

Challenges to the system of reserve medical supplies for public health emergencies: reflections on the outbreak of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic in China

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SUMMARY On December 31, 2019, the Wuhan Municipal Health Commission announced an outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), China is now at a critical period in the control of the epidemic. The Chinese Government has been taking a series of rapid, comprehensive, and effective prevention and control measures. As the pandemic has developed, a fact has become apparent: there is a serious dearth of emergency medical supplies, and especially an extreme shortage of personal protective equipment such as masks and medical protective clothing. This is one of the major factors affecting the progress of epidemic prevention and control. Although China has made great efforts to strengthen the ability to quickly respond to public health emergencies since the SARS outbreak in 2003 and it has clarified requirements for emergency supplies through legislation, the emergency reserve supplies program has not been effectively implemented, and there are also deficiencies in the types, quantity, and availability of emergency medical supplies. A sound system of emergency reserve supplies is crucial to the management of public health emergencies. Based on international experiences with pandemic control, the world should emphasize improving the system of emergency reserve medical supplies in the process of establishing and improving public health emergency response systems, and it should promote the establishment of international cooperative programs to jointly deal with public health emergencies of international concern in the future.

Keywords public health emergency, SARS-CoV-2, COVID-19, medical supplies

1. Introduction

After several cases were identified in Wuhan in Dec. 2019, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has gradually affected China as a country and even spread worldwide. Prior to Feb. 12, 2020, China had reported 59,804 confirmed cases of coronavirus disease 2019 (COVID-19), 1,367 deaths, and 5,911 recoveries (1). Compared to the SARS epidemic in 2003, this time China has apparently made great progress in combating a pandemic through its development of the capacity for biological detection and its greater transparency with regard to information (2,3). However, the situation also revealed that China still faces major problems in terms of public health emergencies.

2. Shortage of medical supplies during the SARS-CoV-2 epidemic in China

The key to a response to a public health emergency

lies in abundant reserves and proper allocation of emergency medical supplies, for timely supplies are crucial to reducing deaths and increasing the rate of successful treatment (4). An epidemic caused by a new pathogen can often deal a blow to the health system, resulting in a shortage of supplies and medicines. For example, the United States was faced with an outbreak of H1N1 influenza in 2009; many hospitals suffered from a shortage of personal protective equipment (5). The SARS-CoV-2 outbreak coincided with Chinese New Year, so most of the manufacturers and distributors were on holiday; this further intensified the shortage of medical protective supplies in combating the epidemic. Hospitals across the country, and especially those in Wuhan where the situation is the most severe, have cited a vast shortage of medical supplies, and especially personal protective supplies such as medical protective clothing and N95 masks; the hospitals are urgently calling for societal support (6). This shows that China is still facing significant challenges and still needs to

enhance the reserve medical supplies program and to remedy the faults in the allocation, distribution, and utilization of supplies to deal with public health emergencies.

3. Policy requirements and status of the reserve medical supplies program in China

China's current reserve medical supplies program dates back to the 1970s (7). In order to ensure the effective supply of medical supplies required after disasters, epidemics, or emergencies, the State Council issued the "Notice on Reforming and Enhancing the Management of Medical Reserves" in 1997. After the SARS outbreak in 2003, the Chinese Government heavily emphasized emergency preparation and related legislation. The government issued the "Regulations on Public Health Emergencies," the "National Emergency Plan for Public Health Emergencies," the "(Draft) Catalogue of health emergency personnel and equipment," and other documents (Table 1). Moreover, the emergency reserve supplies program clearly stipulates that "municipal governments and county governments in areas where emergencies are likely to occur should establish a program for emergency reserve supplies, necessities, and equipment"(8).

Although policies on the emergency reserve medical supplies program have been continuously improved, they are often not fully implemented. The SARS-CoV-2 epidemic shows that the Government failed to heed its responsibility for effectively "reserving medical supplies for the prevention and control of the pandemic" (9). In 2010, all of the Centers for Disease Control and Prevention on the provincial level were evaluated for their capacity to respond to public health emergencies, and the results indicated that the readiness of emergency reserve supplies was only 37.5%, only 4.8% of all centers met standards, and the types and quantities of supplies were far from adequate (10). The first reason for this is because the mechanism for funding reserve medical supplies still has flaws; it lacks long-term and sustainable input (11). Second, a mechanism for managing emergency reserve supplies has yet to be created; there is a lack of integrated planning, timely storage, or rapid distribution. Third, the risks of an emergency and response capabilities vary with the level of economic and social development, necessitating the continuous updating of lists of emergency supplies. Since the issuance of the "(Draft) Catalogue of health emergency personnel and equipment" in 2008, however, no adjustments or updates have been made, resulting in substantial inability to meet current standards (12).

4. Main systems of reserve medical supplies around the world

With the frequent occurrence of public health

emergencies across the world, some countries have established relatively mature medical stockpile systems to protect their populations from potential public health emergencies (13). In 2003, the United States created the Strategic National Stockpile (SNS) Program to maintain a stockpile of life-saving pharmaceuticals and medical supplies for use in a public health emergency. The SNS represents a real material asset in federal warehouses that can be quickly activated to meet the country's needs, enhancing the country's ability to respond effectively to public health emergencies. There are mainly three categories of SNS including 12-hour push packages, vendor managed inventory (VMI), and stockpile managed inventory (SMI). 12-hour push packages can be delivered to the collection reserve within 12 h of an emergency, and each emergency package contains sufficient medicines and medical supplies for hundreds of thousands of individuals to sustain treatment and prevention for several days. Vendor managed inventory (VMI) is managed inventory maintained by specific vendors or manufacturers that is stored at the supplier in the form of signed contracts and that can be delivered within 24 to 36 hours upon approval. Stockpile managed inventory (SMI) is directly managed and reserved by the SNS and includes physical reserves and ordered reserves. The US also has other forms of emergency supplies, such as chemical kits and family medical kits. In the event of an emergency, the SNS Program will deploy a team of advisors to coordinate and assist state and local authorities in receiving, managing, distributing, and recovering emergency medical supplies. The stockpile service advance group (SSAG) and technical advisory response unit (TARU) consist of experts in public health, emergency response, and logistics. In response to public health emergencies, Canada and Australia have also established the National Strategic Stockpile (NESS) (14) and National Medical Stockpile (NMS) (15) systems; these systems provide key reserves of essential medicines and equipment, such as personal protective equipment, antibiotics, and antivirals. The NESS and NMS are maintained in various strategic locations by federally leasing warehouses and by other means (Table 2).

5. How to enhance the reserve medical supplies system to deal with public health emergencies

Emerging pandemic have been increasing around the world over the past few years, and more than 40 emerging infectious diseases have been detected, such as SARS, H7N9 avian influenza, Ebola virus, and MERS. Epidemics of novel infectious diseases have emerged and rapidly spread globally in the context of economic globalization and increasingly frequent international exchanges, and these epidemics have a significant impact on economic development and

Table 1. China's policy documents related to the reserve medical supplies programs

Year	Title of policy documents (<i>ref.</i>)	Regulations
1997	Notice of the State Council on Reforming and Enhancing the Management of Medical Supplies (21). State Council., [1997] Reference No. 23.	Reforms the current national system of medical supplies and pharmaceutical reserves, establishes a reserves program both at the central and local levels, and implements a dynamic reserve and paid redeployment program.
1999	Measures for National Management of Medical Supplies and Pharmaceutical Reserves (22). Pharmacy department, National Economic Trade Committee., [1999] Reference No. 544.	When major disasters, epidemics, or emergencies occur, or several provinces, autonomous regions, or municipalities directly under the central government are involved, the region's own medical reserves are used first. If those reserves are inadequate, the government can request medical reserves from neighboring regions or designated departments based on the paid redeployment program. If there are still unmet needs, the government can apply to access the central medical reserves.
2003	Regulations on Preparedness for and Responses to Emergent Public Health Hazards (23). Order of the State Council of the People's Republic of China (No.376).	Relevant departments of the State Council, governments at or above the county level, and their relevant departments should ensure reserves of supplies such as emergency facilities, equipment, medications, and medical equipment in accordance with the requirements of emergency plans.
2004	The 2004 Revised Law of the People's Republic of China on the Prevention and Treatment of Infectious Diseases (24). Order of the President of the People's Republic of China (No.17).	Governments at or above the county level are responsible for reserving medicines, medical equipment, and other supplies for the prevention and control of future outbreaks of infectious diseases.
2005	Master State Plan for a Rapid Response to Public Emergencies (25).	Establishes and improves the emergency supplies monitoring network, the early warning system, and the emergency supplies production, storage, allocation, and distribution system; improves emergency protocols and ensures the timely supply of emergency supplies and daily necessities; enhances the supervision and management of supply reserves, and provides timely supplements and updates.
2006	National Contingency Plan for Public Health Emergencies (26).	Governments at all levels must establish reserves of supplies and ensure the production capacity to handle public health emergencies. When a public health emergency occurs, reserve supplies should be allocated as needed to manage the emergency. Emergency reserves should be replenished in a timely manner after use.
2007	Law of the People's Republic of China on Emergency Response (8). Order of the President of the People's Republic of China (No.69).	The state should establish a sound emergency reserve supplies program and improve the program for the supervision, production, storage, allocation, and distribution of important emergency supplies. Municipal governments and county governments in areas where emergencies are likely to occur should establish a reserve program for emergency supplies, necessities, and equipment.
2008	(Draft) Catalogue of health emergency personnel and equipment (27). Office of Health Emergency Response, Ministry of Health., [2008] Reference No. 207.	Enhances the creation of health emergency response teams, implements standardized management of health emergency response teams, and continuously improves health emergency response capabilities.
2010	Guidance on Accelerating the Creation and Development of Public Health Emergency Systems (28). Office of Health Emergency Response, Ministry of Health., [2010] Reference No. 57.	Further improves the health emergency reserve supplies and allocation system. Improves the list of health emergency supplies, reasonably determines the type, quantity, and nature of the reserves; establishes procedures for effective use of emergency supplies in conjunction with relevant departments, and improves the mechanism of inter-regional, inter-departmental, and cross-military allocation of emergency supplies. Establishes and improves the emergency reserve supplies program for health institutions at all levels to facilitate the timely availability of emergency supplies.
2016	Notice of the National Health and Family Planning Commission on Issuance of Guiding Opinions on Enhancing the Standardization and Devising of Responses to Health-related Emergencies (29). Office of Health Emergency, Ministry of Health., [2016] Reference No. 68.	Improves supplies and technological reserves. Cooperates with industry and information technology departments to improve the emergency reserve supplies program, reasonably determines the material reserve catalogue, scale, and the extent of physical reserves, social reserves, and production capacity reserves; establishes and improves the supply rotation and allocation system and promotes the digitization of supply reserves records to improve the comprehensive coordination and ensured provision of emergency supplies.

human health. Improving the national public health emergency response system is crucial to the prevention and control of novel infectious diseases, and the emergency medical supplies is an indispensable element of public health emergency response (16).

In the future, China and many other countries should pay close attention to the reserve medical supplies program in the process of enhancing the public

health emergency response system based on the lessons of the SARS-CoV-2 pandemic and the prevention and control of other epidemics. First, China should establish a public health emergency reserve medical supplies system and improve the nature of reserve medical supplies based on the types, needs, and validity of reserves (17), such as contracted reserves, physical reserves, financial reserves, and production capacity

Table 2. Major forms of emergency reserve medical supplies around the world

Country	Reserve form (<i>ref.</i>)	Details
United States	Strategic National Stockpile, SNS (13,30).	Office of the Assistant Secretary for Preparedness and Response (ASPR), HHS manages the SNS program The Stockpile includes 12-hour push packs (less than 5% of the SNS inventory) and managed inventories maintained by specific vendors or manufacturers, or the SNS. Supplies are managed through vendor managed inventory (VMI) and stockpile managed inventory (SMI). The plan is to deliver critical medical resources to the site of a national emergency when local public health resources would likely be or have already been overwhelmed by the magnitude of the medical emergency. The stockpile includes vaccines, antitoxins (<i>e.g.</i> , botulinum), airway equipment, and other medicines for emergency conditions.
Canada	Emergency Strategic Stockpile, NESS (14).	The Public Health Agency maintains the NESS to provide emergency supplies to provinces and territories when requested. A total of 11 federal warehouses are leased by the Public Health Agency: two main depots in the National Capital Region (Ottawa) and nine warehouses located across Canada. There are no federal warehouses located in the territories. The Public Health Agency has contracts in place for both custodians and security for all 11 federal warehouses. In the event of a local emergency that overwhelms available municipal resources, the municipality contacts the provincial/territorial emergency management authorities for additional resources. The NESS contains a variety of assets, including medical equipment and supplies (such as ventilators, personal protective equipment such as masks and gloves, <i>etc.</i>); pharmaceuticals (individual items such as antiviral agents, antibiotics, <i>etc.</i>); social service supplies (such as generators, cots, blankets, flashlights, <i>etc.</i>)
Australia	National Medical Stockpile, NMS (15).	The Health Emergency Management Branch (HEMB), Office of Health Protection, within the Department of Health and Ageing (DHA), is responsible for managing the NMS, including inventory management, planning and developing Memoranda of Understanding with states and territories for deployment of the stockpile. The NMS is kept in various strategic locations around Australia. All jurisdictions possess a pharmaceutical stockpile separate from the NMS and all jurisdictions maintain stockpiles of personal protective equipment (PPE) for responding to chemical, biological and radio-nuclear (CBRN) health disaster or pandemic influenza. Decisions to use the NMS are based on both internal and external expert clinical advice and on threat and risk assessment from the Australian National Security Agency. The NMS is a national strategic reserve of essential vaccines, antibiotics, antiviral drugs, chemical and radiological antidotes, and personal protective equipment. It also includes specialized medical supplies, such as the nation's stock of smallpox vaccine.

reserves. Second, standards for emergency medical supplies should be rationally devised and dynamically adjusted in accordance with changes in international and domestic circumstances. Third, programs for the planning, management, storage, deployment, distribution, emergency production, and urgent requisition of emergency supplies should be improved through legislation, and the roles and responsibilities of various departments and individuals in institutional arrangements should be clarified to ensure the effective implementation of those systems. Interagency agreements among the Ministry of Health, the Ministry of Defense, and logistics companies should be drafted to actively facilitate the transportation of medical supplies in response to a public health emergency without disruption or delay. The World Health Organization has pointed out that the world faces a chronic shortage of personal protective equipment such as respirators and masks because of the COVID-19 pandemic (18). To respond to public health emergencies during special periods, countries around the world should establish a system of international cooperation to jointly cope with major emerging emergencies and they should improve the global system for procurement and deployment of emergency supplies, with priority given to medical personnel.

China has set up a team to ensure medical supplies under the State Council that is responsible for the joint prevention and control of the SARS-CoV-2 epidemic.

The production of key medical supplies such as medical protective clothing, medical goggles, medical masks, and disinfection supplies is organized by the Ministry of Industry and Information Technology, which is also responsible for coordinating and deploying urgently needed materials (19). On January 23, the Ministry of Industry and Information Technology of China expedited the delivery of 10,000 sets of protective clothing and 50,000 sets of gloves to Wuhan from the National Medicines Reserve, and it instituted six measures including the establishment of a national temporary production scheduling system for key enterprises and national temporary reserve supplies for epidemic prevention and control (20). Since the SARS-CoV-2 outbreak, China has also received medical masks, protective clothing, goggles, and other materials donated by South Korea, Japan, Britain, France, and other countries. With joint efforts of the international community, China should be able to deal with the epidemic at an early date and help to safeguard regional and global public health security.

References

1. National Health Commission of the People's Republic of China. Latest information of the prevalence of pneumonia caused by the severe acute respiratory syndrome coronavirus 2 as of 12 AM Feb 12. <http://www.nhc.gov.cn/xcs/yqtb/202002/26fb16805f024382bf>

- flde80c918368f.shtml* (accessed February 13, 2020) (in Chinese)
2. State Council of the People's Republic of China. Secretary-General of the Shanghai Cooperation Organization praises China's efforts to combat novel coronavirus pneumonia. http://www.gov.cn/xinwen/2020-01/31/content_5473474.htm (accessed February 9, 2020) (in Chinese)
 3. World Health Organization. WHO Director-General's statement on IHR Emergency Committee on Novel Coronavirus (2019-nCoV). [https://www.who.int/dg/speeches/detail/who-director-general-s-statement-on-ihf-emergency-committee-on-novel-coronavirus-\(2019-ncov\)](https://www.who.int/dg/speeches/detail/who-director-general-s-statement-on-ihf-emergency-committee-on-novel-coronavirus-(2019-ncov)) (accessed February 9, 2020).
 4. Wang LZ. A system for allocation of emergency medical supplies and reserves primarily in large hospitals. *Soft Science of Health*. 2010; 24:402-403. (in Chinese)
 5. Rebmann T, Wagner W. Infection preventionists' experience during the first months of the 2009 novel H1N1 influenza A pandemic. *Am J Infect Control*. 2009; 37:e5-e16.
 6. National Health Commission of the People's Republic of China. Transcript of a press conference on February 4, 2020. <http://www.nhc.gov.cn/wjw/xwdt/202002/35990d56cfeb43f4a70d7f9703b113c0.shtml> (accessed February 4, 2020) (in Chinese)
 7. Wang ZJ. Discussion on establishing a medical stockpile system for public health emergencies. *Chinese Journal of Public Health Management*. 2004; 6:502-503. (in Chinese)
 8. The Central People's Government of the People's Republic of China. Law of the People's Republic of China on Emergency Response. http://www.gov.cn/ziliao/flfg/2007-08/30/content_732593.htm (accessed February 4, 2020) (in Chinese)
 9. Legalweekly. Medical stockpile system needs to be urgently implemented. <http://www.legalweekly.cn/rwjs/17400.html> (accessed February 4, 2020) (in Chinese)
 10. Wu D, Hu DD, Sun M, Li CY, Chang FS, Zhang JH, Li PP, Ning N, Hao M. CDC emergency response capacity and current state of public health emergency in China. *Chinese Journal of Health Policy*. 2014; 7:30-37. (in Chinese)
 11. Guangming Daily. The transformation of and hidden concerns with China's disease prevention and control system. http://epaper.gmw.cn/gmrb/html/2015-04/24/nw.D110000gmr_b_20150424_1-05.htm (accessed February 4, 2020) (in Chinese)
 12. Sun M, Wu D, Shi JH, Li CY, Lv J, Su ZX, Ning N, Zhang JH, Xu P, Hao M. Policy changes related to the handling of public health emergencies in China: From 2003 to 2013. *Chinese Journal of Health Policy*. 2014; 7:24-29. (in Chinese)
 13. U.S. Department of Health & Human Services. Strategic National Stockpile. <https://www.phe.gov/about/sns/Pages/default.aspx> (accessed February 4, 2020).
 14. Government of Canada. National Emergency Strategic Stockpile. <https://www.canada.ca/en/public-health/services/emergency-preparedness-response/national-emergency-strategic-stockpile.html> (accessed February 4, 2020)
 15. The Department of Health of Australian Government. National Medical Stockpile. https://www1.health.gov.au/internet/main/publishing.nsf/Content/health-publhlth-strateg-bio-factsht_stckpile.htm (accessed February 4, 2020)
 16. Jiang XC, Gao XQ, Li WY. Discussion on the model of an integrated emergency stockpile for public health emergencies. *Jiangsu Health Care*. 2013; 15:36-37. (in Chinese)
 17. Wang LZ. Discussion on the mechanism of an emergency medical stockpile for public health emergencies in Guangzhou. *Chinese Health Service Management*. 2010; 27(3):177-177. (in Chinese)
 18. World Health Organization. WHO Director-General's briefing to the Executive Board on outbreak of 2019 novel coronavirus. <https://www.who.int/dg/speeches/detail/who-director-general-s-briefing-to-the-executive-board-on-outbreak-of-2019-novel-coronavirus> (accessed February 9, 2020).
 19. Ministry of Industry and Information Technology of People's Republic of China. Six departments report on the state of key medical supplies and living supplies for epidemic prevention and control. <http://www.miit.gov.cn/n1146290/n1146402/n7039597/c7662828/content.html> (accessed February 9, 2020) (in Chinese)
 20. Ministry of Industry and Information Technology of People's Republic of China. Six measures of the Ministry of Industry and Information Technology to meet demands for the epidemic prevention and control stockpile. <http://www.miit.gov.cn/n1146290/n1146402/n7039597/c7644932/content.html> (accessed February 9, 2020) (in Chinese)
 21. Law Yearbook of China. Notice of the State Council on Reforming and Enhancing the Management of the Pharmaceutical Stockpile. http://www.pkulaw.cn/fulltext_form.aspx?Db=qikan&gid=1510046077 (accessed February 4, 2020) (in Chinese)
 22. The State Economic and Trade Commission. Provisions for a National Pharmaceutical Stockpile. http://www.ccdi.gov.cn/fqk/law_display/3502 (accessed February 4, 2020) (in Chinese)
 23. National Health Commission of the People's Republic of China. Regulations on Preparedness for and Responses to Emergent Public Health Hazards. <http://www.nhc.gov.cn/wjw/flfg/200804/c0aef6fa264048b3b0af617e445144bc.shtml> (accessed February 4, 2020) (in Chinese)
 24. The Central People's Government of the People's Republic of China. The 2004 Revised Law of the People's Republic of China on the Prevention and Treatment of Infectious Diseases. http://www.gov.cn/gongbao/content/2004/content_62975.htm (accessed February 4, 2020) (in Chinese)
 25. The Central People's Government of the People's Republic of China. Master State Plan for a Rapid Response to Public Emergencies. http://www.gov.cn/yjgl/2006-01/08/content_21048.htm (accessed February 4, 2020) (in Chinese)
 26. The Central People's Government of the People's Republic of China. National Contingency Plan for Public Health Emergencies. http://www.gov.cn/yjgl/2006-02/26/content_211654.htm (accessed February 4, 2020) (in Chinese)
 27. National Health Commission of the People's Republic of China. (Draft) Catalogue of health emergency personnel and equipment. <https://wenku.baidu.com/view/b8261d33f11f18583d05aa6.html> (accessed February 4, 2020) (in Chinese)
 28. National Health Commission of the People's Republic

- of China. Guidance on accelerating the creation and development of a public health emergency system. <http://www.cqvip.com/QK/70161X/20108/664581203.html> (accessed February 4, 2020) (in Chinese)
29. National Health Commission of the People's Republic of China. Issuance of Guiding Opinions on Enhancing the Standardization and Devising of Responses to Health-related Emergencies. <http://www.nhc.gov.cn/yjb/s7859/201612/3a3b5ce97fa940c58a64ff1892f4b3e1.shtml> (accessed February 4, 2020) (in Chinese)
30. Esbitt D. The Strategic National Stockpile: Roles and responsibilities of health care professionals for receiving the stockpile assets. *Disaster Manag Response*. 2003; 1:68-70.
- Received February 1, 2020; Revised February 14, 2020; Accepted February 16, 2020.
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- Released online in J-STAGE as advance publication February 17, 2020.