Features of the Designing of Infectious Diseases Hospitals in a Pandemic

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Abstract. The article describes hospital design in a period of pandemic. In the situation of a rapidly spreading epidemic of coronavirus infection, the Ministry of Health of the Russian Federation has faced a lacking of isolation hospitals in more than a dozen regions of Russia. There were taken various methods of setting up health care institutions for infectious patients during the year, in order to conquer the infection spread. Three of those came out to be the most effective. The first method is adaptation of the existing public buildings for health care needs. Another method is building pre-fabricated field hospitals. The third one is repurposing existing hospitals to infectious ones. This article investigates these basic approaches of creating hospitals in a period of pandemic and giving analysis to the main planning principles for infectious types of health care institutions.

1. Introduction

More than a year has passed since the announcement of the coronavirus pandemic. It has brought irreversible consequences and adjustments to everyday life and stroke the building sector in specific. To stop the spread of infection, the governments of many countries were forced to stop fabrication and impose lockdowns. In most Russian cities a large number of projects were frozen, and a strong outflow of workers from construction sites has happened. In the conditions of a lockdown, the decision was made to continue only important construction projects. Though most of energies were concentrated on the establishing and setting up medical and transport facilities.

The first experience of establishing an emergency field hospital designed to treat people with COVID-19 belongs to China. The project of hospital in Wuhan was completed in two weeks and required multibillion-dollar costs due to engineering networks laying and road-building. Anyway city authorities decided to set up a hospital, though the task seemed almost impossible. The hospital was built in an emergency mode: the construction was made simultaneously with infrastructure and road works. There were about 11,000 builders and more than 1,500 units of construction equipment and machines. More than 300 construction organizations worked at the construction site at a time. The building contractors admitted that they had spread thin providing workers to the project site. (Drawing 1).
When a new unfamiliar infection began spreading within Russian territory, high-density cities have started the construction of emergency hospitals in available urban areas, with the forces and experience of the Ministry of Defense of Russia involved.

Figure 1. The first fast-moving hospital in Wuhan, China.

Moscow took the first hit of the epidemic. Earlier, the infectious patients care has been organized way far from exemplary in the city. There wasn’t found a consensus, how to locate the medical facilities in current situation. So some of the hospitals were rapidly repurposed into infectious disease wards. The newly constructed hospital No. 1 in Kommunarka can be considered as the largest example of the hospital modified for the needs of the pandemic. At the beginning of April 2020, on the territory of the IKB No. 1 on Volokolamskoe highway, the reconstruction of an existing multidisciplinary hospital into an infectious clinical hospital has began. It was decided to erect a capacious hospital, so the treatment of all infectious diseases could be provided there.

As the level of infection in Moscow, St. Petersburg, Nizhny Novgorod and other cities started to get out of control, it was decided to redesign the space of public buildings for medical hospitals. In Moscow hospitals were deployed in the pavilion No. 75 on the territory of VDNK, in the Ice Palace in Krylatskoye and in the pavilion of Sokolniki Park. Each building was able to accommodate 2000 hospital beds. Likewise, in St. Petersburg, in the pavilion 7 at Lenexpo, 1000 beds were arranged. Patients were provided with round-the-clock medical treatment.

Therefore, observing the experience with COVID-19, there can be highlighted three approaches to building medical facilities:
- the construction of pre-fabricated modular hospitals;
- the conversion of public buildings into hospitals;
- partial reconstruction of the existing inpatient hospitals.

2. Theoretical part
The planning core of infectious hospitals is organizing 2 types of isolation rooms, caller “box” and “semi-box” for single or double beds each. The difference between types is that “boxes” have an individual access outside the building and have ensuite bathroom and toilet. While “semi-boxes” could be reached only from the inside of the hospital so incoming patients have to be re-examined by hospital health control and share bathrooms of hospital wing.

In the context of rapid infection growth, the pavilion 75 at VDNKh can be taken as an example of solving the overrun hospitals problem with the help of public places rearrangement, where a 53,000 m² hospital which able to accommodate 2000 beds was deployed. (Drawing 2).
Figure 2. Pavilion 75 at VDNH and its device for the placement of an infectious disease hospital.

Figure 3. Accessory of pavilion No. 75 at VDNH for an infectious disease hospital. Layout diagram of the 1st floor.

There are situated 72 resuscitation beds equipped with ventilators in case of sharp health deteriorated patients. The heath control rooms prevent the spread of infection, dividing facilities into "clean" and "dirty" zones. Patients are admitted through 5 receptions equipped with 10 patient-rooms. Discharge area is equipped with bathrooms. In order to provide respiratory support without being transferred to the intensive care unit, all beds are equipped with oxygen systems. The beds are equipped with special mattresses helping to avoid bed sores. Hospital features modern portable ultrasounds that allow to slip in a central retinal vein catheter and is able to ultrasound lungs. The latest mobile models of X-ray can be used beside the patient beds. Each bed is equipped with special consoles for the supply of three types of medical gases (oxygen, vacuum and compressed air –
providing a full range of respiratory support.) Intensive care unit made it possible to care of patients with chronic diseases. Six beds are designed for hemodialysis procedures to help patients with chronic renal failure. Along with the usual resuscitation equipment, hospital operates a CT scanner, endoscopy, bronchoscopy and an EGD premises. According to sanitary requirements, ambulances disinfecting points were organized within the hospital compound. (Drawing 3).

The facades of the original building have undergone some changes also. Currently, its exterior glazed surfaces were covered with white and mirror film to avoid overheating of the premises.

The number of significant disadvantages arose, while repurposing public buildings as medical facilities: echoing walls, drafts, lack of climate control, risk of structure damages. However, an indisputable positive development is fast deployment of the hospital in an existing building.

Infectious diseases hospital in the settlement of Voronovskoye near Moscow (Drawing 4). can be considered as an example of a prefabricated modular field hospital. 80,000 square meters complex was designed and built in a month. 50 one-story buildings and 14 sections of two-three floor hospital dormitories are placed on the grounds of 40 hectares. The hospital's capacity reaches 800 beds, but the number can be expanded to 900 if needed.

In the hospital patients are treated in units with 2-beds isolation rooms (the boxes). Isolation room consists of a patient room, ensuite and two airlocks. Patients enter the boxes through the anteroom from the outside of the building, while medical staff enters the boxes through an isolated airlock from the inside. This design does not allow patients to move freely within the unit, which excludes the infection spread inside the hospital. (Drawing 5).

Comparing to the previous option of VDNKh pavilion in accommodating patients, this medical facility type is more efficient from both planning and functional points of view, since this approach completely excludes the disease spread and can be established quickly. However, the structures of prefabricated modular field hospitals aren’t sustainable in the long run, which may turn out to be quite costly and unpromising after the end of the pandemic.

Figure 4. Fast-moving modular hospital in Voronovsky, Moscow.
Figure 5. The planning structure of the hospital department of the hospital in Voronovsky.

An important consideration in infectious diseases hospitals planning is access restriction to the hospital compound. The infectious diseases departments must be completely inaccessible. The critical requirement for preventing the spread of infection is separate transportation of the patients. The ambulance might be disinfected both before delivering patient into the hospital compound and after the patient is delivered.

The creation of the largest infectious treatment complex in Russia is held while reconstructing an existing multidisciplinary hospital ‘IKB No. 1’ on Volokolamskoe highway. The newly built complex is planned to be five times bigger than previously existed in the designated area. And, of course, it will be equipped with the most modern diagnostic, laboratory and operational equipment. (Drawing 6).

By now, specialists have completed the demolition of outdated hospital units at the following addresses: Volokolamskoe highway, 63, buildings 2, 3, 6, 11, 12. New waterproofed reinforced-concrete foundation was already completed in place. Building of reinforced-concrete structures, exterior and internal walls, service systems and other above-ground works are made now.

The new complex will consist of three buildings with a total area of 96,500 m² connected by underground spaces and elevated walkways so that patients and medical staff can move around the hospital without need to get outside. The clinic might be equipped with 546 single ‘Meltzer boxes’ – the new standard of modern infectious diseases clinics. Those boxes safely isolate incoming infectious patients, preventing nosocomial cross-spread of diseases. According to the project, the premise is designed for 546 beds. This planning pattern is designed to isolate patients with various viral diseases. The most direct routes for either patients, medical transport or personal belongings were thought out, in order to provide patients isolation. To divide incoming and discharging patients, the building entrance groups and staircase-elevator units are designed separately. Health personnel can enter various units through transport hubs located at the sides of the building. (Drawing 7).
Figure 6. Project ICB No. 1 on Volokolamsk Highway, Moscow.

Figure 7. Planning scheme of the 1st floor of the ICB hospital No. 1.
3. Suggestions and recommendation
Investigations on the COVID-19 infection spread in Russia and means of controlling it; unlimited transmigration, mass tourism and some cases of laboratory failures, showing that it is necessary to create a wider network of inpatient clinics throughout the country, designed to treat patients with various types of infectious lesion. Considering the current economic situation in the country, building new infectious hospitals widely seems economically disadvantageous. Nowadays medical centers are placed in existing infrastructure which doesn’t meet the current safety and comfort requirements, lacking space and therefore causing overload. The buildings are worn out and require significant structural changes. For that reason it is quite conceivable that much-need infectious clinics could appear as a result of renovating the existing medical facilities.

The following requirements during the renovation of the buildings must be met:
• high security level, supported through planning solutions, escape routes, video surveillance, fire extinguishing and alarm systems;
• creating enabling environment for patients and medical staff, ensuring systematic implementation from modernization of engineering and technical systems to renewing interior finishes;
• possibility of special medical equipment installation (radiography rooms, operating rooms, treatment rooms);
• adjustment hospital capacity to real-time needs by increasing of waiting areas (halls, corridors, foyers), adding the number of wards, bathrooms and outpatient department spaces;
• developing an accessible environment for all visitors, including persons with reduced mobility

4. Conclusions
Analyzing these three different approaches to infectious patients care during the epidemic in large cities of Russian Federation, it can be assumed that while handling steadily developing pandemic, the most balanced decision, is renovation of medical facilities established so far. The existing hospitals can be partially demolished, partially reconstructed; though it is already equipped with all necessary medical technology and engineering systems, which is very cost-effective. Properly designed medical facilities can create the most suitable conditions for treating patients not only during the spread of coronavirus infection, but also in possible subsequent epidemics.

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