The Risk Mitigation Measures Implemented in China

Peiyao Sun [1] [†], Sichong Meng [2] [a, *, †] and Yan Zhou [3] [†]

[1]University of Queensland, Australia
[2]The University of New South Wales, Australia
[3]Beijing University of Chinese Medicine, China
[†]These authors contributed equally.

Abstract. To present essential and pragmatic lessons for other countries which are still in pandemic and to prepare for future affections diseases, risk mitigation measures took by Chinese government during the COVID-19 pandemic period were assorted and included. Pertinent information was arranged in three parts, pre-pandemic, during-pandemic and after-pandemic. In the first period, stockpile building, public health workforce training and simulation training in China may account for the in-time mitigation. Although these resources could be insufficient in some severely afflicted areas, resources in other places were concentrated to relieve local stress and prevent further expansion of the disease, and the overall training was in an escalating trend. In the second period, advanced technology to detect the virus and timely risk communications in China were of great importance to go through the obstacle, although initial risk communications were not proper in Wuhan, the first outbreak place in China. In the third period, specific vaccine administration, quarantine policies and contact tracing method were timely and effective to depress the risk in China. Measures took in the spread period are of potential use for the infected countries to stop the disease in a shorter time. And the actions in the first two periods instruct all nations to build up a more solid public health network and to develop the assessment of pathogens in advance to prepare for future threats from some unknown or similar infectious diseases.

1 Introduction

Pandemic COVID-19 caused by the SARS-CoV-2 virus had caused more than 211,000 deaths globally as of April 27, 2020 [1]. Before a vaccine can be widely covered, decrease virus transmissibility via implantation of non-pharmaceutical interventions is very necessary. In China, a peak-and-fall trend was seen in this epidemic of COVID-19. According to National Health Commission, infection individuals in Wuhan China would be 50,000 at the end of February [2] and continue to increase with time if no effective prevention and control measures were applied [3]. The national transmission has been controlled since May 2020 due to public health measures' implementation, including reducing the flow of people and centralized isolation during the outbreak's early stage, population symptom screening in the late stages. China public health risk mitigations have shown effectiveness in disrupting the chain of transmission [4]. As COVID-19 keeps evolving and spreading, understanding China's public health risk mitigations could provide ideas for other international pandemic control.

This research will focus on risk mitigation measures implemented in China from three periods: pre-pandemic, spark period and spread period. Firstly, in pre-pandemic period, stockpile building, public health workforce training and simulation training will be illustrated. Secondly, in spark period, virus detection, pathogen characterization and risk communication would be explained. Finally, in spread period, vaccine administration, contact tracing and quarantine, isolation will be stated.

2 Risk mitigation implemented in the pre-pandemic period

After the SARS epidemic in 2003[5], China has accumulated experience in dealing with large-scale epidemic outbreaks and summarized the problems exposed in the epidemic. After more than ten years of hard work, China's prevention, control and management of infectious diseases have been greatly strengthened. These efforts have played a huge role in responding to COVID-19.

2.1 The stockpile building

The stockpile building is directly related to the stocks of medicines and materials. These storages directly affect the response effect when responding to disease outbreak. In a survey of four places Beijing, Shandong, Guangxi and Hainan [6], 322 hospitals that were effectively investigated, 53.1% could accurately assess the stocks of medicines and materials, and 61.5% of the hospitals could

---

[*] Corresponding author: [a] z5142231@ad.unsw.edu.au

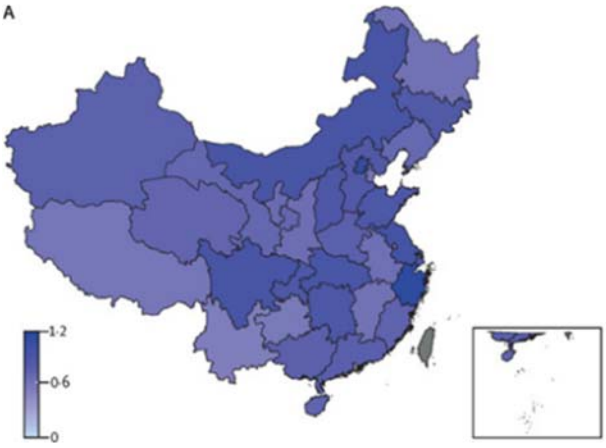
obtain emergency medical supplies through suppliers. However, less than half of hospitals have signed effective written contracts with suppliers to ensure that adequate medicines are enough in the event of a public health incident. Among the 322 hospitals that responded effectively, 47.8% had made plans to allocate emergency medicines, and 21.5% knew the addresses of national and local drug distribution centers. Regarding the drug reserves of hospitals, 80.1% of the hospitals' reserve drugs for public health incidents. The reserves of medicines and materials in different regions are different, and Beijing's reserve capacity is slightly higher than that of other regions. The performance of hospitals of different levels is also different. Generally speaking, the performance of tertiary hospitals is better than that of second-class hospitals.

The dynamic stocks of medicines and materials played an important role during the epidemic. Although this performance is better than in 2003, in the face of a large-scale outbreak of infectious diseases, it will still lead to a shortage of medical supplies. During the response to COVID-19, Wuhan's early medical supplies were once a shortage [7]. However, this situation has eased with the subsequent arrival of support materials from other regions.

2.2 Public health workforce training

Public health workforce training is an important part of ensuring that the public health system can respond appropriately to a public health event that breaks out. It can be discussed from two aspects, one is the number of doctors or personnel in primary health care and public health, and the other is the knowledge level of the staff to deal with public health event.

At present, in China, the number of people engaged in primary health care is increasing. Since 2009, the number of junior doctors is 1.73 million, nurses are 470,000, and pharmacists are 109,000. However, this number still needs to be increased, and there are regional and urban-rural differences are shown in figure 1 [8].



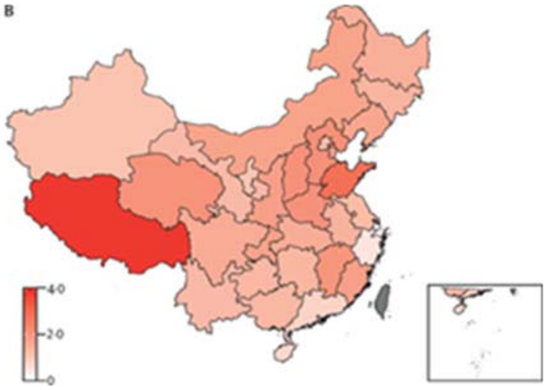


Figure 1. The number of primary health care doctors in China in 2015, from Xi Li el.2017 [8] figure 1. (A) Number of licensed or assistant licensed doctors per 1000 population. (B) The number of village doctors per 1000 rural population.

The performance of hospitals of different levels is also different. Generally speaking, the performance of tertiary hospitals is better than that of second-class hospitals.

The dynamic stocks of medicines and materials played an important role during the epidemic. Although this performance is better than in 2003, in the face of a large-scale outbreak of infectious diseases, it will still lead to a shortage of medical supplies. During the response to COVID-19, Wuhan's early medical supplies were once a shortage [8]. However, this situation has eased with the subsequent arrival of support materials from other regions. Even so, the survey also found that 21% of doctors do not have a corresponding doctor's qualification certificate, which might be higher in community health clinics and rural areas. [9] Many doctors (12%) have not received the systematic training of a medical school, and do not have a degree in a medical school. Professional doctors in the field of public health are even more in short supply. In 2019, there were 2.77 licensed (assistant) physicians per 1,000 population, 3.18 registered nurses per 1,000 population; 2.61 general practitioners per 10,000 population, and 6.41 professionals in public health institutions per 10,000 population. The number of doctors per thousand is lower than that of Russia, France and Australia. This number is currently unable to meet the large demand for professionals in the event of a public health emergency. The structure of a doctor also shows that there are currently a large number of public health doctors who have not received a master's degree or above, who need to further improve their professional standards.

Regarding the current training of medical workers, a survey of 322 hospital staff [6] shows that 94.5% of the staff have received relevant training. Specifically, 56.3% of infection management staff have received training. 92.2% of medical workers in China have received training, and 71.8% of doctors and nurses in infectious wards have received training. Of these pieces of training, 82.3% are supervised by professional personnel, and 66.5% of the personnel's training courses are updated regularly. Not only that, but 50.3% of medical workers regularly need to conduct corresponding assessments to ensure the effectiveness of the training.

This shows that at present, the number of medical personnel in China is not sufficient, and there may be insufficient manpower in response to epidemic outbreaks. This can be seen in Wuhan's initial response to the COVID-19 outbreak. On the other hand, with regard to personnel training, the medical and public health training currently provided by China is sufficient to ensure the first professional response in the event of an infectious disease outbreak.

2.3 Simulation training

Simulation training can effectively improve the level of hospitals in responding to large-scale infectious disease outbreaks. A survey of 400 hospitals shows that 22.9% of the hospitals were able to cooperate with community organizations to deal with large-scale infectious disease outbreaks in simulation training. When large-scale sample testing is required, 76.6% of hospitals can quickly improve their testing capabilities, but only one-third will collect and investigate available samples. At the government level, most (88%) city governments have emergency plans [10]. Although there are still some problems such as insufficient planning and not paying attention to cooperation with other regions, the government can respond immediately to the outbreak of diseases.

Although the level of simulation training can still be improved, it is prepared to respond to most public health emergencies, which can ensure that medical staff and the government know how to avoid the large-scale spread of the infectious disease COVID-19 across regions.

3 Risk mitigation implemented in spark period

After the outbreak of COVID-19, the availability of widespread accurate and rapid testing procedures becoming valuable in unraveling the complex dynamics involved in SARS-CoV-2 infection and immunity [11]. Not until the proper study of passengers' infection on the Diamond Princess Cruise ship, detection challenges start to show the difficulty to identify asymptomatic patients [12]. Initial detection can not only avoid unnecessary quarantines of negative individuals and positive individuals to spread infection but also permit physicians to provide prompt intervention for patients who are at higher risk for developing more serious complications from COVID-19 illness [11].

Currently available and mostly applied COVID-19 tests fall into two major categories and contain overlapping purposes in COVID-19 management. The first category is using molecular assays to detect SARS-CoV-2 viral RNA using polymerase chain reaction (PCR)-based techniques or nucleic acid hybridization-related strategies. And the second category is by using serological and immunological assays to detect antibodies produced by individuals resulting from exposure to the virus or detect the antigenic proteins in infected patients. China mainly applied the molecular assays detection method as it is convenient without compromising the accuracy.

In respect of molecular assays detection, method RT-LAMP, TMA and CRISPR-based assays will be introduced. As for serological and immunological assays, ELISA and biosensor test will be included.

Followed detection method introduction, pathogen characterization and risk communication will also be included to show how China has implanted risk mitigations in the spark period.

3.1 Molecular assays detection

SARS-CoV-2 is a single-stranded, positive-sense RNA virus, and its entire genetic sequence has been shared with the Global Initiative on Sharing All Influenza Data (GISAID) platform from January 10, 2020. Sequencing data plays an important role in facilitating the design of primers and probes needed for the development of SARS-CoV-2-specific testing [13].

3.1.1 Reverse Transcription Loop-Mediated Isothermal Amplification (RT-LAMP)

This method has been recognized as the rapid, cost-effective testing chooses for COVID-19. It can be seen from Figure 2 that RT-LAMP needs sets of four primers specific for the target gene/region to increase the sensitivity. It combines LAMP with a reverse transcription step to detect RNA. Then, the amplified product can be detected via photometry, by measuring the turbidity caused by magnesium pyrophosphate precipitate in solution which is a byproduct of the amplification. Using intercalating dyes to measure turbidity or fluorescence allows for detection in real-time. As real-time RT-LAMP detection only requires heating and visual inspection, its simplicity and sensitivity make it a promising candidate for virus identification [14].

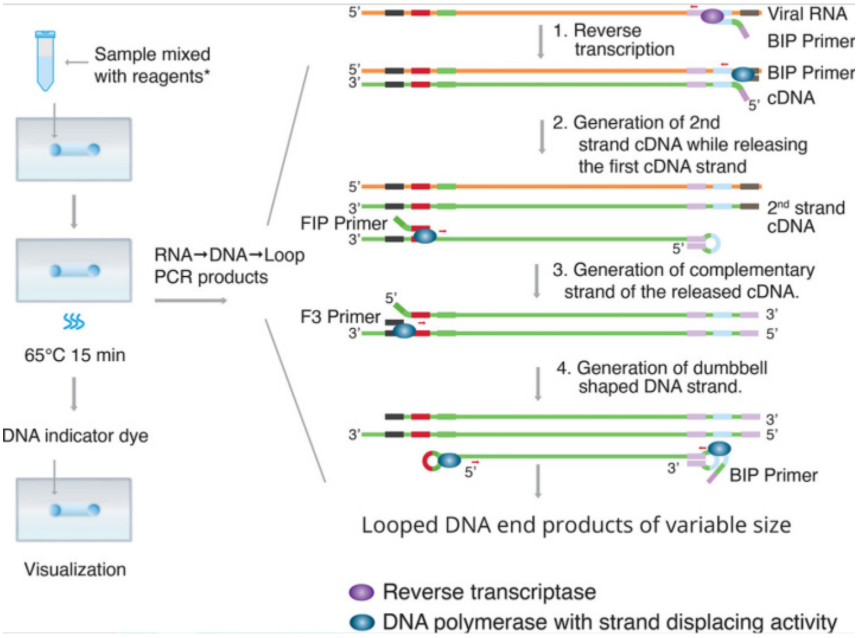


Figure 2. RT-LAMP detection steps.

Zhang et al in China had prepared RT-LAMP test using reverse transcriptase (WarmStart RTx from BioLabs) to convert the viral RNA to cDNA by the DNA-dependent DNA polymerase (Bst2.0 Warmstart) [15]. The enzyme is uniquely in silico designed RNA-directed DNA polymerase coupled with a reversibly bound aptamer which will inhibit RTx activity below 40 °C. The colorimetric LAMP has shown a great effect on detecting viral RNA in cell lysates at 480 RNA copies levels, without interference, providing an alternative to RT-PCR for detecting SARS-CoV-2 RNA [11].

3.1.2 Transcription-Mediated Amplification (TMA)

This is a patented single tube, isothermal amplification technology generated after retroviral replication, and could be used to amplify specific regions of either RNA or DNA much more effectively than RT-PCR [16]. TMA uses a retroviral reverse transcriptase and T7 RNA polymerase to detect nucleic acids of multiple pathogens. Under this situation, Hologic's Panther Fusion platform can perform both RT-PCR and TMA [17] due to its high testing throughput and capability to simultaneously screen for other common respiratory viruses whose symptoms are similar to COVID-19. The detection process involves using single-stranded nucleic acid torches which hybridize specifically to the RNA amplicon in real-time. Followed by each torch conjugated to a fluorophore and a quencher, a signal excitation will be emitted by fluorophore [11].

3.1.3 CRISPR-Based Assays

The sherlock method uses Cas13 to excise reporter RNA sequences in response to activation by SARS-CoV-2-specific guide RNA [14]. While the detector assay uses the Cas12a to cleave reporter RNA, specifically the sequences of E and N genes, followed by isothermal amplification to generate a visual readout with a fluorophore [18]. CRISPR-based methods presented in Figure 3, do not require complex instrumentation and can be read using paper strips to detect SARS-CoV-2 virus without compromising the sensitivity and specificity, these are also low-cost and can be performed within 1 h. It was recognized to have a potential for point-of-care diagnosis [14, 19, 20].

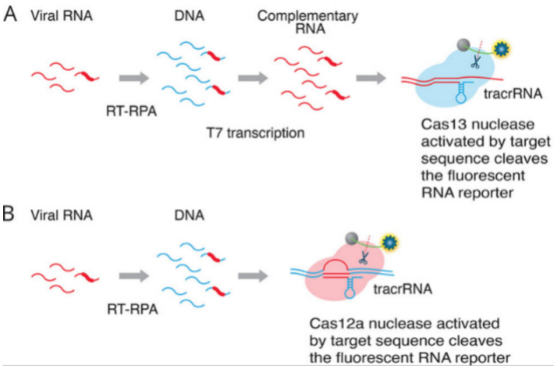


Figure 3. Two CRISPR methods for detecting viral RNA.

3.2 Serological and immunological assays detection

Serological testing is the analysis of blood serum or plasma and the testing includes saliva, sputum, and other biological fluids for the presence of immunoglobulin M (IgM) and immunoglobulin G (IgG) antibodies. This type of test is important in epidemiology and vaccine development, providing the ability to assess both short-term (days to weeks) and long-term (years or permanence) antibody response, as well as antibody abundance and diversity [11].

3.2.1 Enzyme-Linked Immunosorbent Assay (ELISA)

This is a microwell, plate-based assay technique designed

https://doi.org/10.1051/e3sconf/202130801025

to detect and quantify substances such as peptides, proteins, antibodies, and hormones. The test can be qualitative or quantitative, and typically takes 1 to 5 hrs to generate the result. SARS-COV-2 detection is illustrated in Figure 4.

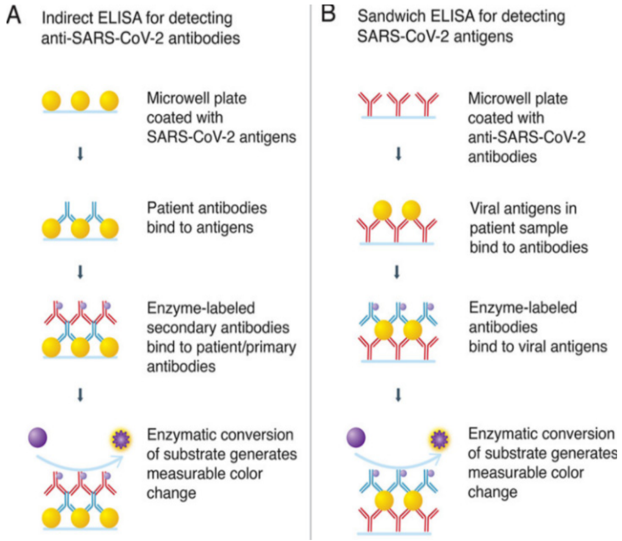


Figure 4. ELISA assays detecting antibodies (A) or antigens (B).

If the virus is present, antiviral antibodies in the samples will bind specifically, and the bound antibody-protein complex can be detected with an additional tracer antibody to produce a colorimetric or fluorescent-based readout. ELISA is efficient and capable of testing multiple samples; it is suitable for point-of-care determinations [11].

3.2.2 Biosensor Test

Biosensor tests depend on interpreting the specific interaction of biomolecules into a measurable readout. A surface plasmon resonance (SPR) based biosensor was developed for the diagnosis of SARS using coronaviral surface antigen (SCVme) anchored onto a gold substrate [21]. The SPR chip could detect 200 ng/mL of anti-SCVme antibodies within 10 minutes. Recently, PathSensors Inc. has invented a CANARY biosensor to detect SARS coronavirus, which uses a cell-based immune-sensor coupling capture of the virus with signal amplification to provide a result in 3–5 min [22].

3.3 Pathogen characterization

Three coronavirus disease have been reported in the past two decades, including COVID-19, Severe Acute Respiratory Syndrome (SARS), and Middle East Respiratory Syndrome (MERS) [23, 24]. The novel coronavirus named SARS-CoV-2 was because of similar characteristics to SARS-CoV. It consists of spike glycoprotein (S), membrane protein (M), an envelope protein (E), nucleocapsid protein (N), and linear single-stranded positive (+) sense RNA of ~30 kb [24].

Reverse vaccinology and immunoinformatic is important for designing potential vaccines against SARS-CoV-2. A suitable vaccine targeting SARS-CoV-2 is based on binding energy between the target protein and the designed vaccine [24]. Therefore, characterizing pathogen in the early stage is necessary.

Characterization of SARS-CoV-2 can be accomplished by using molecular approaches. In 2019, Chinese scientists Zhou et al. [25] and Zhang et al. [26] reported the identification of SARS-CoV-2 and isolated followed by characterized the viral from the bronchoalveolar lavage fluid of SARS-CoV-2 infected patients using RT-PCR with degenerate primers and probes designed for detection of SARS-CoV-2. Using comparative genome analysis, it was found that SARS-CoV-2 showed genome similarity with MERS-CoV and SARS-CoV (Figure 5).

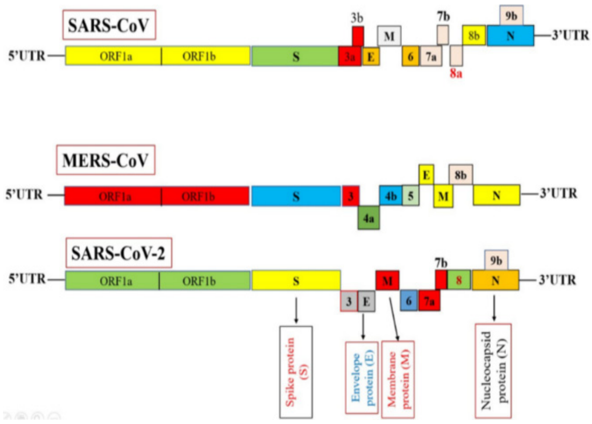


Figure 5. Genome similarity and dissimilarity among MERS-CoV, SARS-CoV and SARS-CoV-2.

After the identification of SARS-CoV-2, the phylogenetic relationship among the viruses of the same family was studied using the bioinformatics method. The genome size of SARS-CoV-2 was 29,891 nucleotides long, with a G + C content of SARS-CoV-2 32 % to 43 %. The genome of SARS-CoV-2 was arranged in series of 5′UTR, replicas (orf1a/b), Spike(S), Envelope (E), Membrane (M), Nucleocapsid (N), 3′UTR. The six functional open reading frames (ORFs) include ORF1a/b, S, E, M, and accessory gene which are ORF3b and ORF8 [27]. This helped to contrast phylogenetic trees,

It was found that SARS-CoV-2, SARS-CoV, MERS-CoV, HCoV-OC43, and HCoV-HKU1 are beta coronavirus while HCoV-NL63, HCoV- 229E are alpha coronaviruses [25]. Based on a phylogenetic tree, SARS-CoV-2 shares a common ancestor with two other bat SARS-like coronaviruses that are bat-SL-CoVZC45 and bat-SL-CoVZXC21, with 88 % sequence similarity [25].

From previous research, homology modeling shows that SARS-CoV-2 has the same receptor-binding domain as SARS-CoV. Therefore, it confirmed that SARS-CoV-2 uses ACE2 as a receptor, despite the presence of difference in amino acid in the SARS-CoV-2 receptor-binding domain [28]. Based on virus genome sequencing and phylogenetic analysis, researchers have considered bats as the primary source and origin of SARS-CoV-2 [25].

3.4Risk communication

Public health outbreaks could increase uncertainty and not adhere to specific boundaries, which makes risk communication more significant for developing effective public health preparedness strategies [29, 30]. Generally, an effective risk is defined as all related risk messages should be presented and shared to participants in a risk communication process openly and timely, in order to fill the knowledge gap between the originators of information and those receiving the information, and adjust the public's behavior to deal with the risk actively [31, 32]. Time is the key to controlling outbreaks. Getting reliable information and acting on it quickly can arrest outbreaks before they need emergency measures. However, the early history of the COVID outbreak in Wuhan showed information disclosure and delayed decision making, which indicates an ineffective risk communication associated with COVID-19 [33].

At the beginning of the outbreak, the Wuhan government did not put a scientific risk communication into decision making and take the outbreak as a common public health issue instead of an emergency without a precise investigation and consensus about the epidemiological characteristics of COVID-19 [34]. Thus, there was no adequate preparedness for outbreak management from a timely warning to the public to active countermeasures for the risk.

Learning the lessons from the first outbreak in Wuhan, affective risk communication should include accessibility and openness of risk information, communication early about risk and strategic method for communicating uncertainty.

Risk communication is composed of two parts: internal communication and external communication. Internal communication means in a situation where risk assessors and managers develop a common understanding of the tasks and responsibilities, which enables risk assessors and managers to appraise the potential impact and all possible results based on the available information. While external communication will enhance stakeholders' awareness of the negative impact of the risk and their recognition of roles in risk governance and initiation of different strategies [35, 36].

Following the message-centered way, three main actors can be extracted from how to build an effective risk communication, this includes the government, experts, and the public. A model can be structured to demonstrate the communicative interaction to better understand how to set strategy and principles (Figure 6) [34]. In this model, the three components of communicative interaction are government–public, government–expert, and expert–public. The government is the core decision-maker in the risk governance process, and all of the government's legislation will have a great impact on the governance effectiveness.

Figure 6. Government–Expert–Public Risk Communication model.

For government–public communication, which is typical external communication, the government has the responsibility to convey adequate and accurate information to the public, which ensures the information disclosure is accessible and open. Government–expert communication is seen as internal communication, is a primary element of risk assessment and decision making. While Expert–public communication representing external communication, is dedicated to bridging the gap between expert and public awareness on public health issues through strategic communication [34].

4 Risk mitigation implemented in spread period

Announced as a pandemic by WHO in March 2020, COVID-19 had invaded all continents including Antarctica sparing just a few Pacific Island nations by the end of 2020 [37]. By March 19, 2021, the total definite cases are 122,211,720 with 2,695,688 died (Figure 7) [38]. However, nearly the same time when COVID-19 was assessed as a pandemic, the number of reported COVID-19 cases in China declined substantially and the number of new autochthonous infections approached zero after months of efficient measures applied in the spark period including lockdown and quarantine [39]. Without relaxing vigilance, the Chinese government insist on implementing several risk mitigation measures in the spread period to impede the potential risk of new spreading, which has turned out to be beneficial not only for its own but also the whole world.

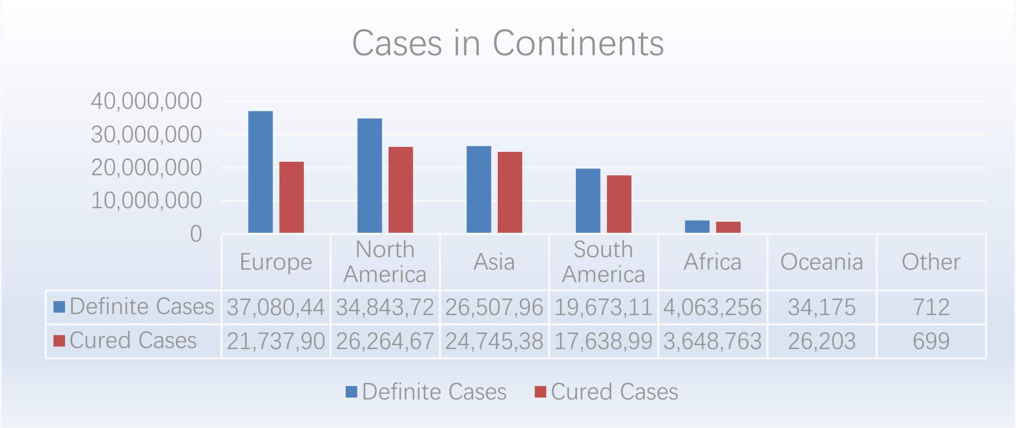


Figure 7. Cases in Continents by March 19, 2021.

4.1 Vaccine administration

One of the most essential methods taken by China is vaccine development and pervading vaccinations in all citizens. Currently, China has approved 4 vaccines via Emergency Use Authorization (EUA) and one of them is PiCoVacc produced by Sinovac Biotech. Three of these vaccines are inactivated vaccines rather than live attenuated vaccines, protein-based vaccines, nucleic acid vaccines and viral vector vaccines which are designed and approved by other countries [40]. The basic principle beneath inactivated vaccines is inactivating viruses with formaldehyde or heat. This kind of vaccines does not have any live component of the viral particles and therefore is noninfectious and safer compared to a live attenuated one [41]. It is also convenient for them to be transported and preserved as they do not require cold chains for distribution after being freeze-dried.

From December 2020, the vaccine administration project has been launched and gradually prevailing in China. Until March 14, 2021, the total number of vaccinated Chinese people is up to 64.98 million. The project continues to march forward with the intention to steadily raise the vaccination rate in the order of key populations, high-risk populations and other populations [42]. Indeed, timely and appropriate vaccination not only functions as a significant risk mitigation measure to prevent a new outbreak in China but also an indispensable action to bolster restoring the order of the whole world including recovering international commercial trade and interactive cultural communications. Comprising one-fifth of all people in the world, China takes its responsibility to suppress the disease risk by driving on the free vaccination project in its public.

4.2 Contact tracing, quarantine and isolation

In addition to the above vaccination plan, China also carries out stringent policies in contact tracing, quarantine and isolation in the spread period. WHO defines that quarantine as the restriction of activities of persons who may have been exposed to an infectious disease, with the primary objective of monitoring symptoms and the early detection of cases. While isolation can be described as separating infected persons from others to avert the spread of infection or contamination [43, 44].

To make these measures feasible, the Chinese government carries out health code and tract code. In China, each region even subdivided into a street or a small village can be classified into 3 risk levels that include low-risk level, medium risk level and high-risk level. The status is updated in time and can be inquired easily online. To enter a public area like a cinema or a restaurant, each person has to show his/her own health code on the phone, in which green represents the little possibility of getting infected and red represents they may contact with definite cases or come from high-risk places. Different places own their own codes, so people have to claim a local health code when they enter another city or province. Contact tracing is also based on their phones which trace their tracks every day. Such real-time stratification and identification are critical for risk mitigation because people with a potential risk of having been infected can get controlled effectively and people from safe places are warned to keep away from those endangered areas. As for quarantine, people in a temporary high-risk region are quarantined and tested several times with nasopharyngeal swab or throat swab until no more positive cases are reported in a given period. And for people who get in touch with positive cases, they will keep quarantined until they are proved to be negative. Those who are diagnosed with COVID-19 will be sent to a specific isolation hospital for treatment. To be specific, after 56 days without COVID-19 cases, reemergent cases came up in Beijing Xinfadi wholesale market on 11th June 2020 and the risk of the district in which the market located was soon elevated to a high-risk status. The health code of pertinent people turned red according to their traces in the recent 14 days. Merchants in the market and consumers who once purchased food in the market were quarantined and asked to screen for COVID-19, and the infected cases among them were sent to Ditan Hospital. Thanks to the efficient contact tracing, quarantine and isolation, the small outbreak were inhibited on 4th July, with a total of 334 COVID-19 cases reported [45].

Besides, quarantine policies for people who come abroad count even more for mitigating risk due to the relatively safe domestic environment and the considerable daily increasing cases abroad. So, it is necessary for the Chinese government to set up rigid quarantine policies for people from outside the China mainland. For succeeding in boarding an international airplane to China, one has to provide negative nucleic acid certification in limited days which ranges from 3 to 7 days. After arriving, people will be sent to quarantine hotels and spend a 2-week solitary quarantine time. During the period, they will be tested several times to preclude any potential infection. As the incubation period in certain cases is found to be over 14 days, now people from abroad have to spend another 7 or 14 days being quarantined at home or local hotel after the first centralized quarantine, according to different policies in each province. With implementing pragmatic and meticulous policies, there are only several import cases being reported during their quarantine period. The whole nation enjoys routine production, education and entertainment under the proper social distancing.

The Chinese government also applies other methods to alleviate risks in the spread period including social distancing, and care and treatment. All people are still required to wear masks in public areas especially in closed areas like elevators and classrooms. People cannot gather together in a large group, so the distance of at least 1 meter between tables in a restaurant is demanded and the seats in a cinema have to be skipped. For care and treatment, all COVID-19 patients in China are provided with free and wholehearted treatment. As a special and therapeutic treatment, traditional Chinese medicine is prescribed for each patient, along with conventional modern therapy. In combination with these measures, China continues to keep the contagious disease under control and fights for the recovery of the whole world.

5 Conclusion

Based on the existing literature, this article summarizes China's preparations and methods for covid-19 from three perspectives. In the three periods (pre-pandemic period, spark period and spread period)，China all have made corresponding preparation and reaction. In summary, China’s current response to COVID-19 is effective and reasonable, and it has also proved that adequate preparation and reasonable response can greatly reduce the harm to public health caused by covid-19. This conclusion hopes to provide a reference for other countries to deal with covid-19 and similar infectious diseases. The content involved in this review cannot fully cover the work China has done in response to the epidemic, but provide a summary of the response to the pandemic.

References

1. LV Garner, JW Smoot, Y Li, Q Zhou, CJ Saveson et al. ACS Cent. Sci **6(5)**:591-605. (2020)
2. H Wang, Z Wang, Y Dong, R Chang, C Xu, X Yu, S Zhang, L Tsamlag, M Shang, J Huang, Y Wang, G Xu, T Shen, X Zhang ,Y Cai . Cell Discov. **6(10)**, 514–23(2020).
3. H Markel, HB Lipman, JA Navarro, A Sloan, et al. Jama, **298(6)**: 644-654(2007).
4. XY Yu, C Xu, HW Wang, et al. Infectious Diseases of Poverty, **9(1)**: 1-3. (2020)
5. LH Chan, L Chen, J Xu, Negotiating and navigating global health: Case studies in global health diplomacy. 203-219. (2012)
6. X Li, J Huang, H Zhang BMC Public Health, **8**: 319. (2008).
7. National Health Commission of the People's Republic of China. Transcript of a press conference on February 4, 2020. (in Chinese)
8. X Li, J Lu, S Hu, KK Cheng, J De Maeseneer, Q Meng, et al. The Lancet, **390(10112)**: 2584-2594(2017).
9. Q Meng, H Fang, X Liu, B Yuan, J Xu, et al. The Lancet, **386(10002)**: 1484-1492(2015).
10. T Ren, J Lyu, CQ Yu, LM Li. Zhonghua yu fang yi xue za zhi [Chinese journal of preventive medicine], **54(5)**: 457-464(2020).
11. G Hu, K Rao, Z Sun, Z Sun, et al. Health policy and planning, **22(6)**: 375-380. (2007).
12. LJ Carter, LV Garner, JW Smoot, Y Li, Q Zhou et al. Assay techniques and test development for COVID-19 diagnosis[J]. 2020..
13. P J Scott, D R Santiago-Dieppa,A R Wali, et al. Cureus , **8(8)**.(2016)
14. HTC Thai, MQ Le, CD Vuong, M Parida, et al. Journal of Clinical microbiology, **42(5)**: 1956-1961(2004).
15. Y Zhang, N Odiwuor, J Xiong, L Sun, RO Nyaruaba et al. MedRxiv, (2020).
16. LJ Carter, LV Garner, JW Smoot, Y Li, Q Zhou et al. Assay techniques and test development for COVID-19 diagnosis[J]. 2020.
17. LJ Carter, LV Garner, JW Smoot, Y Li, Q Zhou et al. Assay techniques and test development for COVID-19 diagnosis[J]. (2020).
18. F Zhang, OO Abudayyeh. A protocol for detection of COVID-19 using CRISPR diagnostics[J]. A protocol for detection of COVID-19 using CRISPR diagnostics, 8(2020).
19. JP Broughton, X Deng, G Yu, CL Fasching et al. Nature biotechnology, **38(7)**: 870-874(2020).
20. A Kobokovich, R West, G Grovall,Serology-based tests for COVID-19. Johns Hopkins Center for Health Security. , (2021).
21. TJ Park, MS Hyun, HJ Lee, SY Lee, S Ko et al. Talanta, **79(2)**: 295-301(2009).
22. PathSensors Inc. Announced the Development of a SARS-CoV-2 Biosensor. PathSensors Inc, PathSensors News and Press, March 24, 2020. (2021).

23. JS Mackenzie, DW Smith. Microbiology Australia, **41(1)**: 45-50(2020).
24. A Zumla, DS Hui, S Perlman, The Lancet, **386(9997)**: 995-1007(2015).
25. N Singh, SN Rai, V Singh, MP Singh. Journal of Chemical Neuroanatomy: 101874(2020).
26. a.Zhou P, Yang X L, Wang X G, et al. R.; Zhu, Y.; Li, B.; Huang, C[J]. L., Chen H.–D., Chen J., Luo Y., Guo H., Jiang R.–D., Liu M.–Q., Chen Y., Shen X.–R., Wang X., Zheng X.–S., Zhao K., Chen Q.–J., Deng F., Liu L.–L., Yan B., Zhan FX, Wang Y.–Y., Xiao G.–F., Shi Z.–L.. Nature, **579**: 270-273.

    b. Zhou Y, Hou Y, Shen J, et al. **6(1)**: 1-18(2020).
27. W Zhang, R H Du, B Li, et al. Emerging microbes & infections, **9(1)**: 386-389(2020).
28. AC Walls, YJ Park, MA Tortorici, A Wall, Cell, **181(2)**: 281-292. e6. (2020)
29. P Kenis, L G C Schol, M M Kraaij-Dirkzwager, et al. Risk, hazards & crisis in public policy, **10(3)**: 275-293(2019).
30. D Campbell-Lendrum, L Manga, et al. Philosophical Transactions of the Royal Society B: Biological Sciences, **370(1665)**: 20130552(2015).
31. L Frewer. Toxicology letters, 149(1-3): 391-39(2004).
32. Effective risk communication [M]. Routledge, 2013.
33. M M Kavanagh. The Lancet Public Health, **5(3)**: e135-e136. (2020)
34. O Renn. Risk Decision and Policy, 3(1): 5-30(1998).
35. M V Florin, M T Bürkler. EPFL, (2017).
36. L Zhang, H Li, K Chen /Healthcare. Multidisciplinary Digital Publishing Institute, 2020, **8(1)**: 64(2020).
37. CR Triggle, D Bansal, H Ding, MM Islam et al. Frontiers in immunology, **12**: 338(2021).
38. https://news.qq.com/zt2020/page/feiyan.htm#/global?ADTAG=kkchnow.Accessed on March 19, (2021)
39. SP Kaur, V Gupta. Virus research, 198114(2020).
40. O Müller, G Lu, A Jahn, O Razum, et al. International journal of health policy and management, **9(10)**: 432(2020).
41. S Kashte, A Gulbake, SF El-Amin III, Human cell, 1-23(2021).
42. The People's Government of Beijing Municipality. (2021)
43. World Health Organization. Considerations for quarantine of individuals in the context of containment for coronavirus disease (COVID-19): interim guidance, 19 March 2020[R]. World Health Organization, (2020).
44. A Patel, S Patel, P Fulzele, et al. Journal of family medicine and primary care, **9(8)**: 3867(2020).
45. Y Zhang, Y Pan, X Zhao, et al.. Biosafety and health, **2(4)**: 202-205(2020).