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Lessons from a COVID-19 hospital, Republic of Korea

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Abstract

Objective To document the experiences of converting a general hospital to a coronavirus disease 2019 (COVID-19) designated hospital during an outbreak in Daegu, Republic of Korea.

Methods The hospital management formed an emergency task force team, whose role was to organize the COVID-19 hospital. The task force used different collaborative channels to redistribute resources and expertise to the hospital. Leading doctors from the departments of infectious diseases, critical care and pulmonology developed a standardized guidelines for treatment coherence. Nurses from the infection control team provide regular training on donning and doffing of personal protective equipment and basic safety measures.

Findings Keimyung University Daegu Dongsan hospital became a red zone hospital for COVID-19 patients on 21 February 2020. As of 29 June 2020, 1048 COVID-19 patients had been admitted to the hospital, of which 22 patients died and five patients still treated in the recovery ward. A total of 906 health-care personnel worked in the designated hospital, of whom 402 were regular hospital staff and 504 were dispatched health-care workers. Of these health-care workers, only one dispatched nurse acquired COVID-19. On June 15, the hospital management and Daegu city government decided to reconvert the main building to a general hospital for non-COVID-19 patients, while keeping the additional negative pressure rooms built, in case of resurgence of the disease.

Conclusion Centralized coordination in frontline hospital operation, staff management, and patient treatment and placement allow for successful pooling and utilization of medical resources and manpower during COVID-19 outbreak.

Introduction

The coronavirus disease 2019 (COVID-19) outbreak have affected almost all countries in the world. Such health crisis call for hospitals and other health-care facilities to develop strategies to manage unprecedented number of patients while competing for a finite set of resources.[1–3] Sharing countries' experiences of handling the outbreak might translate into improved response to the outbreak. Although there are many research publications on clinical characteristics and treatment management of COVID-19,[4–6] discussion on designated hospital operation and management remains limited. Therefore, we describe our experiences from a COVID-19 treatment hospital located in the city of Daegu, the COVID-19 epicentre in the Republic of Korea in the Spring of 2020.

As of 29 June 2020, the country had reported 12 757 confirmed COVID-19 cases (including 1551 imported cases).[7] Of these cases, 11 364 people have been discharged from isolation and 282 patients have died. Daegu has been most affected with 6906 confirmed cases (54.2%), followed by Gyeongsangbuk-do province (1388 cases; 10.9%), the capital Seoul (1305 cases; 10.2%) and Gyeonggi-do province (1200 cases; 9.4%).[8]

The first confirmed COVID-19 case was reported on 20 January 2020.[9] Initial COVID-19 patients in the country were mainly visitors from China. On February 18, the first COVID-19 patient was confirmed in Daegu, a city with approximately 2.5 million inhabitants. Within a month, Daegu had over 6200 confirmed cases, many of which could be linked to the Shincheonji Church. On 15 March, the government designated Daegu as one of four special disaster zones heavily affected by COVID-19.[10] This announcement was the first time the government declared a special disaster zone due to disproportionate impact of an infectious disease on its population.

To respond to the outbreak and improve patient care, Daegu city government and the hospital management agreed to convert Keimyung University Daegu Dongsan Hospital to COVID-19 designated hospital. Here we describe our experiences in anticipating, absorbing and adapting to an increase in the surge of patients during the COVID-19 outbreak.

Methods

Local setting

The private Keimyung University Dongsan Medical Center has three hospitals, of which two are located in Daegu: the tertiary hospital Keimyung University Dongsan Hospital with 992

beds and secondary level Daegu Dongsan Hospital with almost 1000 beds capacity, but only 216 beds in use before the COVID-19 outbreak.[11] When the Keimyung University Dongsan Hospital was transferred to newly built hospital in the western area of Daegu in April 2019, the old hospital building in the central of the city became Daegu Dongsan Hospital. The two hospitals are 10km away part, which takes about 20–30 minutes by car. In January 2020, the daily number of outpatients was approximately 3300 in Daegu Dongsan Hospital and 565 in Keimyung University Dongsan Hospital (unpublished data, Keimyung University Dongsan Medical Center, Daegu, Republic of Korea, August 2020).

In the beginning of the outbreak, the policy in the country was to hospitalize all confirmed COVID-19 cases. However, on 21 February 2020, the accumulated number of patients in Daegu was 59, yet only 15 patients were able to be hospitalized due to limited number of negative pressure rooms in the hospitals. To ensure that all COVID-19 patients could be admitted to a hospital, the Daegu city government agreed with the hospital management that the Daegu Dongsan Hospital should be the designated COVID-19 hospital in the city, since this hospital had a larger plot area and was easier to transform. The non-COVID-19 patients in Daegu Dongsan Hospital was therefore transferred to Keimyung University Dongsan Hospital.

Approaches

Emergency task force team

The management of Daegu Dongsan Hospital focused all its resources and expertise needed for COVID-19 patient care. The both hospitals established a joint emergency task force team, which consisted of leading staff members in the divisions of medicine, infection control, nursing, laboratory medicine, radiology, administration, facilities, logistics, nutrition and public relations. To enable swift communication and decision-making, the emergency task force team resided in the designated hospital's annex building. A daily face-to-face meeting allowed the head of each department to actively discuss different topics of patient care, staffing, medical supplies and issues that need to be resolved.

To reduce misunderstandings in patient care, the heads of the department of infectious diseases, critical care and pulmonology had the ultimate authority. Doctors of different specialties participated in the COVID-19 patient care and they used group chats in the instant messaging application Kakaotalk for smartphones to discuss patient treatment in real time. Physician team, which included doctors from infectious disease, pulmonology, radiology and

laboratory medicine, managed all areas of diagnosis and treatment of COVID-19 and infection control in the hospital. The task force assigned nurses to support the physician team. For example, the nurses managed the inpatient list and daily COVID-19 polymerase chain reaction (PCR) testing list, reported inpatient list and patients who had have two consecutive negative PCR results to the government.

Converting the hospital

Given the large number of patients but limited numbers of beds and negative pressure rooms, the task force decided to convert the entire main building of the hospital into a red zone on 21 February. With help from key health-care workers, i.e. primarily physicians of infectious diseases, who had experience in patient management and infection prevention and control of the Middle East Respiratory Syndrome, the hospital was transformed in one day. These key health-care workers decided the overall process to convert the main building to a red zone and suggested separated routes for medical staff and patients. Only employees wearing personal equipment could enter the main building through the entrance on the first floor, while COVID-19 patients entered the building through an entrance on the third floor. All other entrances were closed. The elevators were used separately by patients and staff. Line stickers were put on the floor to guide the route for patients and staff. Medical personnel could not enter the red zone without putting on personal protective equipment in anteroom A (Fig. 1).

All general wards, located on the fifth to eight floor in the hospital, were now used for COVID-19 patients. Bed-ridden or elderly patients as well as patients with severe pneumonia were placed on the fifth floor so that they could be moved quickly if needed to the intensive care unit, also located on the fifth floor. At first, only three negative pressure rooms were available in the intensive care unit. We expanded the number of beds in the unit to 20 beds. At first, there were no time for creating individual negative pressure rooms in intensive care unit, but we created a station surrounded by a dividing glass wall in the centre of the unit, allowing medical staff to monitor patients inside the station.

To minimize the time health-care workers spend in the hospital wards and to potentially reduce the infection risk, we placed smartphones in each ward. These devices were used for video consultations before ward rounds to check patients' conditions.

To separate patients who was recovering from sicker patients, the task force created a separate recovery ward in an additional hospital building (previously used as research building).

Expensive and hard-to-get medical devices, such as extracorporeal membrane oxygenation and mechanical ventilators, needed for the set-up of new intensive care units were lent by other hospitals or were purchased with funding from nongovernmental organizations.

In the beginning of April, we constructed six additional negative pressure rooms in the general wards to expand the hospital's capacity to isolate suspected COVID-19 patients who may require treatment. Before the construction, we transferred the COVID-19 patients on the relevant floor to other floors within the main building or to the recovery ward. After a 24-hour ventilation, we started the construction of the negative pressure rooms. Entire construction took 10 days and ended on 14 April 2020. Separate anterooms for donning and doffing of personal protective equipment and shared corridor were built, and interlocking doors and portable negative pressure equipment were installed.

Personal protective equipment

All health-care workers in contact with confirmed COVID-19 patients were instructed to wear coveralls, N95 mask, goggle or face shield and double gloves. When treating patients for more than 3–4 hours or in situations where aerosols can be generated (for example during intubation or suction), health-care workers wore a powered air purifying respirator. All medical personnel wore such respirators constantly while working in spaces with high probability of aerosols generation, such as in the intensive care units. Health-care workers discarded coveralls, N95 masks and gloves after use. Due to shortage in supply of goggles and powered air purifying respirators, health-care workers reused them after the equipment had been sterilized. After the first use, powered air purifying respirators were first wiped with alcohol and then with benzalkonium chloride tissue. After 1–2 weeks of use, we used ethylene oxide gas to sterilize them. We discarded reused powered air purifying respirators after they been sterilized with ethylene oxide gas once or twice, because a proper performance of the respirator could not be guaranteed. We sterilized the goggles by cleaning them with 70% (vol/vol) ethanol and wiping with dry tissues, and then disinfected them with ethylene oxide gas.

By having two separate anterooms (Fig. 1), one for donning and one for doffing, we aimed to avoid contamination of the donning area. In each anteroom, managers helped staff putting on and off personal protective equipment and monitored the process. The anteroom also had video surveillance to ensure personal protective equipment were worn and removed in a safe manner.

All health-care workers received one KF94 or surgical mask per day to wear at all times when they resided in the clean zone.

Health workforce

We prioritized more experienced health-care workers and those with experience in other high-consequence pathogens to improve patient care and support less experienced health-care workers in the beginning of this outbreak.

In early stages of the running of the COVID-19 hospital, the ordinary workforce was able to provide treatment to all COVID-19 patients. However, as the number of patients, beds and intensive care units increased additional health-care workers were needed, not only to fill the gap in staffing but also relieve fatigued personnel. Doctors and nurses from other parts of the country were rapidly dispatched to the hospital through different medical societies. First, public hospital doctors and nurses, military doctors, public health doctors and nurse officers were dispatched. Then, civilian nurses recruited from the health ministry and civilian doctors who were volunteering participated in COVID-19 patient treatment. The Medical Association, the Society of Critical Care Medicine and the Nurses Association of the Republic of Korea, also helped to recruit volunteers. The national government covered most of housing fees, daily expenses, hazard pay and other cost associated with dispatchment of workforce. The medical and humanitarian assistance nongovernmental organization, Global Care, also partly supported the dispatchment.

To ensure safety of all health-care workers and to prevent nosocomial infection, nurses from the infection control team provide regular training on donning and doffing of personal protective equipment and basic safety measures, such as how to prevent virus exposure and what to do if one is exposed. The training session, which were given onsite at least twice every day, lasted about one hour. Before the hands-on training, participants were given instructions on wearing and removing of personal protective equipment. If the trainer deemed a participant to be unskilled, the participant was re-trained until reaching a satisfactory level. During training, we also provided N95 mask fit test so individuals could

select the most suitable N95 mask. We allowed regular check-ups of the masks by constructing a N95 mask fit test booth near the anteroom A where personal protective equipment was put on.

The emergency task forced team instructed all health-care personnel to not eat face-to-face or communicate with one another during meals. In staff cafeteria, distances between all chairs were doubled and seats were rearranged so that staff members were not facing each other.

Development of local guidelines

To reduce misunderstandings in patient treatment and negative outcomes, leading doctors from the departments of infectious diseases, critical care and pulmonology developed a standardized guidelines for treatment coherence. They developed two treatment guidelines: one for patients with mild symptoms (i.e. mild illness, pneumonia without hypoxemia) and one for patients who required critical care (i.e. severe pneumonia, acute respiratory distress syndrome, multiorgan failure, etc.). To ensure standardized care was given to all patients, the leading doctors announced the guidelines on the bulletin board and also shared in group chats in instant messaging app. This approach mirrors the recommendation[12] that called for intensive care physicians to act as leaders to make sure standardized treatment is given to all patients with severe disease.[12] For patients without pneumonia, younger than 60 years and without comorbidity(ies), health-care workers only controlled their symptoms. Patients with pneumonia, chronic illnesses or older than 60 years, received an antiviral agent (that is, hydroxychloroquine or ritonavir/lopinavir). For patients with rapid progression of hypoxia or for those in need of oxygen supply of more than 6L/min, we administered intravenous steroid injection (methylprednisolone 30mg).

To help with patient placement in the hospital, we developed a novel scoring system to predict progression to severe pneumonia in patients with COVID-19. The scoring system contains four independent predictive factors for progression (age, C-reactive protein, lactate dehydrogenase, haemoglobin) and each factor's score was based on its regression coefficient, which we obtained through a multivariate logistic regression analysis. The risk score is the sum of the factor scores and a patient risk score can range from 0 to 20 points (Box 1). We constructed two patients groups based on the risk sores: patents with low risk (0 to 8 points) and patients with high risk (9 to 20 points). Medical staff monitored high-risk patients more

intensively than low-risk patients and placed high-risk patients in wards closer to the intensive care unit. Recently admitted, low-risk patients were placed in a separate ward.

Re-conversion to general hospital

As the number of newly confirmed COVID-19 patients in Daegu declined and there were no more COVID-19 patients needing intensive care, the hospital management decided to re-convert the main building in to a general hospital on 15 June 2020.

To prepare for new surge of COVID-19 cases, we maintained 154 beds in the recovery ward for COVID'10 patients presenting with mild symptoms.

Results

After the Daegu Dongsan Hospital was designated as a COVID-19 hospital, its total capacity increased from 216 beds and 5 wards, including one intensive care unit to 465 beds and 10 wards, including two intensive care units (Fig. 2). As of 29 June 2020, a total of 1048 COVID-19 patients had been admitted to the hospital, which is the largest number of COVID-19 patients hospitalized in a single centre in Republic of Korea. Out of the 1048 patients, 520 had pneumonia, 149 required oxygen therapy, 15 needed mechanical ventilation and three were on extracorporeal membrane oxygenation. Out of the 22 patients who died, 11 patients did not receive any intensive care due to do-not-resuscitate orders. As of 29 June, five patients were hospitalized in the recovery ward.

A total of 906 health-care personnel worked in the designated hospital, of whom 402 were regular hospital staff and 504 were dispatched health-care workers. Of these health-care workers, only one dispatched nurse acquired COVID-19.

On 21 May, the remaining COVID-19 patients hospitalized in the main building were transferred to the recovery ward. On June 15, the hospital management and Daegu city government decided to reconvert the main building to a general hospital for non-COVID-19 patients, while keeping the negative pressure rooms, three in the intensive care unit and six in the general ward.

Discussion

Here we describe how a general hospital in the epicentre of a COVID-19 outbreak transformed in to a red zone hospital. Converting the entire hospital into a red zone ensured both isolation and care for COVID-19 patients as well as protection of health-care workers.

While city government and hospital management undertook many measures in response to the surge in cases, we believe three measures in particular played a pivotal role in controlling the outbreak and dealing with resource and personnel constraints. First, the decision to develop and operate COVID-19-specialized red zone hospital was an emergency strategy that allowed efficient use of already limited personal protective equipment and medical personnel. In addition, the conversion enabled us to easily expand specific bed capacity. Second, involving well-experienced staff in setting up the emergency response system is key in providing well-orchestrated care provision and reducing avoidable work-related burden. Their leading roles and experience helped other staff members new to the infectious disease control field. Third, the coordinated approach taken by the government and the hospital allowed for pooling of much needed resources into the COVID-19 hospital and helped to preserve normal functions of other hospitals in the city. Patients in other hospitals detected with COVID-19 were immediately transferred to the designated COVID-19 hospital.

Despite the high number of health-care workers working at the hospital, only one acquired COVID-19. We believe that the thorough training on the use of personal protective equipment, the adequate supply of such equipment, the additional workforce and the social distancing rules for staff contributed to this positive outcome.

Making the hospital a COVID-19 designated hospital guaranteed an adequate supply of personal protective equipment, since the reconverted hospital received direct and prioritized assistance from the central government and Daegu city government. In addition, other entities, including the national Center for Diseases Control and Prevention, companies and citizens, donated personal protective equipment to the hospital. Therefore, all health-care workers in contact with confirmed COVID-19 patients were able to wear personal protective equipment at all times.

As the COVID-19 outbreak continued, we noted that health-care workers began to experience greater physical and mental fatigue. Therefore, placing empowered staff leaders at the designated hospital was important to boost morale and make workers feel valued, as well as protect the health-care workforce. Another challenge was the non-medical personnel, such as cleaners and people distributing the meals, who were not familiar with infectious diseases and infection control. Without adequate training they posed a higher risk of virus exposure virus and nosocomial infection, which could lead to great personnel shortage. We, therefore also provide the training for them and gave them feedback.

We hope our experiences and lessons learnt while converting a hospital in to a designated COVID-19 hospital will be useful for public health officials in other countries experiencing similar situations.

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Competing interests:

None declared.

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Box 1. Scoring system to identify COVID-19 patients with high risk of progression of severe pneumonia, Daegu, Republic of Korea, 2020

Age

< 50 years: 0 points

50–59 years: 4 points

60–69 years: 5 points

70–79 years: 7 points

> 79 years: 10 points

C-reactive protein

< 1.4 mg/dL: 0 points

≥ 1.4 mg/dL: 3 points

Lactate dehydrogenase

< 500 U/L: 0 points

500–700 U/L: 2 points

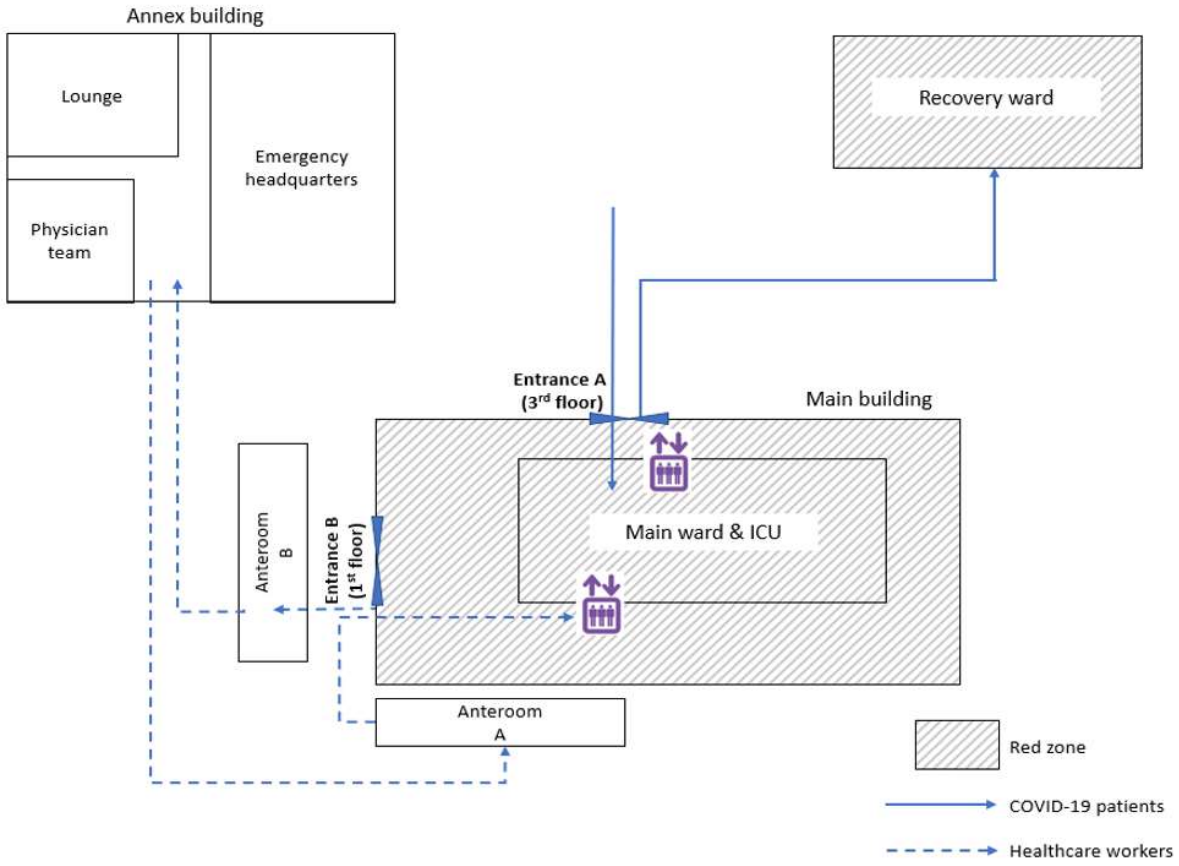
≥ 700 U/L: 4 points

Haemoglobin

< 13.3 g/dL: 0 points

≥ 13.3 g/dL: 3 points

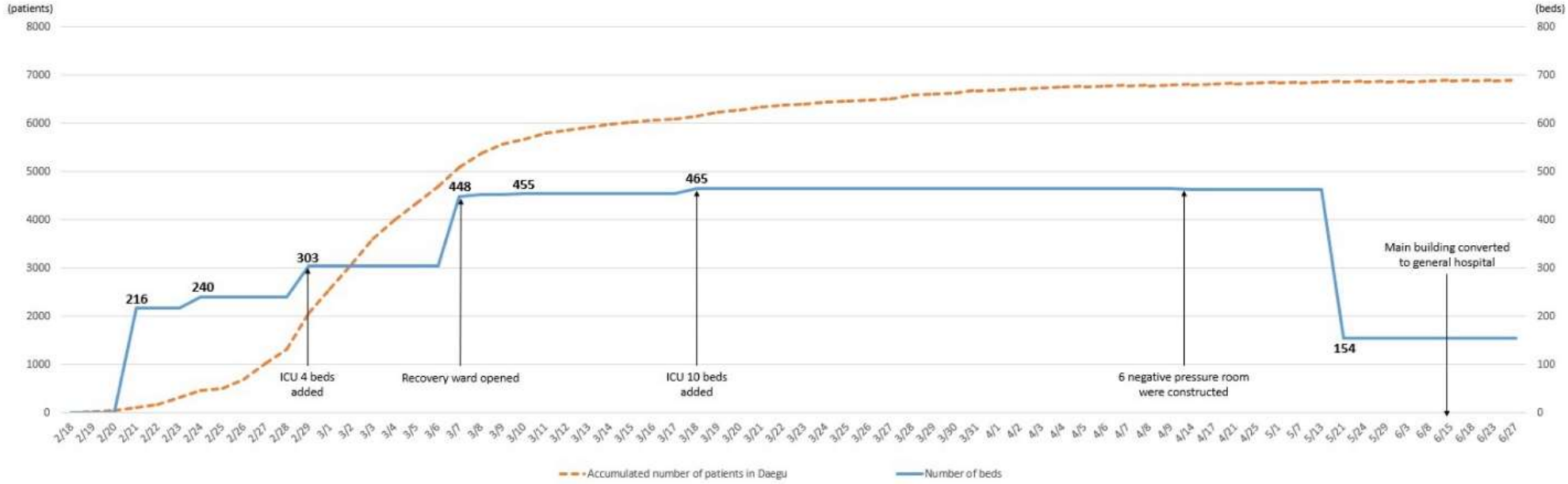
Fig. 1. **Schematic layout of a COVID-19 hospital in Daegu, Republic of Korea, 2020**



COVID-19: coronavirus disease 2019.

Notes: Health-care workers were putting on personal protective equipment in Anteroom A and removed them in Anteroom B. Pathways of COVID-19 patients and health-care workers were separated in the main building

Fig. 2. **Number of beds in Keimyung University Daegu Dongsan hospital and accumulated number of COVID-19 patients in Daegu, Republic of Korea, 18 February to 27 June 2020**



COVID-19: coronavirus disease 2019.