve information sharing, so as to enable the public to better understand the actual situation of public health emergencies as soon as possible.

Second, continuously alter risk communication content in response to public needs is of great importance in this regard. At different stages of the development of public health emergencies, the public may have different requirements for risk communication. When responding to public health emergencies and they do not understand the general needs, risk communication may be ineffective. Relevant agencies should be entrusted to assess the public's risk communication needs regularly, especially to dig deeper into the public's unmet information needs, and timely adjust and expand the content of information disclosure to provide true and accurate information.

Third, it is essential to pay attention to the two-way interactive risk communication method with the public. Relevant government departments should actively collect information of general interest through the Internet and other forms, and use press conferences, official websites of relevant government departments, hotlines, and mass media websites to strengthen interaction with the public, respond to public concerns promptly, and better meet the individual needs of the society.

Emerging infectious diseases once again remind us of the necessity and urgency of integrating health into all policies. If there is a plan for risk communication that be initiated at the right time, all departments can achieve coordinated cooperation and seamless connection. On the one hand, medical staff can be prevented in time. On the other hand, people can learn about new coronary pneumonia related knowledge and prevention and control measures as soon as possible, and understand the country’s response strategies, which can reduce panic, consciously maintain social distance, and avoid the spread of the epidemic on a larger scale.

2.2 Curtailing Interactions between infected and uninfected populations

Once a pandemic has begun, the principal focus is to minimize its spread. In the absence of vaccines and antivirals, curtailing interactions between infected and uninfected population is generally the most important strategy. For this, risk mitigation measures like isolation, contact tracing, quarantine, and social distancing can be significantly contributing.

2.2.1 Isolation, contact tracing, and quarantine. The basic idea of isolation is to separate the infected people during the infectious period, to reduce the chance of transmission to others [19]. Isolation is normally used for severe infections, taking place in the particular hospital facility like the negative pressure rooms. For less serious infections like measles, infected individuals can be isolated at home.

Contact tracing will be conducted by the Public Health staffs via epidemiological investigation to find the potentially infected persons, like family numbers, classmates, work colleges, health care workers, and passengers in the same vehicle that came into close contact with the patients [20]. This is usually achieved by inquiring patients, insiders, or doctors to investigate the recent routes of the patients, assisted with big data like the record of taking public transportation if necessary [21]. After identified, the relevant quarantine will be implemented.

Quarantine separates and conducts detention of people who have been exposed to infected individuals for close medical observation until it is apparent that they have not been infected [19]. However, persons who show signs of infection during quarantine will typically be moved to isolation.
In order for quarantine to be effective, potentially exposed persons must be observed for the duration of the potential incubation period. For instance, in the case of SARS, the mean incubation period was around five days, and a quarantine period of 14 days would capture more than 95% of incubation [22]. Now, the recommended quarantine time for COVID-19 is 14 days.

In China, contact tracing, quarantine and isolation were the critical risk mitigation measures to curb the spread of COVID-19. Receiving the report of confirmed or suspected cases from hospitals, Center for Disease Control and Prevention (CDC) in the specific districts were required to conduct contact tracing for potentially infected people within 24 hours [21]. After identified, the Public Health Department would deploy the quarantine of those people as well as medical observation for 14 days since the last time that the persons closely contacted with confirmed cases without sufficient safeguards [20]. Typically, there were home quarantine, or the concentrated quarantine (mainly at hotels) for those who could not achieve self-quarantine at home, like migrant workers [20]. During the quarantine, specific staffs measured the body temperature in the morning and evening, inquired the health status, filled in the medical observation form (see Table 3), and gave the necessary help and guidance [20]. And if the persons developed respiratory tract infection symptoms such as fever and cough during medical observation, they would be immediately sent to a specific medical institution for diagnosis and isolation if confirmed.

More specifically, in China, the most resounding quarantine should be the one taken place in Wuhan, the epicenter of the COVID-19 outbreak in China. Considering the high incidence of cases in or from Wuhan, it was at 10 a.m. on January 23, 2020 that the Chinese government formally placed Wuhan, the whole city, in quarantine to mitigate the spread of infection to other cities [23]. The mass quarantine had been continued for 76 days (1814 hours) until April 8, 2020, the day when Wuhan was allowed for reopening [23].

These practices were rather effective for spread controlling. It was reported that after the quarantine of Wuhan on January 23, the effective reproductive number (Rt) of SARS-CoV-2 in the city began to decrease rapidly, and it dropped below 1.0 on February 6, followed by 0.1 on March 8 [24]. Since then, the outbreak in Wuhan has been considerably contained.

### 2.2.2 Social distancing

Social distancing is another important risk mitigation measure for curbing transmission between people in a broader community, in which individuals may be infectious but have not yet been identified. It has also been referred to as physical distancing, emphasizing keeping space between yourself and other people outside the home [25]. Usually, social distancing recommends that people should stay with a proper distance (about two arms’ length) from others, do not gather in groups and stay out of crowded places and avoid mass gathering [25].

Social distancing has been being applied in China during the spread period of COVID-19. During the surge of COVID-19 cases, mobility of residents was much restricted, like closing public transportation, limiting the use of private vehicles, and encouraging staying at home with limited outdoor activities (eg. only activities within communities or outside with limited frequency like once three days per family) [26]. Besides, there were also serious socioeconomic restrictions. For instance, closure of schools, museums, restaurants, and stadiums, suspension of retail trade, and limitation or even cancellation of productions in factories were conducted to restrict the interactions among the population [26].

Social distancing has proven to be dramatically contributing to containing the spread of COVID-19. As reported, in the early stage of Wuhan quarantine (from January 23 to February 1), the city applied a series of interventions, including maintaining social distance like traffic control and requirements of staying at home [24]. These practices reduced the Rt value from 3.88 (before the quarantine) to about 1.25 [24]. And it is worth mentioning that the results have been successfully replicated in some other countries around the world, such as Italy and Germany, where social distancing practices led to a rapid decline in Rt and a flattening later [24].

Although social distancing is a classical and effective measure to prevent the spread of infections, decisions about its application should comprehensive analysis. Social distancing may lead to many
problems. Obviously, social distancing practices like cancellation of mass gathering for a long while may cause social alienation. And the closure of factories, restaurants, stores, etc. could lead to economic shock as well as a big scale of unemployment in the country. For instance, it was estimated that retail sales of the catering industry lost up to 500 billion yuan due to the mass closure in just seven days of the Chinese Spring Festival this year [27]. Moreover, closure of cinemas, shopping malls, and other entertainment venues reduce public recreational activities and may impact their mental health like suffering from depression. Therefore, before decisions, a context-specific risk assessment should be conducted to analyze the current situation, and weigh the effectiveness and adverse effects of social distancing practices.

2.3 Vaccine and antiviral administration are needed facing the COVID-19

2.3.1 Antivirals. It's noted that no specific treatment for COVID-19 is currently available [28]. Antivirals is one of candidate drug in clinical treatment. Chloroquine and hydroxychloroquine are used as anti-infective drugs. And their indications include malaria, lupus erythematosus and rheumatoid arthritis [29]. Besides, it was recently found that HCQ plays a new role in the treatment of Graves’ ophthalmopathy [30]. The clinical trials of HCQ against COVID-19 are also conducted in China [31]. HCQ is similar to chloroquine in molecular structure, and the toxic of HCQ is only half of that of CQ [29]. Thus, it's a highly anticipated drug against COVID-19. The molecular structures are shown in Figure 2.

![Molecule structures of Chloroquine and Hydroxychloroquine](image)

Fig 2. The molecule structures of Chloroquine and Hydroxychloroquine [32]

The existing data suggests that the antiviral mechanism of hydroxychloroquine is that it interferes with the binding of the virus and ACE2 receptor, to prevent the infection from entering the host cell for further reproduction [29]. The use of hydroxychloroquine has been approved in many COVID-19 clinical trials [28]. In many recent clinical trials, hydroxychloroquine is combined with other antiviral drugs such as Favipiravir, Lopinavir, hoping to get the better curative effect [33].

What’s more, it is worth mentioning that Remdesivir is currently one of the most widely used antivirals in the treatment of COVID-19. The mechanism of Remdesivir is to affect the RNA replication process of the virus by inhibiting its RNA polymerase activity, thus preventing the virus from spreading in the human body.

Since NEJM reported on January 31, the first case of a COVID-19 patient in the United States that rapidly improved after administrating Remdesivir, the drug has been dubbed "People's Hope" and has become a focus [34].

Given the positive results of Remdesivir, the United States, Japan, the United Kingdom and other countries have successively approved Remdesivir to be marketed and used for the treatment of COVID-19.

2.3.2 Vaccines. The purpose of a vaccine is to expose the body to an antigen that won’t cause disease, but will provoke an immune response that produces the corresponding antibodies and memory cells. Once the body is infected with the virus, an immune response that can block or kill the virus will be provoked immediately. At least eight types of vaccines are being tried against coronavirus, and they depend on different viruses or viral parts [35]. Meanwhile, a new vaccine technology based on mRNA provides new ideas for vaccine research.
2.3.2.1 Virus vaccines
At least seven teams are developing vaccines using the virus itself (in a weakened or inactivated form), and already in clinical trials [36].

In general, a virus is weakened for a vaccine by being passed through animal or human cells until a mutation makes it less likely to cause disease. While, in inactivated vaccines, chemicals such as formaldehyde or heat are used to make the virus non-infectious. Making them, however, starts with a lot of infectious viruses.

Most virus vaccines against SARS-CoV-2 are in the inactivated form. This form requires handling a large number of infectious viruses (which can be alleviated by using attenuated seed viruses) and the integrity of the antigen and/or epitope needs to be confirmed [36].

The inactivated SARS-CoV-2 vaccine developed by Sinovac Biotech has already entered Phase III clinical trial stage in Brazil and Bangladesh, which is the first vaccine to enter Phase 3 trial in the world [37].

Table 3. Some candidate virus vaccines that already in clinical trials

| Developer(s)                                           | State(s)                                      | Status                                                                 | Research progress                                                                                                                                               |
|--------------------------------------------------------|-----------------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| Sinovac Biotech                                        | China, Brazil, and Bangladesh                 | Phase 1/2 clinical trials are underway in China, while Phase 3 trail is underway in Brazil                                                                       | On June 15th, Sinovac Biotech issued an announcement stating that the phase 1/2 clinical study (0, 14-day procedure) of the inactivated vaccine was unblinded. The preliminary results showed that the vaccine is safe and has good immunogenicity. |
| Group 42 (G42), the Abu Dhabi Department of Health, and China National Pharmaceutical Group (Sinopharm) | United Arab Emirates                           | Phase 3 clinical trial is underway in UAE                               | It is the first inactivated COVID-19 vaccine to enter Phase 3 trials in the world.                                                                          |
| Wuhan Institute of Biological Products and China National Pharmaceutical Group (Sinopharm) | China                                         | Phase 3 trials are underway in China                                    | On June 16th, the results of Phase 1/2 clinical trial of Wuhan Institute of Biological Products showed that the vaccine is safe, and there was no serious adverse reaction. After different procedures and different doses of vaccination, the volunteers received vaccinations produced high-titer antibodies. |
| Beijing Institute of Biological Products and China National Pharmaceutical Group (Sinopharm) | China                                         | Phase 1/2 trials are underway in China                                  | According to a paper published in Cell in June, the vaccine is effective in animal study, and Sinopharm claimed that the titers of antibodies were high. |
| Immunitator                                             | Canada and Mongolia                           | Phase 1/2 trials are underway in British Columbia and Mongolia         | Heat-inactivated plasma from donors with COVID-19. The volunteers will receive a pill daily for 15 days.                                                      |
| Bharat Biotech                                          | India                                         | Phase 1/2 trials are underway in India                                  | The vaccine was effective and safe in guinea pigs and mice.                                                                                                  |

2.3.2.2 Viral-vector vaccines. A viral-vector vaccine uses weakened viruses that won’t cause disease, such as measles or adenovirus, as the vector to deliver some parts of the antigen. That is, the vector virus is genetically engineered so that it can produce coronavirus proteins in the body and provoke an immune response. Virus vectors can be divided into two types: those that cannot replicate in the host cells by knockout key genes and those that can be vectors of foreign genes but still remain its replicating ability.

No infectious virus needs to be handled in this approach, and its excellent preclinical and clinical data for many emerging viruses, including MERS-CoV, makes viral-vector vaccine a “star”. However, vector immunity might negatively affect vaccine effectiveness, it depends on the vector chosen [36].

CanSino Biologics and the Academy of Military Medical Sciences are working together to develop a non-replicating adenovirus 5 (Ad5) vector vaccine carrying the gene for the SARS-CoV-2 spike protein, which is the first team to publish results from the Phase 2 trial in The Lancet in July. Compared
with Phase 1 clinical trials, Phase 2 clinical trials have liberalized the upper age limit, allowing some senior volunteers over 60 years old to join it. The paper suggested that the vaccine can achieve an immune response to the SARS-CoV-2 and induce an efficient T cell immune response [38].

Table 4. Some candidate viral-vector vaccines that already in clinical trails

| Developer(s) | State(s) | Method | Status | Research progress |
|--------------|----------|--------|--------|-------------------|
| CanSino Biologics and the Academy of Military Medical Sciences | China and Canada | Nonreplicating adenovirus5 (Ad5) vector carrying the gene for the SARS-CoV-2 spike protein | Phase 3 trials are underway in China and Phase 1/2 trail has been approved to begin in Canada | Chen’s team is the first to publish results from the Phase 2 clinical trial in The Lancet in July. It suggested that the vaccine is safe and elicits an immune response. Following the positive results, China’s Central Military Commission approved the vaccine for use in the country’s military. |
| University of Oxford and AstraZeneca | UK, Brazil, and South Africa | A chimpanzee adenovirus vaccine vector (ChAdOx1) carrying the gene for the SARS-CoV-2 spike protein | Phase 2/3 trials of the vaccine are currently under way in the United Kingdom, Brazil and South Africa | On July 20, AstraZeneca announced that interim results from the ongoing Phase 1/2 COV001 trial, led by the University of Oxford, showed that the recombinant adenovirus vaccine AZD1222 was resistant to SARS-CoV-2 in all participants under evaluation and produced a strong immune response against the virus. |
| Gamaleya Research Institute of Epidemiology and Microbiology, Health Ministry of the Russian Federation, Acellena Contract Drug Research and Development | Russia | Adenovirus vector displaying the SARS-CoV-2 spike protein on its surface | Phase 1/2 clinical trials are underway in Russia | The developers have yet to release test data on the vaccine. |
| Janssen | US | Nonreplicating adenovirus 26 (Ad26) vector carrying undisclosed genetic material of SARS-CoV-2 is delivered via intramuscular injection | Early stage clinical trials are underway in the US and Belgium | Janssen published preclinical data in Nature in July demonstrating that the vaccine protected monkeys against SARS-CoV-2 infection. With BARDA’s support, the company will scale up to produce up to 300 million doses of vaccine in the US each year. |

2.3.2.3 Nucleic-acid vaccines. Nucleic-acid vaccines are safe and easy to develop, because to produce them involves making genetic material only, not virus.

At least 20 teams are working on using nucleic acids (in a DNA or RNA form) as vaccines to produce coronavirus proteins that boost the immune response. That is, DNA enters human cells via electroporation, while RNA is encased in a lipid coat. DNA or RNA produces viral proteins in the cells, which are then engulfed by antigen-presenting cells, which present the antigens on the cell surface and thus stimulate an immune response. Most of these vaccines encode the virus’s spike protein [35].

It is worth mentioning that among these different candidate vaccines, there is a new participant—mRNA vaccine. The mRNA sequence encoding a specific antigen is synthesized in vitro and then delivered to the body. The mRNA is expressed in the cell to generate the antigen protein, which induces the body to produce a specific immune response. mRNA vaccines can express intracellular antigens like DNA vaccines. What’s more, it solves the problem of low immunogenicity and generating non-specific immunity against vectors of DNA vaccines.
Moderna developed the world's first SARS-CoV-2 mRNA vaccine (mRNA-1273) based on the foundation of the preliminary mRNA vaccine research and development in cooperation with the American government. On July 14, Moderna Company published the interim results of Phase 1 clinical trials of mRNA-1273 in NEJM magazine. The results of the study showed that all volunteers produced high-titer antibodies, whose levels were higher than those found in most COVID-19 recovered patients. See more, and no serious adverse events occurred [39].

Table 5. Some candidate nuclei-acid vaccines that already in clinical trails

| Developer(s)                                      | State(s)                  | Method                                                                 | Status                                                                 | Research progress                                                                 |
|--------------------------------------------------|---------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Inovio Pharmaceuticals                           | US                        | A special device administers spike protein–encoding DNA molecules through the skin. | Phase 1 clinical trial underway in Pennsylvania, Missouri, and Kentucky with plans to manufacture 1 million doses of its candidate this year | In a study published in The Journal Nature Communications in May 2020, Inovio researchers published preclinical data on their DNA vaccine for SARS-CoV-2, suggesting that the vaccine produces a strong neutralizing antibody and T-cell immune response to SARS-CoV-2 |
| BioNTech and Pfizer                              | Germany and the US         | mRNA vaccine                                                           | In July, the companies announced that they had picked their lead candidate and had begun a Phase 2/3 trial in the US, Germany, Brazil, and other countries. | Pfizer and BioNTech announced on medRxiv the further results of the Phase I clinical trial of their mRNA new crown vaccine. The article pointed out that the mRNA vaccine can simultaneously induce an effective antibody response and T cell response. The companies plan to supply hundreds of millions of vaccines to the US. |
| Moderna and USA National Institutes of health     | US                        | Lipid nanoparticles containing mRNAs for the SARS-CoV-2 spike protein  | Phase 1, Phase 2, and Phase 3 clinical trials underway across the US      | Results from the Phase 1 trials published in the New England Journal of Medicine in July suggest that the vaccine is safe and elicits higher levels of SARS-CoV-2 antibodies than most COVID-19 recovered patients. A later study published in the same journal reported that vaccinated monkeys quickly cleared the virus. |
| Imperial College London                          | UK                        | The RNA vaccine uses a revolutionary technology—RNA self-amplification technology, which will quickly synthesize viral proteins to produce antibodies after intramuscular injection. | Phase 2 trail is underway in UK                                           | The Phase 2 clinical trial of the Imperial College team will target 300 healthy volunteers. If the human experiment at this stage goes well and the expected immune response appears, the Imperial College team will launch more human clinical trials in October and enter the Phase 3 of 6,000 healthy volunteers. |
| Chinese Academy of Military Medical Sciences     | China                     | This new mRNA vaccine uses advanced preparation technology and can be stored for at least one week at room temperature while still remaining stable. | This vaccine has been approved for clinical trials in China                  | On July 24, in a article published in the journal Cell, researcher Qin’s team from the Chinese Academy of Military Medical Sciences and developed a new type of mRNA COVID-19 vaccine through which can stimulate an immune response and induce the production of neutralizing antibodies in mice and non-human primates. |
| Zydus Cadila                                     | India                     | Engineered DNA plasmid encoding a SARS-CoV-2 antigen                   | Phase 1/2 trial underway in India                                         | In a preclinical study, the vaccine neutralized SARS-CoV-2 in a virus neutralization assay. |

2.3.2.4 Protein-based vaccines. Many researchers hope to inject coronavirus proteins directly into the body. It is also possible to use proteins or protein coat fragments that mimic the coronavirus coat.
At least 28 research groups are working on vaccines with viral protein subunits, and most research groups are focusing on the virus’s spike protein or a key part of its receptor-binding domain. In order to work, these vaccines may require adjuvants and multiple doses.

Virus-like particles mimic the structure of coronavirus through an empty virus shell, but they are not infectious due to lack of genetic material. Five teams are working on a "virus-like particle" (VLP) vaccine, which can trigger a strong immune response but may be difficult to produce [36].

It is worth mentioning that recombinant protein vaccine is considered to be the safest vaccine, which integrates the target gene of the virus into the expression vector, and then converts the expression vector into bacteria, yeast, mammalian or insect cells, inducing the expression of a large number of antigen proteins, and the vaccine is obtained through purification.

Table 6. Some candidate protein-based vaccines that already in clinical trails

| Developer(s)                  | State(s)    | Method                                                                 | Status                                      |
|------------------------------|-------------|------------------------------------------------------------------------|---------------------------------------------|
| Clover Biopharmaceuticals    | Australia   | The vaccine delivers pieces of the SARS-CoV-2 spike protein            | Phase 1 clinical trial underway            |
| Medicago                     | Canada      | Virus-like particles that resemble SARS-CoV-2 are produced in a close relative of tobacco | This vaccine has been approved for Phase 1 clinical trials. |
| Valine, Medytox              | Australia   | Recombinant SARS-CoV-2 spike protein plus a polysaccharide adjuvant    | This vaccine has been approved for Phase 1 clinical trials in Australia. |

3. Conclusion

This paper introduces, analyzes and considers the successful measures of China in fighting against the COVID-19 from various angles. Meanwhile, various promising antiviral drugs and vaccines are included to demonstrate the current progress and provide new ideas for further research.

Risk communication is an integral part of emergency response to health emergencies. After the outbreak, the Chinese government has closely contacted the public health profession and performed its duties, provided the public with a correct scientific education, and transparently reported the epidemic. These measures timely help the public relieve their emotions and take effective protective measures. Compared with foreign countries, due to the government’s disregard of the importance of publicizing protective measures, a large number of citizens still have not changed their health behaviors like going outside without wearing masks. It is necessary to use the experience of China for reference. However, while we fully affirm the achievements in system construction such as public health emergency risk communication and government affairs public opinion response, we should also see that the Internet has reconstructed the information dissemination order and power relations in public crises, and has realized the redistribution of the right to speak.

Curtailing interactions between infected and uninfected populations is a crucial strategy to contain the spread of intense infectious diseases like COVID-19. Specifically, the classical public health measures like isolation, contact tracing, quarantine and social distancing play vital roles for this. In China, the quarantine and social distancing implemented in Wuhan considerably contributed to the drop of Rt number of SARS-CoV-2 in the city, and also made similar results in some countries later, indicating the feasible and effective strategies for other countries [20]. But, it is worth noting that although social distancing is considered rather instrumental, it should be conducted on the basis of a context-specific risk assessment, as it may bring unfavorable impacts on society, economy and mental health.

Antivirals and vaccines for COVID-19 are under development. This article focuses on antivirals—Remdesivir, which is one of the most widely used drugs in the treatment of COVID-19 currently. For the vaccines, we summarized the principles, candidate vaccines and research status of the eight methods. At present, there are about 165 vaccines are under research in the world, 26 are in clinical trials, and 6 are in Phase 3 clinical trials, but it will still take several months to conduct the trials. Each vaccine preparation method has advantages and disadvantages, but it is difficult to say which vaccine will be.
developed first. If the research goes well, it is expected to be put into production at the earliest by the end of this year.

In this paper, effective references are provided for other countries to contain COVID-19 pandemic. Furthermore, in the long terms, for the whole society, when it is attacked again by an epidemic, it can act as a set of general schemes for preventing and fighting against the future epidemic. In combination with the national conditions of various countries, we strongly believe that the risk mitigation measures discussed will considerably contribute to the controlling of COVID-19 in more countries, and the ultimate triumph over the battle between human and coronavirus!

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