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Influence and analysis of ambulance on the containment of COVID-19 in China

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A B S T R A C T

New coronavirus (COVID-19) is a newly emerging and highly infectious form of typical pneumonia with a high rate of transmission. The COVID-19 pneumonia has spread to 147 countries and areas as of Mar. 16th 2020, which has tremendous impact on the global public health. It is well known that, in China, the pandemic has been contained effectively with a series of emergency measures. It is necessary to share the existing experience of China in the fight against the pandemic to the world. Especially, during the process of prevention and containment of the pandemic, ambulances play an important role in transporting infectious patients. In this paper, focusing on the safety and quantity of negative pressure ambulances, the influence of ambulance on newly confirmed cases is given. Analysis of negative pressure ambulance on the containment of COVID-19 is shown. The potential development of ambulance is discussed. While the pandemic still continues spreading across the world, we hope to share our experience in the implementation of these strategies by China to save more life.

1. Introduction

Since late December 2019, an outbreak of pneumonia caused by the new coronavirus (COVID-19) in Wuhan, China, has a huge impact on the country and the world (WHO). The first case was reported in Dec. 8th; 2019, and most cases were linked to a local seafood market. It is a newly emerging and highly infectious disease with a high rate of transmission. The social and economic impact of COVID-19 is tremendous. On Jan. 31th, 2020, the World Health Organization (WHO) declared the COVID-19 crisis as a “Public Health Emergency of International Concern”. Therefore, this has been brought to global attention and declared a pandemic by the WHO on March 11, 2020. Public health concerns mount as the situation evolves with an increasing number of infection hotspots around the globe. Based on the WHO report, there are only 4 newly confirmed local cases in China on Mar. 16th 2020, while there are 7622 confirmed cases have been reported outside China at the same day.

As of Mar. 16th, 2020, a total of 168,603 cases were confirmed worldwide with 6503 deaths and 77,643 cured, of which China had a total of 81,079 confirmed, 3218 deaths in 146 countries outside China, of which 20,603 were confirmed in Italy, 13,938 in Iran and 8236 in South Korea. Italy, Iran and South Korea have become the three countries with the largest cumulative number of confirmed coronavirus cases outside China. China has implemented many practices rapidly, such as home quarantine, combination of isolation treatment, traffic control, and personnel investigation and so on. Thus the spread of COVID-19 has been contained effectively. Simultaneously, effective prevention and treatment measures in Chinese mainland have provided useful reference for other countries (The Lancet). In addition, China has shared the latest medical progress with the world, which was affirmed and recommended by WHO (GMW). Recently, the number of new diagnosed and fatalities in China has plummeted every week. On Mar. 16th, there were only 4 new confirmed local cases in China, and there were no new confirmed cases in China except Hubei Province. It can be seen that the COVID-19 pandemic has been under control in China.

However, with the spread of the pandemic, the virus raged in many countries, including South Korea, Italy, Iran, Japan, France, Germany, and Spain. As of Mar. 16th, there were a total of 18,479 confirmed cases and 3218 deaths in 146 countries outside China, of which 20,603 were confirmed in Italy, 13,938 in Iran and 8236 in South Korea. Italy, Iran and South Korea have become the three countries with the largest cumulative number of confirmed coronavirus cases outside China. According to an analysis by Marc Lipsitch (Harvard Professor), a professor

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of epidemiology at Harvard, the coronavirus pandemic will spread worldwide, thus areas that are not in serious condition should prepare for the outbreak of COVID-19 seriously. Therefore, it is urgent for China to share the existing experience in the fight against the pandemic with other countries.

During the fight against the pandemic in China, even there were no specific antiviral drugs or vaccines, various advanced medical measures had been formulated and adopted. For example, we used Type I IFNs, potential antiviral compounds such as ribavirin, lopinavir, remdesivir and so on. Also we tried convalescent plasma, protective monoclonal antibody (Pascarella et al., 2020). Even lung transplantation was completed. Advanced medical equipment had been developed and manufactured and put into use, such as ECMO (Hou et al., 2020).

During the process of prevention and containment of the pandemic, ambulances play an important role in transporting infectious patients. Ambulance originated in France in the 15th century. Normally, there are two types of common ambulances, the ward type and the transfer type. The ward type ambulance refers to an ambulance that has first-aid resuscitation equipment and necessary medicines. It can rescue critically injured people on the scene or during transportation. The transfer type ambulance can be used to transfer relatively stable patients to the hospital. During the transfer, only some simple medical treatments such as infusion, oxygen inhalation, hemostasis, and bandaging are allowed. According to various conditions of patients, different ambulances with different functions are generated. Especially, the negative pressure ambulance urgently needed in this epidemic is a type of transfer vehicle.

Negative pressure ambulances used to transport infected patients are regarded as the key point in the containment of COVID-19. Negative pressure ambulance is a vehicle used for first aid and transfer of patients with highly infectious disease. It first appeared during the SARS epidemic in 2003 (Commercial Vehicle, 2003). The working principle of the negative pressure ambulance is to add a negative pressure cabin or negative pressure equipment in the ambulance, causing a pressure difference of 10 Pa to 30 Pa between the exhaust and supply equipment in the ambulance. The influence of the negative pressure ambulance on COVID-19 has not yet been reported, and this information needs to be shared to assist countries with severe epidemics in formulating control strategies.

In this paper, focusing on the safety and quantity of negative pressure ambulances, the influence of ambulance on newly confirmed cases is given. Analysis of negative pressure ambulance on the containment of COVID-19 is shown. The potential development of ambulance is discussed. While the pandemic still continues spreading across the world, we hope to share our experience in the implementation of these strategies by China to save more life.

2. Influence of ambulance numbers on newly confirmed cases

After the outbreak, the output of ambulances in China increased rapidly. As can be seen from Fig. 1, the total output of ambulances in China in 2019 was 8949 (Wenxiang, 2020). During the epidemic, the output of ambulances in the first quarter of 2020 reached 9396, exceeding the total amount of 2019. In particular, comparing the proportion of the number of ambulances in Hubei Province to China, it can be found that the ratio of ambulances in Hubei Province in the first quarter of 2019 was 4%, and this was increased to 14.3% in 2020. It shows that during the epidemic, the increase in the number of ambulances in Hubei Province is one of the important measures to control the spread of the epidemic.

Ordinary ambulances are inadequate in transporting new crown patients. New coronavirus spreads mainly through direct transmission and contact. On Feb. 5th, 2020, the National Health and Health Commission issued the Diagnosis and treatment of pneumonia caused by novel coronavirus infection (trial version 5) (Diagnosis and treatment), aerosol and gastrointestinal transmissions were also listed as possible routes of transmission to be identified. Therefore, COVID-19 can not only be transferred to subsequent patients and to EMS workers by direct contact with the surfaces or by indirect transmission via hands, but also there is a risk of leakage of virus with air as the medium. According to WHO, when a person coughs, sneezes, laughs, or talks, large (>5 μm diameter) and small (<5 μm diameter) droplets or aerosols are generated. Due to gravity, larger droplets fall to the ground quickly. Therefore, droplet transmission requires close physical proximity between an infected individual and a susceptible individual. On the other hand, small droplets or small particle residues of evaporated droplets have a low settling velocity, so they may remain in the air for a longer time and travel further before they can enter the respiratory tract or contaminate surface (Ge et al., 2020). Kutter et al. (Kutter et al., 2018) suggested that aerosols especially in highly virulent pathogens could travel more than 6 feet. Therefore, in the treatment and transfer of infected patients, ordinary ambulances are incapable. Some special protective ambulances are needed to prevent the epidemic from spreading further, as well as protect the EMS workers and also other people nearby.

At the beginning of the pandemic, negative pressure ambulance resources were insufficient because too many patients needed to be transferred and treated. Then, the Ministry of Industry (short for ‘Ministry of Industry and Information Technology of the People’s Republic of China’) took steps, and requested some domestic auto companies to work overtime, as shown in Fig. 2. Up to Feb. 5th, it took 10 days to produce 244 negative pressure ambulances. As of Feb. 15th, 360 negative pressure ambulances were transported to Hubei. On Mar. 3rd, there were 690 negative pressure ambulances in Hubei Province, and 239 in Wuhan. As of Mar. 5th, major manufacturers have transported nearly 2000 negative pressure ambulances to all parts of the country, while a total of 700 negative pressure ambulances had been transported to Hubei. On Mar. 12th, a total of 800 negative pressure ambulances were transported to Hubei. Thanks to manufacture’s efficient production, more infectious patients could be transferred quickly, thus more life.
were saved. From these figures, it can be seen intuitively that from February to March, there have been more and more negative pressure ambulances in Hubei Province, while the number of new cases dropped rapidly. On Feb. 5th, there were 224 negative pressure ambulances, and 2957 newly confirmed cases. Interestingly, on Mar. 12th, there were 800 negative pressure ambulances, and only 8 newly confirmed cases. In order to make this point clearer, the variation of newly confirmed cases with negative pressure ambulance is shown in Fig. 3. There was an obvious monotonic decreasing law between the two data. The variation curve fitted well with the actual data. The ratio of negative pressure ambulances to newly confirmed cases in Hubei increased from 0.08 to 100, which ensured that infectious patients could be safely transported and treated in time. The pandemic has been effectively contained in China. However, the pandemic still continued spreading across the world, worsening the situation in many countries. The number of confirmed cases in some countries is not directly proportional to the supply of negative pressure ambulances, and patients cannot be resettled in time. In South Korea, the number of confirmed cases across the whole country increased largely from Jan. 20th to Feb. 23th. But transportation of all patients is no longer possible. As of Feb.26th, there is only one negative pressure ambulance in Gwangju (GFN 98.7MHz). With 7 cases of COVID 19 infected in Gwangju, 6 were transported by ordinary ambulances and only 1 was transported by negative pressure ambulances. Even though the government took many steps, as of Mar. 5th, many patients in Daegu and Gyeongsangbuk-do still cannot be transported to hospitals (Daegu). In Iran, many drugs and medical equipment rely on imports. Due to U.S. sanctions on Iran, many advanced medical devices are banned and medical resources are in short supply. In Italy, as of Mar.9th, the scope of the blockade in response to the epidemic has been extended to the whole country. On Mar. 8th, doctor Daniele Macchini from Bergamo Intensive Care Unit (Con le nostre) stated that, as the number of confirmed cases continued to rise, medical equipment and beds could not cope with the increasing patients. On Mar. 9th, the Niguarda Hospital in Milan (Covid-19) stated that, in the face of the shortage of resources, the Niguarda Hospital began to classify patients to ensure targeted treatment for critically ill patients.

3. Analysis of negative pressure ambulance on containment of COVID-19

Through the analysis in the previous section, after increasing the number of negative pressure ambulances, the number of confirmed cases decreased significantly. In many epidemics, negative pressure ambulance has made great contributions to the safe and effective transfer of patients due to its special functions. With the outbreak of COVID-19, on Jan. 29th, in accordance with the relevant requirements of the Technical specifications for disinfection of medical institutions (WST367-2012) (Liuyi et al., xxxx) and the characteristics of the epidemic, the National Health and Health Commission has formulated the Work plan on the transfer of cases of pneumonia due to new coronavirus infection (Work plan). It clarified the transfer workflow of specific patients, and gave the requirements for ambulance cleaning and disinfection. The disposal of medical waste shall be carried out in accordance with the Hospital infection management measures and Technical standard for disinfection and related regulations. Focusing on the influence of negative ambulance, the mechanism of adding negative pressure ambulances to control the epidemic mainly includes the following aspects.

3.1. Effective negative pressure

During the using of the negative pressure ambulance, the air can only flow from the outside to the inside of the ambulance. The disinfection and filtering device are used to sterilize the air entering the ambulance before discharging (which can kill 99.97% of bacteria). Therefore, a fixed air flow field area is formed in the negative pressure compartment. The air can flow from the clean area (medical staff area) to the infectious source area (patient area). The dead space and vortex of the air flow can be minimized. Schematic diagram of negative pressure ambulance is shown in Fig. 4.

To achieve the goal of protective isolation, the negative pressure ambulance is mainly equipped with three devices: negative pressure generator, ventilation equipment and isolation stretcher. The negative pressure generator is responsible for generating a pressure difference between the inside and outside of the ambulance, and creating a negative pressure environment for the interior of the ambulance. The ventilation equipment is responsible for delivering fresh air to the interior of the vehicle. It has a purification function to ensure that the air entering and outside the vehicle is clean. The isolation stretcher is responsible for transporting and placing patients. It is shaped like a capsule. It has an air filter inside to ensure that air contaminated by the viruses or microbes cannot flow out. It can be seen that, compared with traditional ambulances, negative pressure ambulances are easier to control the virus under this function to protect the safety of other personnel.

3.2. Strict disinfection requirements

During the procedures for the disinfection of negative pressure ambulance, disinfectants such as ether, 75% ethanol, chlorine-containing disinfectants, peracetic acid, and chloroform can be highly effective at killing coronavirus. After each transportation the ambulance

**Fig. 2.** Comparison of the number of negative pressure ambulances and newly confirmed cases in Hubei Province.

**Fig. 3.** Relationship of the number of negative pressure ambulances and newly confirmed cases in Hubei.
needs to be disinfected. The procedures include: Spraying the compartment with 5% peroxacetic acid disinfectant, closing the compartment for two hours for fumigation, opening the window for 30 min, wiping the compartment with a concentration of 1000 mg / L disinfectant, and wiping the instruments with 75% alcohol or disinfection water, and using ultraviolet germicidal irradiation for half an hour in the final step. These procedures are tedious and time-consuming. On some negative pressure ambulances, automatic biological disinfection or sterilization equipment is installed, which can shorten the time from 90 min to 30 min compared with traditional disinfection methods. Some negative pressure ambulances are equipped with a linear ozone sensor, which can monitor the ozone concentration in the ambulance in real time. When the ozone concentration in the ambulance drops to a safe range, the detector will send a notice to the management staff as soon as possible. This saves the time for the driver and medical staff to wait for the purified negative pressure ambulance compartment. In terms of wearing protective equipment for hospital medical staff, the national emergency issued the Technical guidelines for the protection of medical personnel during a new coronavirus-infected pneumonia outbreak (Technical guidelines, xxxx). Taking the standards of the Shanghai Public Health Clinical Center as an example. Table 1 shows the protection requirements of the medical staff responsible for the operation and disinfection of the ambulance.

With the strict disinfection and cross-infection prevention measures, the ambulance can ensure the safety of patients and medical staff during transportation. The right types of disinfectants and the optimization of ultraviolet sterilization devices are crucial to disinfection. Since there is an additional negative pressure chamber, virus could be concentrated in it and the disinfection could be more focused on the chamber, which thus need more strict disinfection, and also increase the efficiency. Compared with other final disinfection, UVGI (ultraviolet germicidal irradiation) systems have several potential advantages for terminal disinfection. They are relatively simple and easy to use, and do not leave chemical residues or risk exposing patients and workers to toxic chemicals. However, UVGI systems has limitations (William and Lindsley, 2018). Also, reasonable staffing of the ambulance medical team and the provision of adequate disinfection equipment in the hospital, can help improve the safety and reliability of the ambulance (Park et al., 2017), improve the treatment rate of infectious patients, and ensure the safety of medical staff.

### 3.3. Fast supply of hospital beds and negative pressure ambulance

In Wuhan, Hubei, in order to treat the critical ill patients in time, on Jan. 23th, the Wuhan Municipal Government decided to build the Huoshenshan (Fire God Mountain in Chinese) hospital and Leishenshan (Thunder God Mountain in Chinese) hospital. In Chinese traditional culture, gods of fire and thunder are responsible for eradicating the epidemic.

From Jan. 24th to Feb. 2nd, the Huoshenshan hospital was completed in only 10 days with an area of 34,000 square meters, and 1000 beds equipped with. From Jan. 24th to Feb. 6th, the Leishenshan hospital was completed in only 14 days with an area of about 60,000 square meters, and 1600 beds equipped with and a living area for 2000 medical staff. The construction progress of the Huoshenshan hospital is as follows: On Jan. 24th, hundreds of machines began to level the land; on Jan. 25th, the construction of the hospital was officially started; on Jan. 26th, the first model house was completed; on Jan. 27th, the container board house started to be hoisted and constructed; on Jan. 28th, the steel structure was built in the double-layer ward area; on Jan. 29th, the board room construction was fully rolled out, and the electromechanical equipment was installed; on Jan. 30th, the impermeable membrane laying work was fully completed; on Jan. 31st, 90% containers assembly were completed; on Feb. 1st, medical supporting equipment was fully installed; on Feb. 2nd, the hospital was completed. The progress of the construction of Huoshenshan and Leishenshan hospitals is shown in Fig. 5.

The rapid completion of Huoshenshan and Leishenshan hospitals ensured that critical ill patients in Wuhan could be treated in time. And the centralized management prevented the spread of the pandemic and reduced the scope of the susceptible infectious area as much as possible. The two quickly built hospitals provided with 2600 beds available. With the continuous increasing supply of facilities and equipment, the pandemic can be effectively contained.

It is reported that in the morning of Feb. 4th, 10 negative pressure ambulances set off from Wuhan emergency center to Huoshenshan hospital, and the first batch of 50 critical ill patients received by Huoshenshan hospital were transferred safely and efficiently. The number of negative pressure ambulances in Huoshenshan and Leishenshan hospitals at the initial stage is shown in Table 2.

With the implementation of the emergency work on Huoshenshan and Leishenshan hospitals, the supply of negative pressure ambulances has become more and more sufficient. In a short time, all walks of life...
donated a large number of negative pressure ambulances to designated hospitals in various areas in China. The production of negative pressure ambulances in China has increased from 50 per year to 100 per day. Adequate supply of negative pressure ambulances ensured efficient and orderly development of emergency work, bought time for the prevention and contain of the pandemic, and decreased the spread of the pandemic.

In order to fight against Covid-19, a number of Chinese automotive and air equipment manufacturers resumed production in advance (under the premise of safety) and worked overtime to make products while guaranteeing product quality. A large number of advanced negative pressure ambulances were provided in a short time, as shown in Table 3.

Table 2: Supply of negative pressure ambulances in Huoshenshan and Leishenshan hospitals (China logistics, xxxx).

| Date      | Newly | Total | Hospital              |
|-----------|-------|-------|-----------------------|
| Feb.3rd   | 20    | 20    | Huoshenshan           |
| Feb.5th   | 30    | 65    | Leishenshan           |
|           | 10    | 5     | Huoshenshan and Leishenshan |
| Feb.6th   | 6     | 71    | Huoshenshan and Leishenshan |
| Feb.8th   | 2     | 73    | Huoshenshan and Leishenshan |
| Feb.10th  | 20    | 93    | Huoshenshan and Leishenshan |
| Feb.15th  | 14    | 107   | Huoshenshan and Leishenshan |

After the outbreak of SARS in 2003, plentiful experiences have been accumulated and strategic deployment of highly infectious diseases has been implemented. Some auto companies were committed to researching ambulances for infectious diseases and developing related patented technologies. From 2003 to 2020, China authorized more than 37 invention patents and utility model patents for negative pressure isolation equipment, and authorized more than 12 invention patents and utility model patents for negative pressure ambulances. JMC Group, China’s largest ambulance company, quickly developed the nation’s first SARS transfer ambulance during the SARS epidemic in 2003 (mobile N95, xxxx). In 2010, JMC’s self-developed negative pressure ambulance technology first obtained a national utility model patent in China, which had contributed to multiple influenza epidemic such as H1N1 influenza.

Table 3: Urgent production of negative pressure ambulances by auto companies (Economic Observer, xxxx).

| Auto Company       | Urgent Order | Delivery Situation                                      |
|--------------------|--------------|--------------------------------------------------------|
| JMC Group          | 40           | 20 Delivered on Feb.3rd, and 180 delivered as of Feb.14th |
| SAIC Chase Company | 30           | 30 Delivered on Feb.5th, and 60 delivered to Wuhan as of Feb.6th |
| Yutong Auto        | 55           | 55 Delivered on Feb.5th, and another 300 orders were being expedited |
| Brilliance Auto    | 30           | 10 Delivered on Feb.5th and 20 delivered on Feb.20th    |
| Qirui Auto         | 20           | 20 Delivery on Feb.5th                                |
| Ningbo Kaifule     | 10           | 10 Delivery on Feb.5th                                |
| Fujian Mercedes Benz | 20          | 20 Delivery on Feb.5th                                |
| FOTON Company      | 50           | 40 Delivered on Feb.8th, and 10 delivered as of Feb.15th |

Fig. 5. The construction progress of Huoshenshan hospital on (a) Jan.24th (b) Jan.31st (c) Feb.2nd and Leishenshan hospital on (d) Jan. 26th (e) Feb.4th (f) Feb.6th.
In 2013, JMC Group and its head of R&D became the main drafting unit and main drafter of the *National ambulance industry standard*. On Feb. 4th, 2020, Geely Group started the research of “all-round healthy car” with virus prevention function (Geely invests, xxxx). On Feb. 24th, 2020, Geely ICON went on the market, becoming the first mass-produced car equipped with the CN95 air filter in the auto industry. ICON has functions of isolating harmful substances in the external air and purifying the air in the car. Focusing on making a breakthrough in the functions and technologies of virus prevention, the “all-round healthy car” will use materials with higher environmental protection, lower emission. Also it needs abilities of inhibiting bacteria and surface sterilization. Anti-virus vehicles launched by Geely for ordinary consumers can realize the goal of civilization of anti-virus, and make people travel more safely.

Before the outbreak of COVID-19, the annual production and sales of negative pressure ambulances in China was only about 50. And as of Mar. 5th, the daily output of negative pressure ambulances in China had exceeded 100. The daily output of negative pressure systems has been increased from less than 20 to more than 120. To date, many manufacturers had delivered nearly 2000 negative pressure ambulances to the whole country, of which a total of 800 negative pressure ambulances had been delivered to Hubei (Ministry of Industry, xxxx).

4. Potential development of ambulance in the future

The development of the 5G, big data and smart technologies will promote the innovation of pre-hospital treatment methods. During the epidemic, the traffic was inconvenient, because all the public transportation and private cars were all restricted. Also there was a risk of infection when going out. So far, a wide range of distinct operational procedures and measures have been implemented with respect to the inconvenient traffic, such as community service vehicle, remote consultation technology. The continued challenges of social distancing, containment, isolation, and surge capacity in already stressed hospitals, and emergency departments also have led to a swell in remote consultation. Through remote consultation technology, high-level hospitals could provide guidance to some county- and town-level health centers, also this could help avoid cross-infection. Moreover, remote consultation technology could help reduce some patients’ financial burden on treatment because of traffic fees and higher fees of high-level hospitals. In addition, it could balance the level of hospitals’ response to emergencies.

On Feb. 12th, the first 5G + 4K transfer ambulance of the New Coronavirus Pneumonia Patient Transfer Command was put into use in Nanjing, Jiangsu (Jiangsu’s first 5G, xxxx). Through the mobile 5G high-definition video consultation equipment on board, the staff of the emergency center reported the condition of a 41-year-old suspect to the headquarters 17 km away. The 5G + 4K transfer ambulance was equipped with 5G CPE and 4K high-definition video surveillance equipment. The video and image data in the car were transmitted back to the command department in real time through the mobile 5G network. The details of the transfer work and the instruction transmission were fully communicated with the on-board personnel. If necessary, the headquarters can also initiate a 5G remote consultation with hospital experts or even high-level hospital experts, and quickly handle the emergency conditions of patients in the transfer ambulance. Since the common communication already takes place between ambulances and their corresponding hospitals and doctors, this is different with 5G + 4K transfer ambulance. As of Feb. 26th, Nanjing New Coronavirus Pneumonia Patient Transfer Command had launched 3 5G + 4K New Coronavirus Pneumonia Patient Transfer Vehicles, which will be promoted and applied in the whole province at a later stage (Mobile 5G, xxxx).

What’s more, experts could perform some medical procedures through 5G network. For example, on Feb. 18th, experts in Zhejiang Provincial People’s Hospital completed remote ultrasonic examination through 5G network. In addition, on Feb. 8th, medical staff in Beijing and Wuhan implemented remote case discussion by using Huawei Cloud WeLink + 5G (Huawei Cloud WeLink, xxxx). As of Mar. 3rd, Huawei Cloud WeLink has provided services to more than 6000 hospitals including Peking University Hospital, Peking Union Medical College Hospital, CUHK First Hospital and CUHK Five Hospital. The WeLink opened the “telemedicine solution”, which included five major functions such as remote diagnosis and treatment, remote visits, remote conferences, medical record collection and targeted push. Doctors can provide comprehensive high-definition remote consultation guidance, provide diagnosis and treatment timely. Moreover, doctors can uniformly view cases in the background, and observe the condition variety of patients all the time.

As is known, physical distancing strategies (PDSs), ranging from less restrictive social distancing to complete closure of society, or “shelter-in-place” orders, is an approach to contain and mitigate the severity of the COVID-19 pandemic. Since the WHO declaration of a pandemic, governments around the world have advised people to stay at home as much as possible. Under such conditions, the development and utilization of telemedicine-based services are critical to allowing high-risk and vulnerable patients to continue receiving care. With the development of Internet, and the telemedicine platform supported by 5G technology, the application of ambulance will be more intelligent, efficient and personalized.

The development of the Internet and 5G technology can ensure the efficiency of pre-hospital treatment. In terms of COVID-19 epidemic in China, on Feb. 8th, medical staff in Beijing and Wuhan used Huawei Cloud WeLink + 5G technology to implement remote case discussions. As of Mar. 3rd, Huawei Cloud WeLink has provided services to more than 6000 hospitals in China. Through the WeLink, doctors can provide a full range of careful remote consultation guidance, timely diagnosis and treatment. Also, doctors can uniformly view cases in the background, and observe the patients’ situation all the time.

The combination of intelligent technology and the big data can bring a major breakthrough in ambulance rescue. In Japan, the researchers developed a smart ambulance approach alarm system, which could open the position information of ambulances within a necessary minimum range. This information helps an ambulance operation to choose a traveling route avoiding a heavy traffic jam. Thus the combination of smart phones, car navigation equipment and car navigation application can make ambulance be operated more efficiently in the future (Kobayashi et al., 2019, E102.D(9):1689–1692). Iranian scholars studied that, for some patients who need real-time monitoring or in unstable conditions, wearable electronic devices can continuously monitor the situation of patients. Nowadays, the rapid development of intelligent systems and advanced devices provides the possibility for the use of wearable systems in the future. Designing smart tools such as wearable smart blankets plays an important role in monitoring, recording, and transferring vital signs especially in ambulance (Rezayi et al., 2019). With the development of vehicle networks and driver-less technology, ambulance is expected to provide patients with more secure and private remote consultations (Gopi and Rajesh, 2017). Self-driving ambulances can increase the rate of consultations (Zarkeshev and Cizzar, 2019). Active collaboration of intelligent technology and emergency personnel can improve the efficiency of pre-hospital treatment for patients (Johnson et al., 2017).

Moreover, the ambulance dispatch data can intuitively reflect the spread speed of acute infectious diseases (such as influenza) in a certain region. It is suggested as a means of real-time, syndromic surveillance for early detection for infectious diseases. Due to ambulance’s wide reach into the community, the onset and outbreak of infectious diseases can be figured out, thus guidance for the prevention and control of seasonal influenza can be provided. Researchers from Australia (Coory et al., 2009) and the Netherlands (Monge et al., 2020) had studied the ambulance dispatch data of the city of Melbourne and the Netherlands respectively, and revealed that ambulance dispatch data really could
analysis the situation of pandemic.

In summary, the development of the 5G, big data and smart technologies will promote the innovation of pre-hospital treatment methods. Combination of advanced technology and medical equipment will enable future ambulances to provide patients with more efficient, safe and intelligent services. This can help to improve the efficiency of the treatment for patients, thus reduce the burden on hospitals, and make a new medical breakthrough. Still, there are no definite answers when will the COVID-19 pandemic end and whether COVID-19 will re-emerge. The threat posed by this most recent emerging disease has however prepared improved ambulance not only to be used in potential future cases of COVID-19 but also other emerging threats to public health.

5. Conclusion

New coronavirus (COVID-19) is a newly emerging and highly infectious form of typical pneumonia with a high rate of transmission. The pandemic has been contained effectively with a series of emergency measures in China. Ambulances play an important role in transporting infectious patients. Focusing on the safety and quantity of negative pressure ambulances, the existing experience of China in the fight against the pandemic is shared from the following aspects.

1) The number of ambulances of China was greatly increased, especially for the negative pressure ambulance. The production of ambulance in the first quarter of 2020 has exceeded the whole number of 2019. In addition, the ratio of ambulance in Hubei Province to the whole country has been increased a lot comparing the data in 2019 and 2020.

2) Negative pressure ambulances had positive influence on the contain of COVID-19. The newly confirmed cases were decreased dramatically from 8 to 8 with the negative pressure ambulance from 200 to 800 in Hubei Province. There was an obvious monotonic decreasing law between the two data. The variation curve fitted well with the actual data.

3) The reason of negative pressure ambulance on the containment of COVID-19 is analyzed. The effective negative pressure and strict disinfection measures ensured the control and elimination of the virus. Meanwhile, the fast supply of hospital beds and negative pressure ambulance supporting by all the country can quickly handle confirmed patients and avoid further spread of the virus.

4) The development of the 5G, big data and smart technologies will promote the innovation of pre-hospital treatment methods. Combination of advanced technology and medical equipment will enable future ambulances to provide patients with more efficient, safe and intelligent services.

While the pandemic still continues spreading across the world, we hope to share our experience in the implementation of these strategies by China to save more life.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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