

# Management and operation of extra-large Fangcang hospitals: experience and lessons from containing the highly contagious SARS-CoV-2 Omicron in Shanghai, China

Yun Xian<sup>1,\*</sup>, Chenhao Yu<sup>1,\*</sup>, Minjie Chen<sup>2,\*</sup>, Lin Zhang<sup>15,\*</sup>, Xinyi Zheng<sup>12</sup>, Shijian Li<sup>3</sup>, Erzhen Chen<sup>4</sup>, Zhongwan Chen<sup>1</sup>, Weihua Chen<sup>5</sup>, Chaoying Wang<sup>1</sup>, Qingrong Xu<sup>7</sup>, Tao Han<sup>1</sup>, Weidong Ye<sup>6</sup>, Wenyi Xu<sup>1</sup>, Xu Zhuang<sup>8</sup>, Yu Zheng<sup>14</sup>, Min Chen<sup>9</sup>, Jun Qin<sup>10</sup>, Yu Feng<sup>2</sup>, Shun Wei<sup>2</sup>, Yiling Fan<sup>11</sup>, Zhiruo Zhang (✉)<sup>1</sup>, Junhua Zheng (✉)<sup>13</sup>

<sup>1</sup>School of Public Health, Shanghai Jiao Tong University School of Medicine, Shanghai 200025, China; <sup>2</sup>Renji Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China; <sup>3</sup>SUNY Old Westbury, Department of Public Health, Old Westbury, NY 11568, USA; <sup>4</sup>Department of Emergency Intensive Care Unit, Ruijin Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai 200025, China; <sup>5</sup>Emergency Department, Renji Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China; <sup>6</sup>Shanghai Construction Group Co., Shanghai 200080, China; <sup>7</sup>Department of Orthopaedics, Renji Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China; <sup>8</sup>Department of Obstetrics and Gynecology, Renji Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China; <sup>9</sup>Nursing Department, Renji Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China; <sup>10</sup>Department of Gastrointestinal Surgery, Renji Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China; <sup>11</sup>Department of Neurosurgery, Renji Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China; <sup>12</sup>Department of Pharmacy, Huashan Hospital, Fudan University, Shanghai 200040, China; <sup>13</sup>Department of Urology, Renji Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China; <sup>14</sup>Department of Pulmonology, Renji Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China; <sup>15</sup>Civil Aviation Administration of China (CAAC), East China Regional Administration Aviation Personnel Examination Center, Shanghai Hospital of Civil Aviation, Shanghai 200336, China

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## Introduction

Omicron is more contagious and stealthier than the previous strains. The basic reproduction number of Omicron is around 8–12, whereas that of the previous mainstream strain Delta is only 5–8 [1]. Omicron's symptoms are relatively mild [2] compared with Delta's symptoms; however, Omicron's transmission ability is very strong, and its risk to children and the elderly remains high [3]. In addition, the vaccine's preventive effect on Omicron has weakened. Therefore, Omicron can easily cause a rapid outbreak in a city. The population density of megacities and the limited public health resources further exacerbate the difficulty of Omicron prevention and control.

In March 2022, an imported case was found in Shanghai Hua-ting Hotel, leading to a rapid outbreak of

Omicron in Shanghai. As of May 31, a cumulative total of 583 death cases had been confirmed, and more than 620 000 individuals have been infected. This scenario represents the most severe test of China's epidemic prevention and control since the emergence of SARS-CoV-2. The large number of infected people has caused a shortage of isolation facilities and treatment resources. For infected patients, early supportive treatment positively affects the patients' coping effort against the Omicron infection [4]. In this Shanghai epidemic, Shanghai has established five extra-large Fangcang hospitals with a capacity of more than 10 000 people to cope with a large number of new patients: the National Convention and Exhibition Center (capacity: 50 000 people), Lingang Canghai Road (capacity: 16 000 people), Shanghai New International Expo Centre (capacity: 14 000 people), Jiading F1 Circuit (capacity: 14 000 people), and Yangshan Port (capacity: 13 600 people). As temporary hospitals, Fangcang hospitals played an important role in supplementing public health resources when the SARS-CoV-2 outbreak broke out in Wuhan in 2020 [5]. However, compared with the construction needs of Fangcang hospitals in the initial

Received June 7, 2022; accepted September 6, 2022

Correspondence: Zhiruo Zhang, zhangzhiruo@sjtu.edu.cn;

Junhua Zheng, zhengjh0471\_02@163.com

\*These authors contributed equally to this work and shared first authorship.

stage of the SARS-CoV-2 outbreak in early 2020, the construction needs of Fangcang hospitals during the Omicron outbreak have changed according to the characteristics of the Omicron strain. The most notable progress is the expansion of Fangcang hospitals in size and capacity because of the large number of patients that need management. The large number of patients leads to two new demands: specific management of various types of patients and an increase in the number of medical staff. Therefore, managing medical staffs, particularly those from different hospitals and provinces and required to meet the needs of different patients, has also become the focus in constructing extra-large Fangcang hospitals.

The main change in the extra-large Fangcang is the huge increase in the number of medical teams and patients. Thus, medical team members must exert all their abilities and reduce the cost of collaboration. Different medical teams join the same Fangcang and become an organization under the common principles of diagnosis and treatment guidelines and the common belief in rescuing patients. Therefore, from a definitional point of view, the medical organization in the extra-large Fangcang fits the concept of loose coupling organization [6–8].

Therefore, we took loose coupling as our perspective and analysis framework in the present study. Another benefit of adopting such a perspective is that the patient care approach is generally homogeneous even though medical and nursing teams are heterogeneous [9]. Thus, we were able to focus on dealing with the circumstance with extremely limited medical resources and a large number of patients. On the basis of this theory, we analyzed why the extra-large Fangcang is suitable for the loose coupling organization in epidemic prevention, how to organize the loose coupling organization of the extra-large Fangcang, and the experience of the extra-large Fangcang in the Shanghai New International Expo Centre.

We analyzed the operation of the extra-large Fangcang hospital built in the Shanghai New International Expo Centre through investigation and interviews. We also summarized the experience in managing the extra-large Fangcang hospital. According to the results of the investigation, the conclusions of this study are as follows [1]: during the operation of extra-large Fangcang hospitals, the background culture and organizational habits cause conflicts because medical staffs come from different hospitals and different cities. A loose coupling organization would maximize the performance of each medical team [2]. Children, pregnant women, and elderly patients in the Fangcang have special needs. These special needs can be provided by the medical team in a loose coupling organization, thereby reducing the degree of coupling between different wards in the form of blocks and enhancing work efficiency [3]. Self-organization

voluntarily formed by patients helps manage extra-large Fangcang hospitals.

## Characteristics of an extra-large Fangcang

### Definition and characteristics

Fangcang hospitals have two basic functions: isolation and treatment [5]. The chain of transmission would be effectively cut with Fangcang hospitals, and its further spread in communities would be prevented by isolating a large number of infected individuals, leaving no patient unattended or untreated. The isolation costs are reduced because Fangcang hospitals are converted from large public venues, such as stadiums and exhibit centers. Aside from providing basic medical care for patients with no or mild symptoms, some Fangcang hospitals upgraded their facilities to provide a triage function for patients with COVID-19 and pre-existing conditions before transferring them to designated hospitals. This approach effectively avoided a massive influx of patients into healthcare facilities, thereby releasing pressure on the designated hospitals taking and treating COVID-19 patients.

Based on the basic function of Fangcang hospitals, extra-large Fangcang hospitals refer to the Fangcang converted from large public venues (e.g., stadiums and expo centers). These facilities have more than 10 000 beds for quarantine and healthcare delivery of patients with mild and moderate symptoms. Extra-large Fangcang hospitals can be quickly constructed and effectively operated in megacities with more than 10 million residents in case of an outbreak. Timely quarantine and treatment of confirmed and asymptomatic patients in these hospitals are vital for disease prevention and control. The characteristics of extra-large Fangcang hospitals are determined by the megacities themselves.

Fangcang hospitals must meet the daily living needs of patients and ensure their quality of life in addition to providing patients isolation and treatment. Support personnel for public security, fire, commuting, food, sanitation, hygiene, safety, nursing, and maintenance should be quickly deployed to guarantee an orderly community of patients. Consolidation of resources guarantees essential living and social engagement. Effective mobilization of human and material resources in construction and operation leads to the smooth, efficient, and safe operation of the hospitals. Thus, these extra-large Fangcang hospitals can improve treatment efficiency and patients' recovery rate, making them among the best efforts in fighting the pandemic. Therefore, rapid response, cost-effectiveness, and accommodating large crowds are the basic characteristics of extra-large Fangcang hospitals.

### Issues specific to extra-large Fangcang hospitals

During the rapid outbreak of COVID-19, extra-large Fangcang hospitals must respond rapidly. Moreover, different medical teams and even medical teams from different regions are required to participate in the collaboration during the process of rapid response. The collaborative model [10] raises the core issue of overcoming the costs caused by the habits of different teams. This cost consists of two aspects: one is the cost of cooperation in the team process, and the other is the cost of the team result handover process.

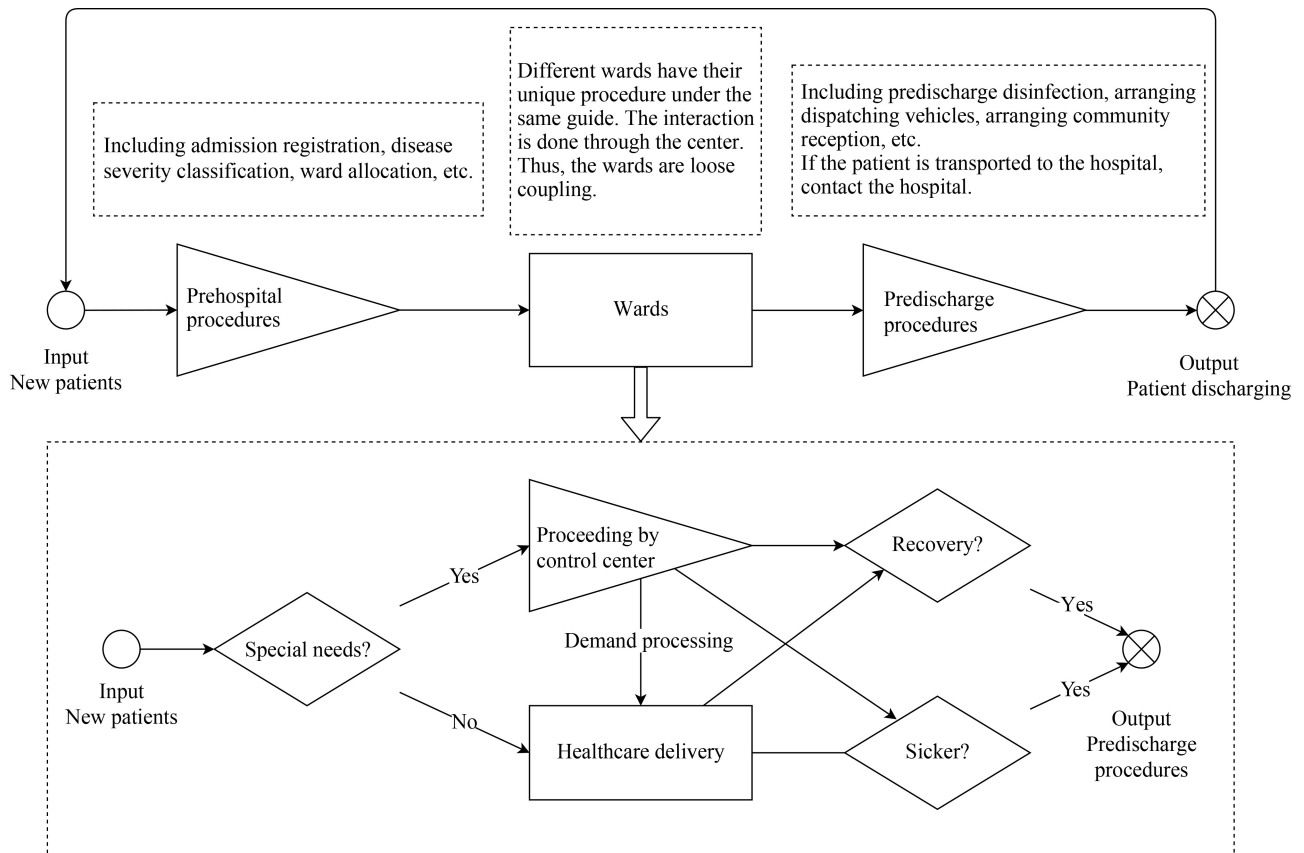
### Extra-large Fangcang under loose coupling perspective

Rapidly reaching the operational status of extra-large Fangcang hospitals during an outbreak is the key to responding to an epidemic. As an organization, extra-large Fangcang hospitals must reduce the factors that decrease performance to achieve operational status. This analysis also presents the basic characteristics of the extra-large Fangcang organization model, that is, the

combination of each medical team due to the same beliefs, guidelines, and institutionalized expectations [11]. If we further weaken the mutual connection between patients in different wards, we can consider that the patients in different wards are independent in the course of the disease. Therefore, the organizational form of an extra-large Fangcang conforms to the definition of the loose coupling organization formation mechanism in the model (2009) [12].

In addition, loose coupling rather than complete decoupling is used as the organizational form because extra-large Fangcang hospitals must remain stable when facing external resource limitations and external input. In particular, the transfer process and transfer efficiency of cases are important performance goals. Therefore, mutual responses exist between various wards. Even wards that meet the special needs of patients can be created based on loose coupling organization.

In sum (in Fig. 1), different wards in the system transmit signals through unified scheduling to maximize the acceptance of patients and provide patients with healthcare. The interactions between the ward and the outside world and those among wards are mainly



**Fig. 1** The life cycle (or feedback loop) of a patient in the extra-large Fangcang, which is loose coupling organized. The main loop (the top half) shows that the extra-large Fangcang has three main stages: prehospital procedures, inpatient stage, and predischarge procedures. The three stages have standardized consensus that can be modified by a specific team. The inpatient loop (the second half) shows the interaction and basic life cycle in the inpatient stage. The special needs of patients are the main interactions that may occur in this stage.

completed through the coordinating center.

### **The experiment and lessons from the extra-large Fangcang in Shanghai New International Expo Centre**

In this section, the extra-large Fangcang in Shanghai New International Expo Centre was taken as the research object. It was investigated under the analysis structure mentioned above. The analysis included the whole feedback loop in Fig. 2. We started from the organizational structure, which included the coordinating center, the wards, and the department in the input and output stages. Then, the interactions during the loop were analyzed. We took the token parent-child ward as an example. Finally, we analyzed the innovation in the extra-large Fangcang that may promote the performance of the organization.

#### **Organizational structure**

The organizational structure of the extra-large Fangcang in Shanghai New International Expo Centre can be mainly divided into three parts: the coordinating center, the wards, and the support departments. The coordinating center can be regarded as the third department. It builds a tunnel when the interaction occurs between the wards and support departments, which mainly includes on-duty, log reporting, nosocomial infection management, and staff access management. The wards comprise different medical teams that provide health delivery in the extra-large Fangcang. The medical team of the extra-large Fangcang in Shanghai New International Expo Centre consists of 3635 medical personnel from five provinces and municipalities (Jiangxi, Hubei, Shaanxi, Tianjin, and Shanghai). The support departments include the information department, logistic department, and pharmacy department.

Fig. 2 shows the life cycle (or feedback loop) of a patient in the extra-large Fangcang hospital in Shanghai New International Expo Centre. The coordinating center is managed by the principal of the Fangcang. This center is in charge of the interaction between the Fangcang and outside organizations, such as the Center for Disease Control and Prevention (CDC). Our survey indicates that the wards can work efficiently despite some typical and routine issues, such as registration, discharging, and patients' needs. Thus, the core responsibility of the coordinating center is to balance the capacity of different wards. This approach plays a vital role in eliminating the outbreak. The support departments mentioned in Fig. 2, such as the nursing department, information department, and logistic department, are functional departments independent of the wards. Some interactions between the

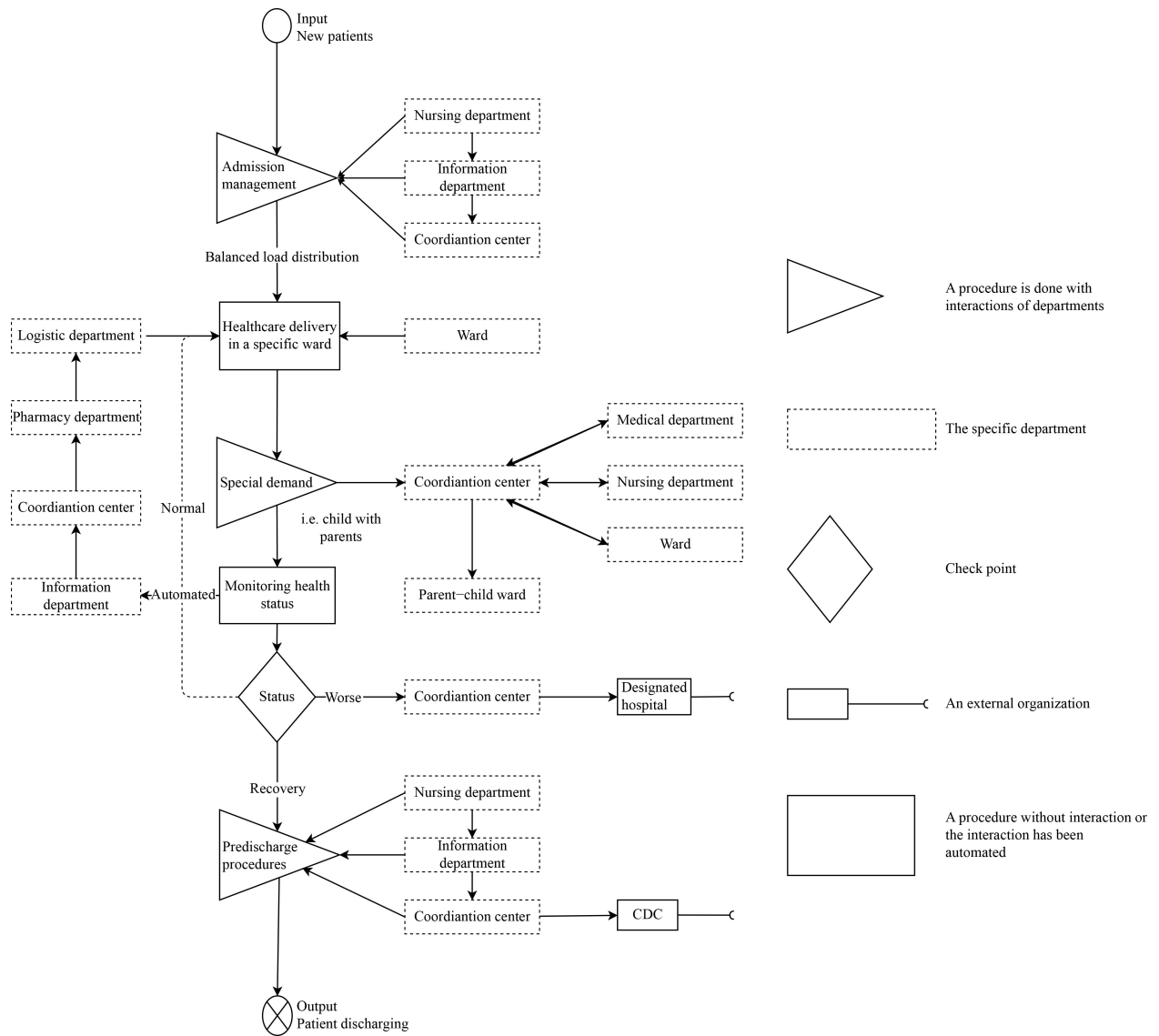
support departments and the wards are reduced with automation and informatization, particularly in the information department and the logistic department. The medical teams in the wards follow uniform guidelines. Each ward comes from the same medical team. Thus, the guidelines can be implemented according to the team's habits. If a ward has different medical teams, the cost of collaboration can be reduced by dividing the subwards in the ward in the early stage.

#### **Parent-child ward: the interactions between departments**

The interactions between departments are mainly managed through the coordinating department. However, several situations requiring different departments or wards to cooperate well exist to achieve patient expectations, such as the healthcare delivery to parent-child families.

In the early stage of the outbreak, the separation of children from parents led to a heated debate. Multiple studies pointed to the positive impact [13–15] of parental companionship on children's recovery and the role of medical ethics in healthcare delivery. Thus, the family module was established to reduce psychological burden and harm to parents and children. Children are mentally immature, and separating them from their parents may have long-term negative physical and psychological impacts. Therefore, family modules were launched in the hospital where parents and children can stay together. A subdesignated ward can offer assessment and temporary treatment to critically ill patients before they are transferred to an off-site hospital for care. The pediatric team is dominant in a parent-child ward because of the particularity of pediatric medicine. Other teams provide multidisciplinary support for healthcare delivery. Thus, the interaction between different wards or departments is mainly initiated by the pediatric team. Moreover, the coordinating department and the permanent staff from different teams in the parent-child ward participate in the communication and reduce the cost of communication that occurs during the respective work.

Compared with ordinary Fangcang hospitals, family modules create an environment where parents can accompany children rather than leave them alone. These family modules also host recreational and sports activities to provide a learning environment for children. The experience and lessons from family modules provide an empirical foundation of humane care during pandemics. The success of the unique family modules within the extra-large Fangcang is mainly supported by loose coupling organization and achieved by fulfilling the expectation of patients' parents without incremental medical burden. This successful scenario can also be a good reference in the future.



**Fig. 2** This illustration shows an instance of the extra-large Fangcang, which is loose coupling organized. It summarizes the life cycle in the extra-large Fangcang in Shanghai New International Expo Centre. Compared with that in Fig. 1, this instance shows how the Fangcang operated during the outbreak. The interactions between the outside area and Fangcang regarding new patients, transferring patients to designated hospitals, and discharging procedures, including reports to CDC, are managed through the coordination center.

**Supporting innovation in the extra-large Fangcang**

The innovations mainly support information flow, automation, and community management during the outbreak. Under the perspective of loose coupling organization, automation and information flow improve the coordination and work efficiency between various departments by strengthening the information processing and feedback capabilities of the coordination center, such as automatic information processing, automatic disinfection routine, and manual reduction of additional instructions. Given that each ward is independent, the communities and volunteer organizations in each ward also have their own characteristics.

The innovation of information flow mainly includes two aspects: patient information entry and update and patient diagnosis. During the admission stages, the digitization of patient information entry and transfer can effectively achieve load balancing in extra-large Fangcang hospitals. During the hospitalization stage, the medical staff can update the patient’s medical information through the terminal. The corresponding diagnosis and healthcare delivery plan can also be set to monitor effectively the changes in the health level and condition of many patients. A unified database and patient file data can effectively improve the efficiency of remote consultation in patient diagnosis.

Automation innovation is based on information flow

innovation. It aims to serve patients, further improving the work efficiency of medical staff. For example, unified ward management information has been established in the innovation of information flow, which provides an implementation basis for intelligent robots to enter the ward for automatic disinfection and transportation of meals.

Rather than merely a medical institution, an extra-large Fangcang mainly serves as a patients' community, where they are offered accommodation, food, sanitation, health care, and a sense of social participation. A massive number of patients are admitted to the hospital from different communities, cultural backgrounds, ages, and occupations. Many factors, such as infections, isolation, negative news report, and change in the environment, lead to anxiety among patients. Different wards can exert subjective initiative through loose coupling. Residents in the hospital are provided emotional support and introduced to various community activities according to their strength, such as reading, dancing, and Ba Duan Jin (traditional Chinese medical healing exercise). This approach not only enhances the emotional connection between patients and between doctors and patients but also improves psychological health for quick recovery.

## Discussion

Fangcang hospitals, which can rapidly improve a city's healthcare capacity [5,16,17], served as the key measure to control the COVID-19 pandemic and reduce the mortality rate in Wuhan. The isolation of patients with mild to moderate COVID-19 symptoms in Fangcang hospitals effectively improved the medical service capacity in Wuhan; the daily living needs and medical services of these patients were provided by Fangcang hospitals converted from exhibition centers or stadiums [18]. For example, Dongxihu Fangcang Hospital, the largest Fangcang hospital built in Wuhan with a capacity of more than 1000 people, was converted from an exhibition center [19]. The Shanghai Fangcang hospitals are much larger than Wuhan's largest Fangcang hospital. They have 10 000 beds to handle the rapid surge of cases that exceed the traditional hospitals' capacity for patient isolation. In the context of the Omicron pandemic in Shanghai, the present study analyzed the experience and lessons of operating and managing extra-large Fangcang hospitals under the perspective of loose coupling theory.

First, reducing the collaboration cost of different medical teams in extra-large Fangcang hospitals was a prerequisite for the normal operation of these facilities. The extra-large Fangcang hospital in Shanghai New International Expo Centre investigated in this study was managed by each team loosely, and the handover by special personnel or a specific coordinating center was

effective in emergencies. This method reduced the time and cost of training during outbreaks and allowed each medical team to return to work quickly, thereby improving the facility's capacity. Second, the loose coupling organization provided an opportunity to deliver patients with humane care and meet their family's needs. Therefore, opening parent-child wards and allowing children to be accompanied by their parents under the premise of controllable risks is an innovation of Fangcang hospitals. Given that most of the patients have mild symptoms, managing patients through community management in an extra-large Fangcang helps reduce the management pressure of patients and medical staff in the hospital. Moreover, it eases patients' mental health state. In addition, allowing recovered patients to serve as volunteers can alleviate the dilemma of medical staff shortage. Third, the short course of the disease, mild symptoms, and the large number of people caused considerable pressure on hospital management. Therefore, receiving patients to the greatest extent was the operational focus of extra-large Fangcang hospitals. We found during the research that the admission and discharge process, information management, and communication are vital in accelerating the turnaround time. Moreover, superlarge cabins have considerable risk-resistance capabilities in the process of receiving patients because they are also equipped with vital medical areas for high-risk patients.

Given their highly dense population, megacities are faced with the rapid spread of infectious diseases during the COVID-19 epidemic or in a possible future epidemic. Interrupting the transmission route is one of the most effective means of infectious disease control. Constructing extra-large Fangcang hospitals becomes an available tool for the sustainable development of megacities. Although some permanent Fangcang hospitals exist at present, the medical teams in the Fangcang hospitals may still be composed of medical teams from different hospitals in the future. Therefore, the loose coupling organization in Fangcang hospitals is very suitable and worth trying for extra-large and ordinary Fangcang hospitals.

## Limitations

The present study has three main limitations as following: (1) the extra-large Fangcang is studied through case analysis because of the limited survey samples and survey time; (2) the limited sample size makes conducting horizontal and vertical comparative studies on various Fangcang hospitals impossible; (3) this study did not follow up further visits to patients and residents because of the tremendous psychological trauma caused by the epidemic to patients and citizens and because of ethical

requirements.

Given such limitations, future research can start with analyzing the psychological mechanism of patients and medical staff and the performances under different organizational structures. The long-term impact of extra-large Fangcang hospitals on patients and the research on community relationships in extra-large Fangcang hospitals can be also further explored.

## Acknowledgements

We would like to thank the reviewers for taking the time and effort necessary to review the manuscript.

## Compliance with ethics guidelines

Yun Xian, Chenhao Yu, Minjie Chen, Lin Zhang, Xinyi Zheng, Shijian Li, Erzhen Chen, Zhongwan Chen, Weihua Chen, Chaoying Wang, Qingrong Xu, Tao Han, Weidong Ye, Wenyi Xu, Xu Zhuang, Yu Zheng, Min Chen, Jun Qin, Yu Feng, Shun Wei, Yiling Fan, Zhiruo Zhang, and Junhua Zheng declare that they have no conflict of interest. This manuscript presents a perspective on the management and operation of extra-large Fangcang hospitals and does not involve a research protocol requiring approval by the relevant institutional review board or ethics committee.

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