

# Innovative Strategies and Efforts of Clinical Pharmacy Services During and After COVID-19 Epidemic: Experience from Shanghai Children's Hospital

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**Abstract:** Coronavirus disease 2019 (COVID-19), the result of infection by the SARS-CoV-2 virus, has caused a global pandemic. To respond to this outbreak rapidly and properly, clinical pharmacists in Shanghai Children's Hospital carried out innovative measures based on previous artificial intelligence experiences, such as using service robots for contactless drug delivery between Fever Clinic and Pharmacy Storage, providing telemedicine counseling on specific platforms and offering multimedia health education. With good control of the pandemic in Shanghai, these contactless services have been retained and expanded at the patients' request. The aim of this article is to share our strategies and efforts with peers who are fighting against COVID-19 in other countries and regions.

**Keywords:** COVID-19 pandemic, China, pharmacists, hospital pharmacy services, contactless services

## Introduction

Coronavirus disease 2019 (COVID-19), caused by infection with the novel coronavirus SARS-CoV-2, has since spread throughout the world. The disease was declared a pandemic on March 12, 2020, by the World Health Organization (WHO).<sup>1</sup> Shanghai is a large international city (population over 27 million) in China, where approximately 9.7 million of the residents commute. COVID-19 was first reported in Shanghai on January 20, 2020. Because of their immature immune systems and respiratory tracts, children are often susceptible to respiratory viral infections, and it was thus necessary for clinicians to prevent the spread of the virus among children, although subsequent observations showed that the disease was generally both milder and had a better prognosis in pediatric patients than in adults.<sup>2,3</sup> In Shanghai, the Pediatric Hospital of Fudan University is the only hospital designated for treating children with COVID-19. Shanghai Children's Hospital is an academic hospital, as well as a comprehensive regional medical center, which is equipped with 800 beds and serves 2500–2600 thousand out-patients yearly. It is a serious challenge for all hospitals to respond properly to the pandemic, requiring an efficient, synchronized, and event-driven pharmacy support system. The Department of Pharmacy in Shanghai Children's Hospital gave emergency responses to this outbreak by carrying out some innovative

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measures, such as using service robots for contactless drug delivery between Fever Clinic and Pharmacy Storage, providing telemedicine counseling on specific platforms and offering multimedia health education. By the third week of March 2020, China had reported no new domestic cases, indicating the end of the first peak.<sup>4</sup> Although there have been several imported cases identified in Shanghai since then, pre-COVID-19 medical service is gradually being restored in this area, including Shanghai Children's Hospital. Since then, a number of the hospital's contactless services have reverted to their former face-to-face forms, while some of them are still in operation and have even been expanded during the post-pandemic period at the patients' request.

In this article, we summarized the experiences of clinical pharmacists in Shanghai Children's Hospital during this pandemic, in which artificial intelligence and robotics play an important role. As a result of these adaptations and innovations, pharmacists have acquired invaluable experience and knowledge that can be applied in future practice. The purpose of this article is to share and discuss the use of these strategies and efforts to meet evolving health care challenges.

## Materials and Methods

We performed an extensive literature search to identify publications pertaining to innovative strategies and efforts of clinical pharmacy services. PubMed database from January, 2020 to July, 2021 was searched for related published articles, the search strategy was implemented and keywords (in the title/abstract) were used as below: "COVID 19" OR "coronavirus" OR "SARS-CoV-2" AND "Pharmacists" OR "Hospital pharmacy services" OR "Contactless services". Non-English articles and duplicated studies were excluded. Furthermore, references cited in the included articles were systematically reviewed to further identify any studies that might have been missed.

## Drugs Supply Management

Disruptions to both production and logistics during the pandemic may lead to problems in the supply and delivery of drugs.<sup>5</sup> An Emergency Leadership Committee was established to fulfill an administrative response to the outbreak. To prevent and resolve logistical delays during the epidemic, pharmacists used the information network technology for drug procurement. It used previous sales records from the Hospital Information System (HIS) to automatically create new orders which the pharmacists could then adjust and

submit. It used previous sales records from the Hospital Information System (HIS) to automatically create new orders, which the pharmacists could then adjust and submit. The orders were submitted electronically to the suppliers, allowing timeous delivery of the medicines. This system allows the sharing of information between hospitals and suppliers, optimizing the procurement procedure, improving efficiency, and reducing the risk of infection by minimizing human contact as much as possible.

In addition, possible shortages of protective and preventative products, such as masks and hand sanitizer, need to be addressed. Pharmacists tried to accumulate pharmaceutical product stocks, using the guidelines of the

CORONAVIRUS SARS-CoV-2 INFECTION: Expert Consensus on Guidance and Prevention Strategies for Hospital Pharmacists and the Pharmacy Workforce (Chinese Pharmaceutical Association; 2nd ed)

for environmental protection recommendations determined according to risk levels.<sup>6</sup>

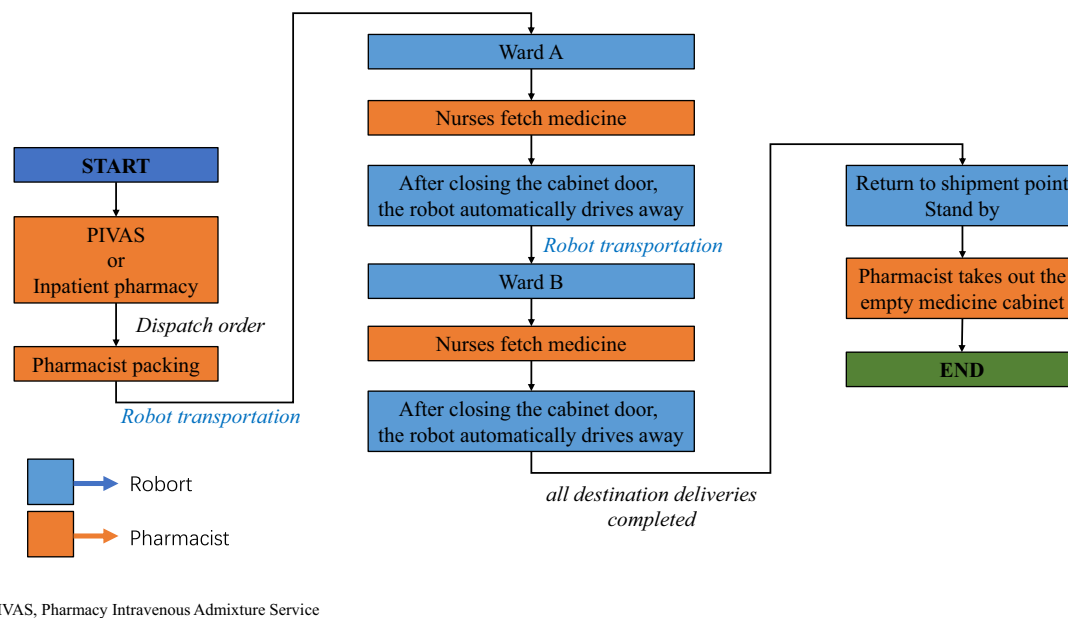
## Drugs Delivery

Innovative methods for the dispensing and storage of drugs, such as the use of automation and intelligent storage facilities, are advocated in medical organizations to reduce the possibility of cross-infection.<sup>7</sup> Contactless drug delivery plays a vital role in preventing virus transmission in the COVID-19 pandemic. The pharmacy dispensing in our hospital was partly supported by four service robots (The NOAH hospital logistics robot, JDN-W09D, FC SAN+IP SAN System). Robots are able to perform a variety of tasks, including medication and food delivery, the measurement of vital signs, sample collection, disinfection, and monitoring border controls. The pandemic has escalated the potential applications of robotics.<sup>8</sup> As early as June 2018, two autonomous navigating robots were first used to transport heavy medical supplies in Shanghai Children's Hospital. The route was designed between Drug Allocation Center and the wards of Respiratory Department. It stored a map of the hospital by importing CAD drawings of the building and it was used to create an on-board map. The robot contained infrared and ultrasonic sensors as well as a scanning laser that were used in real-time to monitor and model its surroundings to control its position and movements. It could also transmit instructions to the elevator as to the destination floor via a wireless network. Once the delivery has been completed, the robot returns to its charging dock (Figure 1).

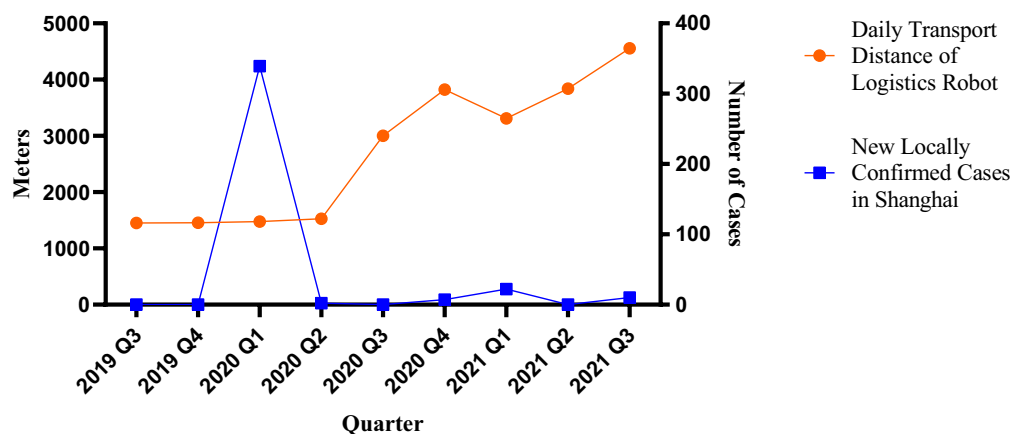
Robots are characterized by great load, stable transportation, time stability and so on. Several technical challenges were overcome gradually, including navigating through narrow, snake-like corridors, and high human footfall, and a total of four logistics robots had been used for transporting the intravenous medication to the wards of Respiratory Department, Digestive Department and Cardiology Department by the end of June, 2019.

According to official data from the Shanghai Municipal Health Commission, the outbreak began in January 2020 and was rapidly controlled before the second quarter of 2020,

while people were still in voluntary isolation. The transport region of robots turned into 13 wards in the early days of the COVID-19 epidemic, and pharmacist services based on telemedicine were provided at that time. The average daily transportation distance of our logistics robots in the third quarter of 2020 has doubled due to the explosive growth in medical demand and continued to increase except during the first quarter of 2021 when the local confirmed cases in Shanghai affected the number of hospitalized patients in Shanghai Children's Hospital again. The application of robots not only increased the efficiency but also allowed



**Figure 1** Work flow chart of logistics robot. The robot loaded up by pharmacists heads to the ward, where the nurse fetches medicine, and the robot heads to the next ward automatically until it's done and back to the pharmacy.



**Figure 2** Operation data of robots (July 01, 2019- September 30, 2021). The average daily transportation distance of our logistics robots in the third quarter of 2020 has doubled due to the explosive growth in medical demand and continued to increase except during the first quarter of 2021 when the local confirmed cases in Shanghai affected the number of hospitalized patients in Shanghai Children's Hospital again.

the staff to focus their attention on higher priority tasks (Figure 2).

During the pandemic in Shanghai, specialized fever clinics were established in each of the city's comprehensive hospitals as well as in approximately 160 community hospitals. These clinics were physically separated from the hospital emergency departments and were designed specifically as the first station for outpatients with fever. The clinics' ventilation was also redesigned to avoid backflow of air. A separate COVID-19 fever clinic was established in the Shanghai Children's Hospital, with four quarantine rooms for patients strongly suspected of being infectious. Based on the successful experiences of using service robots for delivering drugs between the central supply and the ordinary wards, a robot was assigned to be supportive for drug delivery between fever clinics and the pharmacy. Until May 1st, 2021, the contactless drug delivery of robotic system in Shanghai Children's Hospital had operated for 1000 days and it helped to reduce virus transmission to a large extent.

The walking speed of the normal person is 1.5m/s, and the distance of each step is about 0.75 m, the total distribution distance of the robot in 2020 is 731082 m, which is equivalent to 97 thousand steps of manual walking. The maximum load of a single manual distribution is about 120 kg, and the total deadweight of the robot in 2020 is 77423 kg, which is equivalent to 645 times of manual distribution. In terms of cost-effectiveness, it takes about 16.97 min (round trip) to get to a single ward in the model of manual distribution, and it needs at least 4 times of daily distribution for every single ward. Since there are 13 hospitalized wards, then the daily working hours of manual distribution is  $16.97 \times 52 = 882.44 \text{ min} = 14.71 \text{ h}$ , which means 1.8 manual workers are needed (8 hours per person per day). The salary expenditure is calculated at 3500 yuan per month, and the annual labor cost is about  $3500 \times 1.8 \times 12 = 75,600$  yuan per year. The cost of single input and transformation related to logistics robot in hospital is about 1.212 million yuan. The daily power consumption of recharging is about 4 kw (h) per unit, then the annual power consumption of 4 robots is about  $(4 \times 4 \times 365) \times 0.8 = 4672$  yuan per year. The annual maintenance cost of four robots is about 50,000 yuan. From the point of view of the life cycle, the annual cost saving of the robot distribution mode is about  $76,500 - 4672 - 50,000 = 21,828$  yuan.

As the robot serving the fever clinic is likely to have been exposed to the coronavirus, it was subject to strict

disinfection procedures. Before and after each delivery, the robot's surface was sponged with 75% alcohol and disposable bags were used for medicine. The room used for robot charging was disinfected by an automatic air disinfection machine twice daily (04:00–6:00 and 20:00–22:00), and the floor in the room was washed with disinfectant containing 1000–2000 ppm chlorine at least once a day. The routes between the infusion pharmacy on the second floor to fever clinic, intestinal clinic and infection (respiratory) clinic are in the planning stages to reduce manual contact and the occurrence of cross-infection. In next phases, we will deploy automatic loading-unloading platforms for some departments to improve transportation efficiency. We hope the experiences will extend to other hospitals through the Pediatric Medical Combination.

## Telemedicine Counseling

During the disruptions caused by COVID-19 to the health services, telemedicine has proved to be an invaluable means of maintaining delivery continuity for patients.<sup>9,10</sup> It has also assisted in protecting healthcare facilities and their staff at a time of intense pressure from the risk of infection.<sup>11</sup> During COVID-19, 6 large comprehensive hospitals in Shanghai were designated as licensed internet hospitals to ensure rapid response to the virus outbreak, offering patients both online and offline diagnosis and treatment. Shanghai Children's Hospital is one of those hospitals, and pharmacists were able to collaborate with pediatricians to dispense and process prescriptions, as well as conveying the medication to the patient and following up.

Revisit patients can get the pharmaceutical services from "cloud pharmacy care" platform. According to previous regulations, the drugs ordered by hospital were transported from pharmaceutical enterprises to the hospital warehouse through logistics, and then pharmacists distribute the drugs to the patients according to the doctor's prescription. "Cloud pharmacy care" is an innovation of pharmaceutical supply chain that supply a telemedicine consultation. According to "Cloud pharmacy care" implemented during the COVID-19 pandemic, if guardians apply for an online revisit, specialists will write an electronic prescription based on patients' personal information on the internet platform. The prescriptions then will be sent to pharmacists automatically to confirm the reasonableness. After payment, the information of prescription is transmitted directly to the pharmaceutical distributors, and

then the pharmaceutical enterprises allocate the drugs in the warehouse, print the list, and distribute the parcels to the home by special personnel. “Cloud pharmacy care” contribute to optimize configuration with the advantages of lower costs of turnover time, labor and logistics.

Patients can consult with the pharmacists by text, pictures, or online calls on issues related to medications, such as chronic medication management, drug reformation, guidance, and counselling on WeChat social media groups. All questions will be answered within 24 hours. There were about 30 thousand inquiries have been resolved by clinical pharmacists on WeChat from January 2020 to December 2020. Children are prone to respiratory infections, and parents are more likely to be presented with excessive concern and anxiety, and pharmacists give substantial support for the emotional management of the parents.

The use of telemedicine in China began in 2014 with the establishment of an online hospital.<sup>12</sup> The use of telemedicine, which does not require person-to-person interaction between the patient and the healthcare provider, expanded during the pandemic due to many patients’ preference for contactless online consultations.<sup>13</sup> This proved effective and provided significant patient satisfaction, leading the Department of Administration in our hospital to adopt more artificial intelligence technology to improve the current telemedicine framework for future clinical services in the post-pandemic era.

## Multimedia Health Education

Misinformation and rumors abound during a pandemic, especially when the public is unable to access authoritative information in a timely manner.<sup>14</sup> The pharmacists provided information on the prevention and control of coronavirus infection, as well as on medication, which were helpful to relieve the patients’ nervousness or even panic about the disease.<sup>7</sup> They provided a series of lectures related to dietary advice, self-protection, medication instructions and lifestyle modification during home quarantine. Those videos were posted on WeChat or some other popular social media platforms, which were free for the public. Specific topics on children’s hygiene habits were set up, such as advice on the proper wearing of masks and effective hand-washing. Parents were encouraged to interact with pharmacists through comments or comments.

To date, there is no specific medicine to treat COVID-19; therefore, the development of vaccines has always been the focus of public attention. On

February 26th, 2020, the first shots of COVID-19 vaccine in Shanghai were given to the staff in the Shanghai Public Health Clinical Center, the only designated hospital for adult COVID-19 patients in Shanghai. The safety and efficacy of COVID-19 vaccines from different manufacturers have been discussed continuously. Increased vaccination of adults is one of the best protective mechanisms for children, however, there were many concerns in the adults, especially those with chronic diseases. Specific lectures about COVID-19 vaccines were posted on social media platforms and broadcasted by radio sequentially. Clinical pharmacists in Shanghai Children’s Hospital set up a WeChat group for vaccine consultation. The quick response (QR) code was advertised in both outpatient and inpatient hospital departments of the hospital, and nurses assisted parents in scanning the code to join the group. The pharmacists explained the precautions and the contraindications of the vaccine shots, potential discomfort after vaccination and corresponding treatment.

## Conclusions

The COVID-19 pandemic caused an unparalleled public health crisis involving hospitals and institutions, healthcare providers, and communities. Clinical pharmacists in the Shanghai Children’s Hospital played an important role in the swift formulation of telemedicine strategies and provided innovative and efficient services to procure and deliver medication safely. Nonetheless, many services have utilized artificial intelligence technology even before the pandemic for diagnosing and managing patient care and administration. Technical means, including hospital logistics robots and telemedicine, have been studied before the outbreak of COVID-19, but the technology had the feature of immature system and limited practicability at that time.<sup>15,16</sup> Increasingly complex medical needs caused by coronavirus have put severe stress on medical system and therefore provide stronger development momentum and wider application space for intelligence technology. Logistics robots have been widely used in 13 wards on the 7th to 13th floors since the beginning of COVID-19, one of them specializes in fever clinic. At some point telemedicine consultation even turned to the mainstream methods to meet medical needs under the public policy of epidemic control and prevention. Due to its convenience and efficiency, the techniques mentioned in this article have become widely recognized and applicable since the epidemic. The move to telemedicine and contactless services



was, this, not a sudden occurrence and suggests the feasibility and viability of the expansion of contactless services to deliver hybrid services (a combination of online and offline services).<sup>17</sup>

New technology enabled clinical pharmacists to play a greater role. For example, Logistics robot freed pharmacists from repetitive labor. Online prescription checking contributed to a timelier interaction and feedback between pharmacists and doctors. Telemedicine consultation and multimedia health education dominated by pharmacists provided domestic health services and effectively alleviated public anxiety. In short, pharmacists took the initiative to improve and application of technology mentioned in our article and therefore became more deeply involved in public health management. As a new internet hospital, Shanghai Children's Hospital will continue to offer innovative pharmaceutical care services in which pharmacists and doctors are able to collaborate and cooperate in different ways. Advances in technology and artificial intelligence necessitate that pharmacist be equipped with the necessary skills to meet future challenges.

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## Disclosure

Zhiling Li and Li Gan are co-first authors of this study. The authors report no conflicts of interest in this work.

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